STANDARD TECHNICAL SPECIFICATIONS

FOR

O&MA PROJECTS, KOREA

October 1, 2003

DEPARTMENT OF THE ARMY
INSTALLATION MANAGEMENT AGENCY
KOREA REGION OFFICE

DEPARTMENT OF THE ARMY
INSTALLATION MANAGEMENT AGENCY (IMA)
KOREAN REGION OFFICE (KORO)
Unit 15742 APO AP 96205

REPLY TO
ATTENTION OF:

SFIM-KO-PW-ES 18 JUN 2003

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: New Standard Technical Specification for OMA Projects, Korea

1. The 6th edition of the Standard Technical Specifications for OMA Projects, Korea, 1 Oct 2003, will be used in the performance of OMA construction contracts. Each individual construction package will list the specific contract specifications that apply to that contract.

2. The hard copy version of the specifications is broken down into four volumes:

   a. Volume I involves General and Civil work, Division 1 through 3.

   b. Volume II involves Architectural and Structural work, Division 4 through 12.

   c. Volume III involves Mechanical work, Division 15.

   d. Volume IV involves Electrical work, Division 16.

3. The electronic version of the specifications is in an Acrobat PDF format and can be read with the Acrobat Reader software. In addition, the specifications will be available on the CCK web site, http://www.cckbid.com and will be on the KORO website currently under construction.

4. These specifications will be updated and/or revised to conform to the requirement of individual projects. Revisions and/or changes made will be included in the project's contract package.

5. Comments, suggested changes, proposed additions, improvements and additional hardcopy requests should be forwarded to Mr. Danny Hong (DSN 724-5069), Chief of RESC's Technical Review Section, at Hongd@usfk.korea.army.mil.

JOHN A. MACDONALD 6/18/03
Brigadier General, US Army
Director

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FOR
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STANDARD TECHNICAL SPECIFICATIONS

FOR

O&MA PROJECTS, KOREA

Volume I

October 1, 2003

DEPARTMENT OF THE ARMY
INSTALLATION MANAGEMENT AGENCY
KOREA REGION OFFICE

DIVISION 01 GENERAL REQUIREMENTS

SECTION 01320

PROJECT SCHEDULE

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of the specification to the extent referenced. The publications are referenced in the text by basic designation only.

U.S. ARMY CORPS OF ENGINEERS (USACE)

ER 1-1-11 (1995) Progress, Schedules, and Network Analysis Systems

1.2 QUALIFICATIONS

The Contractor shall designate an authorized representative who shall be responsible for the preparation of all required project schedule reports.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Pursuant to the Contract Clause, SCHEDULE FOR CONSTRUCTION CONTRACTS, a Project Schedule as described below shall be prepared. The scheduling of Construction design and construction shall be the responsibility of the Contractor. Contractor management personnel shall actively participate in its development. Subcontractors and suppliers, Designers, Subcontractors and suppliers working on the project shall also contribute in developing and maintaining an accurate Project Schedule. The Project Schedule shall be approved by the Contracting Officer and shall be used to measure the progress of the work, to aid in evaluating time extensions and to provide the basis of all progress payments.

3.2 BASIS FOR PAYMENT

The schedule shall be the basis for measuring Contractor progress. Lack of an approved schedule or scheduling personnel will result in an inability of the Contracting Officer to evaluate Contractor's progress for the purposes of payment. Failure of the Contractor to provide all information, as specified below, shall result in the disapproval of the entire Project Schedule submission and the inability of the Contracting Officer to evaluate Contractor progress for payment purposes. In the case where Project Schedule revisions have been directed by the Contracting Officer and those revisions have not been included in the Project Schedule, the Contracting Officer may hold retainage up to the maximum allowed by contract, each payment period, until revisions to the Project Schedule have been made.

3.3 PROJECT SCHEDULE

The computer software system utilized by the Contractor to produce the Project Schedule shall be capable of providing all requirements of this specification. Failure of the Contractor to meet the requirements of this specification shall result in the disapproval of the schedule. Manual methods used to produce any required information shall require approval by the Contracting Officer.

3.3.1 Use of the Critical Path Method

The Critical Path Method (CPM) of network calculation shall be used to generate the Project Schedule.

3.3.2 Level of Detail Required

The Project Schedule shall include an appropriate level of detail. Failure to develop or update the Project Schedule or provide data to the Contracting Officer at the appropriate level of detail, as specified by the Contracting Officer, shall result in the disapproval of the schedule. The Contracting Officer will use, but is not limited to, the following conditions to determine the appropriate level of detail to be used in the Project Schedule:

3.3.2.1 Activity Durations

Contractor submissions shall follow the direction of the Contracting Officer regarding reasonable activity durations. Reasonable durations are those that allow the progress of activities to be accurately determined between payment periods (usually less than 2 percent of all non-procurement activities' Original Durations are greater than 20 days).

3.3.2.2 Design and Permit Activities

Design and permitting activities, including necessary conferences and follow-up actions and design package submission dates, shall be integrated into the schedule.

3.3.2.3 Procurement Activities

Tasks related to the procurement of long lead materials or equipment shall be included as separate activities in the project schedule. Long lead materials and equipment are those materials that have a procurement cycle of over 90 days. Examples of procurement process activities include, but are not limited to: submittals, approvals, procurement, fabrication, and delivery.

3.3.2.4 Critical Activities

The following activities shall be listed as separate line activities on the project schedule:

a. Submission and approval of mechanical/electrical layout drawings.

b. Submission and approval of O&M manuals.

c. Submission and approval of as-built drawings.

d. Submission and approval of 1354 data and installed equipment lists.

e. Submission and approval of testing and air balance (TAB).

f. Submission of TAB specialist design review report.

g. Submission and approval of fire protection specialist.

h. Submission and approval of testing and balancing of HVAC plus commissioning plans and data.

i. Air and water balance dates.

j. HVAC commissioning dates.

k. Controls testing plan.

l. Controls testing.

m. Performance Verification testing.

n. Other systems testing, if required.

o. Prefinal inspection.

p. Correction of punchlist from prefinal inspection.

q. Final inspection.

3.3.2.5 Government Activities

Government and other agency activities that could impact progress shall be shown. These activities include, but are not limited to: approvals, design reviews, environmental permit approvals by Local State regulators, inspections, utility tie-in, Government Furnished Equipment (GFE) and Notice to Proceed (NTP) for phasing requirements.

3.3.2.6 Responsibility

All activities shall be identified in the project schedule by the party responsible to perform the work. Responsibility includes, but is not limited to, the subcontracting firm, contractor work force, or government agency performing a given task. Activities shall not belong to more than one responsible party. The responsible party for each activity shall be identified.

3.3.2.7 Work Areas

All activities shall be identified in the project schedule by the work area in which the activity occurs. Activities shall not be allowed to cover more than one work area. The work area of each activity shall be identified.

3.3.2.8 Modification or Claim Number

Any activity that is added or changed by contract modification or used to justify claimed time shall be identified by a mod or claim number that changed the activity. Activities shall not belong to more than one modification or claim item. The modification or claim number of each activity shall be identified by the Mod or Claim Number. Whenever possible, changes shall be added to the schedule by adding new activities. Existing activities shall not normally be changed to reflect modifications.

3.3.2.9 Bid Item

All activities shall be identified in the project schedule by the Bid Item to which the activity belongs. An activity shall not contain work in more than one bid item. The bid item for each appropriate activity shall be identified by the Bid Item Number.

3.3.2.10 Phase of Work

All activities shall be identified in the project schedule by the phases of work in which the activity occurs. Activities shall not contain work in more than one phase of work. The project phase of each activity shall be by the unique Phase of Work Number.

3.3.2.11 Feature of Work

All activities shall be identified in the project schedule according to the feature of work to which the activity belongs. Feature of work refers, but is not limited to, a work breakdown structure for the project. The feature of work for each activity shall be identified by the Feature of Work.

3.3.3 Scheduled Project Completion

The schedule interval shall extend from NTP to the contract completion date.

3.3.3.1 Project Start Date

The schedule shall start no earlier than the date on which the NTP was acknowledged. The Contractor shall include as the first activity in the project schedule an activity called "Start Project". The "Start Project" activity shall be equal to the date that the NTP was acknowledged, and a zero day duration.

3.3.3.2 Constraint of Last Activity

Completion of the last activity in the schedule shall be constrained by the contract completion date. Calculation on project updates shall be such that if the early finish of the last activity falls after the contract completion date, then the float calculation shall reflect a negative float on the critical path. The Contractor shall include as the last activity in the project schedule an activity called "End Project". The "End Project" activity shall be equal to the completion date for the project, and a zero day duration.

3.3.3.3 Early Project Completion

In the event the project schedule shows completion of the project prior to the contract completion date, the Contractor shall identify those activities that have been accelerated and/or those activities that are scheduled in parallel to support the Contractor's "early" completion.
Contractor shall specifically address each of the activities noted in the narrative report at every project schedule update period to assist the Contracting Officer in evaluating the Contractor's ability to actually complete prior to the contract period.

3.3.4 Interim Completion Dates

Contractually specified interim completion dates shall also be constrained to show negative float if the early finish date of the last activity in that phase falls after the interim completion date.

3.3.4.1 Start Phase

The Contractor shall include as the first activity for a project phase an activity called "Start Phase X" where "X" refers to the phase of work. The "Start Phase X" activity shall be equal to the date on which the NTP was acknowledged, and a zero day duration.

3.3.4.2 End Phase

The Contractor shall include as the last activity in a project phase an activity called "End Phase X" where "X" refers to the phase of work. The "End Phase X" activity shall be equal to the completion date for the project, and a zero day duration.

3.3.4.3 Phase X

The Contractor shall include a hammock type activity for each project phase called "Phase X" where "X" refers to the phase of work. The "Phase X" activity shall be logically tied to the earliest and latest activities in the phase.

3.3.5 Default Progress Data Disallowed

Actual Start and Finish dates shall not be automatically updated by default mechanisms that may be included in CPM scheduling software systems. Actual Start and Finish dates on the CPM schedule shall match those dates provided from Contractor Quality Control Reports. Failure of the Contractor to document the Actual Start and Finish dates on the Daily Quality Control report for every in-progress or completed activity, and failure to ensure that the data contained on the Daily Quality Control reports is the sole basis for schedule updating shall result in the disapproval of the Contractor's schedule and the inability of the Contracting Officer to evaluate Contractor progress for payment purposes. Updating of the percent complete and the remaining duration of any activity shall be independent functions. Program features which calculate one of these parameters from the other shall be disabled.

3.3.6 Out-of-Sequence Progress

Activities that have posted progress without all preceding logic being satisfied (Out-of-Sequence Progress) will be allowed only on a case-by-case approval of the Contracting Officer. The Contractor shall propose logic corrections to eliminate all out of sequence progress or justify not changing the sequencing for approval prior to submitting an updated project schedule.

3.3.7 Negative Lags

Lag durations contained in the project schedule shall not have a negative value.

3.4 PROJECT SCHEDULE SUBMISSIONS

The Contractor shall provide the submissions as described below. The reports and network diagrams required for each submission are contained in paragraph SUBMISSION REQUIREMENTS.

3.4.1 Preliminary Project Schedule Submission

The Preliminary Project Schedule, defining the Contractor's planned operations for the first 60 calendar days shall be submitted for approval within 10 calendar days after the NTP is acknowledged. The approved preliminary schedule shall be used for payment purposes not to exceed 60 calendar days after NTP.

3.4.2 Initial Project Schedule Submission

The Initial Project Schedule shall be submitted for approval within 30 calendar days after NTP. The schedule shall provide a reasonable sequence of activities which represent work through the entire project and shall be at a reasonable level of detail.

3.4.3 Periodic Schedule Updates

Based on the result of progress meetings, specified in "Periodic Progress Meetings," the Contractor shall submit periodic schedule updates. These submissions shall enable the Contracting Officer to assess Contractor's progress. If the Contractor fails or refuses to furnish the information and project schedule data, which in the judgement of the Contracting Officer or authorized representative is necessary for verifying the Contractor's progress, the Contractor shall be deemed not to have provided an estimate upon which progress payment may be made.

3.5 SUBMISSION REQUIREMENTS

The following items shall be submitted by the Contractor for the preliminary submission, initial submission, and every periodic project schedule update throughout the life of the project:

3.5.1 Narrative Report

A Narrative Report shall be provided with the preliminary, initial, and each update of the project schedule. This report shall be provided as the basis of the Contractor's progress payment request. The Narrative Report shall include: a description of activities along the 2 most critical paths, a description of current and anticipated problem areas or delaying factors and their impact, and an explanation of corrective actions taken or required to be taken. The narrative report is expected to relay to the Government, the Contractor's thorough analysis of the schedule output and its plans to compensate for any problems, either current or potential, which are revealed through that analysis.

3.5.2 Approved Changes Verification

Only project schedule changes that have been previously approved by the Contracting Officer shall be included in the schedule submission. The Narrative Report shall specifically reference, on an activity by activity basis, all changes made since the previous period and relate each change to documented, approved schedule changes.

3.5.3 Schedule Reports

The format for each activity for the schedule reports listed below shall contain: Activity Numbers, Activity Description, Original Duration, Remaining Duration, Early Start Date, Early Finish Date, Late Start Date, Late Finish Date, Total Float. Actual Start and Actual Finish Dates shall be printed for those activities in progress or completed.

3.5.3.1 Activity Report

A list of all activities sorted according to activity number.

3.5.3.2 Logic Report

A list of Preceding and Succeeding activities for every activity in ascending order by activity number. Preceding and succeeding activities shall include all information listed above in paragraph Schedule Reports. A blank line shall be left between each activity grouping.

3.5.3.3 Total Float Report

A list of all incomplete activities sorted in ascending order of total float. Activities which have the same amount of total float shall be listed in ascending order of Early Start Dates. Completed activities shall not be shown on this report.

3.5.3.4 Earnings Report

A compilation of the Contractor's Total Earnings on the project from the NTP until the most recent Monthly Progress Meeting. This report shall reflect the Earnings of specific activities based on the agreements made in the field and approved between the Contractor and Contracting Officer at the most recent Monthly Progress Meeting. Provided that the Contractor has provided a complete schedule update, this report shall serve as the basis of determining Contractor Payment. Activities shall be grouped by bid item and sorted by activity numbers. This report shall: sum all activities in a bid item and provide a bid item percent; and complete and sum all bid items to provide a total project percent complete. The printed report shall contain, for each activity: the Activity Number, Activity Description, Original Budgeted Amount, Total Quantity, Quantity to Date, Percent Complete (based on cost), and Earnings to Date.

3.5.4 Network Diagram

The network diagram shall be required on the initial schedule submission and on monthly schedule update submissions. The network diagram shall depict and display the order and interdependence of activities and the sequence in which the work is to be accomplished. The Contracting Officer will use, but is not limited to, the following conditions to review compliance with this paragraph:

3.5.4.1 Continuous Flow

Diagrams shall show a continuous flow from left to right with no arrows from right to left. The activity number, description, duration, and estimated earned value shall be shown on the diagram.

3.5.4.2 Project Milestone Dates

Dates shall be shown on the diagram for start of project, any contract required interim completion dates, and contract completion dates.

3.5.4.3 Critical Path

The critical path shall be clearly shown.

3.5.4.4 Banding

Activities shall be grouped to assist in the understanding of the activity sequence. Typically, this flow will group activities by category of work, work area and/or responsibility.

3.5.4.5 S-Curves

Earnings curves showing projected early and late earnings and earnings to date.

3.6 PERIODIC PROGRESS MEETINGS

Progress meetings to discuss payment shall include a monthly onsite meeting or other regular intervals mutually agreed to at the preconstruction conference. During this meeting the Contractor shall describe, on an activity by activity basis, all proposed revisions and adjustments to the project schedule required to reflect the current status of the project. The Contracting Officer will approve activity progress, proposed revisions, and adjustments as appropriate.

3.6.1 Meeting Attendance

The Contractor's Project Manager and Scheduler shall attend the regular progress meeting.

3.6.2 Update Submission Following Progress Meeting

A complete update of the project schedule containing all approved progress, revisions, and adjustments, based on the regular progress meeting, shall be submitted not later than 4 working days after the monthly progress meeting.

3.6.3 Progress Meeting Contents

Update information, including Actual Start Dates, Actual Finish Dates, Remaining Durations, and Cost-to-Date shall be subject to the approval of the Contracting Officer. As a minimum, the Contractor shall address the following items on an activity by activity basis during each progress meeting.

3.6.3.1 Start and Finish Dates

The Actual Start and Actual Finish dates for each activity currently in-progress or completed.

3.6.3.2 Time Completion

The estimated Remaining Duration for each activity in-progress. Time-based progress calculations shall be based on Remaining Duration for each activity.

3.6.3.3 Cost Completion

The earnings for each activity started. Payment will be based on earnings for each in-progress or completed activity. Payment for individual activities will not be made for work that contains quality defects. A portion of the overall project amount may be retained based on delays of activities.

3.6.3.4 Logic Changes

All logic changes pertaining to NTP on change orders, change orders to be incorporated into the schedule, contractor proposed changes in work sequence, corrections to schedule logic for out-of-sequence progress, lag durations, and other changes that have been made pursuant to contract provisions shall be specifically identified and discussed.

3.6.3.5 Other Changes

Other changes required due to delays in completion of any activity or group of activities include:

a. delays beyond the Contractor's control, such as strikes and unusual weather.

b. delays encountered due to submittals, Government Activities, deliveries or work stoppages which make re-planning the work necessary.

c. actual or planned prosecution and progress of the work.

3.7 REQUESTS FOR TIME EXTENSIONS

In the event the Contractor requests an extension of the contract completion date, or any interim milestone date, the Contractor shall furnish the following for a determination as to whether or not the Contractor is entitled to an extension of time under the provisions of the contract: justification, project schedule data, and supporting evidence as the Contracting Officer may deem necessary. Submission of proof of delay, based on revised activity logic, duration, and costs (updated to the specific date that the delay occurred) is obligatory to any approvals.

3.7.1 Justification of Delay

The project schedule shall clearly display that the Contractor has used, in full, all the float time available for the work involved with this request. The Contracting Officer's determination as to the number of allowable days of contract extension shall be based upon the project schedule updates in effect for the time period in question, and other factual information. Actual delays that are found to be caused by the Contractor's own actions, which result in the extension of the schedule, will not be a cause for a time extension to the contract completion date.

3.7.2 Submission Requirements

The Contractor shall submit a justification for each request for a change in the contract completion date of under 2 weeks based upon the most recent schedule update at the time of the NTP or constructive direction issued for the change. Such a request shall be in accordance with the requirements of other appropriate Contract Clauses and shall include, as a minimum:

a. A list of affected activities, with their associated project schedule activity number.

b. A brief explanation of the causes of the change.

c. An analysis of the overall impact of the changes proposed.

d. A sub-network of the affected area. Activities impacted in each justification for change shall be identified by a unique activity number contained in the required data file.

3.7.3 Additional Submission Requirements

For any requested time extension of over 2 weeks, the Contracting Officer may request an interim update with revised activities for a specific change request. The Contractor shall provide submission within 4 days of the Contracting Officer's request.

3.8 DIRECTED CHANGES

If the NTP is issued for changes prior to settlement of price and/or time, the Contractor shall submit proposed schedule revisions to the Contracting Officer within 2 weeks of the NTP being issued. The proposed revisions to the schedule will be approved by the Contracting Officer prior to inclusion of those changes within the project schedule. If the Contractor fails to submit the proposed revisions, the Contracting Officer may furnish the Contractor with suggested revisions to the project schedule. The Contractor shall include these revisions in the project schedule until revisions are submitted, and final changes and impacts have been negotiated. If the Contractor has any objections to the revisions furnished by the Contracting Officer, the Contractor shall advise the Contracting Officer within 2 weeks of receipt of the revisions. Regardless of the objections, the Contractor shall continue to update the schedule with the Contracting Officer's revisions until a mutual agreement in the revisions is reached. If the Contractor fails to submit alternative revisions within 2 weeks of receipt of the Contracting Officer's proposed revisions, the Contractor will be deemed to have concurred with the Contracting Officer's proposed revisions. The proposed revisions will then be the basis for an equitable adjustment for performance of the work.

3.9 OWNERSHIP OF FLOAT

Float available in the schedule, at any time, shall not be considered for the exclusive use of either the Government or the Contractor.

SECTION 01330

SUBMITTAL PROCEDURES

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PART 1 GENERAL

1.1 REFERENCES

The publication listed below form a part of this specification to the extent referenced. The publication is referred to in the text by basic designation only.

IMA-KORO PAMPHLET 420-1

Facilities Engineering, Inspection of Construction Contracts

1.2 SUBMITTAL IDENTIFICATION

Submittals required are identified by SD numbers and definitions are as follows:

SD-01 Data

Submittals which provide calculations, descriptions, or documentation regarding the work.

SD-04 Drawings

Submittals which graphically show relationship of various components of the work, schematic diagrams of systems, details of fabrication, layouts of particular elements, connections, and other relational aspects of the work.

SD-06 Instructions

Preprinted material describing installation of a product, system or material, including special notices and material safety data sheets, if any, concerning impedances, hazards, and safety precautions.

SD-07 Schedules

Tabular lists showing location, features, or other pertinent information regarding products, materials, equipment, or components to be used in the work.

SD-08 Statements

A document, required of the Contractor, or through the Contractor, from a supplier, installer, manufacturer, or other lower tier Contractor, the purpose of which is to confirm the quality or orderly progression of a portion of the work by documenting procedures, acceptability of methods or personnel, qualifications, or other verifications of quality.

SD-09 Reports

Reports of inspections or tests, including analysis and interpretation of test results.

SD-13 Certificates

Statement signed by an official authorized to certify on behalf of the manufacturer of a product, system or material, attesting that the product, system or material meets specified requirements. The statement must be dated after the award of the contract, must state the Contractor's name and address, must name the project and location, and must list the specific requirements which are being certified.

SD-14 Samples

Samples, including both fabricated and unfabricated physical examples of materials, products, and units of work as complete units or as portions of units of work.

SD-18 Records

Documentation to record compliance with technical or administrative requirements.

SD-19 Operation and Maintenance Manuals

Data which forms a part of an operation and maintenance manual.

1.3 SUBMITTAL CLASSIFICATION

Submittals are classified as follows:

1.3.1 Government Approved

Governmental approval is required for extensions of design, critical materials, deviations, equipment whose compatibility with the entire system must be checked, and other items as designated by the Contracting Officer. Within the terms of the Contract Clause entitled "Specifications and Drawings or Construction," they are considered to be "shop drawings."

1.3.2 Information Only

All submittals not requiring Government approval will be for information only. They are not considered to be "shop drawings" within the terms of the Contract Clause referred to above.

1.4 APPROVED SUBMITTALS

The Contracting Officer's approval of submittals shall not be construed as a complete check, but will indicate only that the general method of construction, materials, detailing and other information are satisfactory. Approval will not relieve the Contractor of the responsibility for any error which may exist, as the Contractor under the CQC requirements of this contract is responsible for dimensions, the design of adequate connections and details, and the satisfactory construction of all work. After submittals have been approved by the Contracting Officer, no resubmittal for the purpose of substituting materials or equipment will be considered unless accompanied by an explanation of why a substitution is necessary.

1.5 DISAPPROVED SUBMITTALS

The Contractor shall make all corrections required by the Contracting Officer and promptly furnish a corrected submittal in the form and number of copies specified for the initial submittal. If the Contractor considers any correction indicated on the submittals to constitute a change to the contract, a notice in accordance with the Contract Clause "Changes" shall be given promptly to the Contracting Officer.

1.6 WITHHOLDING OF PAYMENT

Payment for materials incorporated in the work will not be made if required approvals have not been obtained.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 GENERAL

The Contractor shall make submittals as required by the specifications. The Contracting Officer may request submittals in addition to those specified when deemed necessary to adequately describe the work covered in the respective sections. Units of weights and measures used on all submittals shall be the same as those used in the contract drawings. Each submittal shall be complete and in sufficient detail to allow ready determination of compliance with contract requirements. Prior to submittal, all items shall be checked and approved by the Contractor's Quality Control (CQC) representative and each item shall be stamped, signed, and dated by the CQC representative indicating action taken. Proposed deviations from the contract requirements shall be clearly identified. Submittals shall include items such as:

Contractor's, manufacturer's, or fabricator's drawings; descriptive literature including (but not limited to) catalog cuts, diagrams, operating charts or curves; test reports; test cylinders; samples; O&M manuals (including parts list); certifications; warranties; and other such required submittals. Submittals requiring Government approval shall be scheduled and made prior to the acquisition of the material or equipment covered thereby. Samples remaining upon completion of the work shall be picked up and disposed of in accordance with manufacturer's Material Safety Data Sheets (MSDS) and in compliance with existing laws and regulations.

3.2 SUBMITTAL REGISTER (IMA-KORO FORM 74)

The IMA-KORO FORM 74 listing in the IMA-KORO Pamphlet 420-1 lists items of equipment and materials for which submittals are required by the specifications. This list may not be all inclusive and additional submittals may be required. This form should be submitted to the Contracting Officer for approval prior to the preconstruction meeting. The approved submittal register will become the scheduling document and will be used to control submittals throughout the life of the contract and shall submit it to the Government together with the monthly payment request. The submittal register and the progress schedules shall be coordinated.

3.3 SCHEDULING

Submittals covering component items forming a system or items that are interrelated shall be scheduled to be coordinated and submitted concurrently. Certifications to be submitted with the pertinent drawings shall be so scheduled. Adequate time (a maximum of 30 calendar days, after arriving at Regional Engineer Support Center, IMA-KORO, exclusive of mailing time) shall be allowed and shown on the register for review and approval. No delay damages or time extensions will be allowed for time lost in late submittals. Additional 10 calendar days shall be allowed and shown on the register for review and approval of submittals for food service equipment and refrigeration and HVAC control systems.

3.4 TRANSMITTAL FORM (ENG FORM 4025)

The sample transmittal form (ENG Form 4025) attached to this section shall be used for submitting both Government approved and information only submittals in accordance with the instructions on the reverse side of the form. These forms will be furnished to the Contractor. This form shall be properly completed by filling out all the heading blank spaces and identifying each item submitted. Special care shall be exercised to ensure proper listing of the specification paragraph and/or sheet number of the contract drawings pertinent to the data submitted for each item.

3.5 SUBMITTAL PROCEDURE

Submittals shall be made as follows:

3.5.1 Procedures

Submittals shall be in accordance with the requirements of paragraphs 3.1 through 3.4 and presented by the contractor to the Contracting Officer, Contracting Officer's Representative, or Technical Contracting Officer's Representative for review and approval.

3.5.2 Deviations

For submittals which include proposed deviations requested by the Contractor, the column "variation" of ENG Form 4025 shall be checked. The Contractor shall set forth in writing the reason for any deviations and annotate such deviations on the submittal. The Government reserves the right to rescind inadvertent approval of submittals containing unnoted deviations.

3.6 CONTROL OF SUBMITTALS

The Contractor shall carefully control his procurement operations to ensure that each individual submittal is made on or before the Contractor scheduled submittal date shown on the approved "Submittal Register."

3.7 GOVERNMENT APPROVED SUBMITTALS

Upon completion of review of submittals requiring Government approval, the submittals will be identified as having received approval by being so stamped and dated. Three (3) copies of the submittal will be retained by the Contracting Officer and one (1) copy of the submittal will be returned to the Contractor.

3.8 INFORMATION ONLY SUBMITTALS

Normally submittals for information only will not be returned. Approval of the Contracting Officer is not required on information only submittals. The Government reserves the right to require the Contractor to resubmit any item found not to comply with the contract. This does not relieve the Contractor from the obligation to furnish material conforming to the plans and specifications; will not prevent the Contracting Officer from requiring removal and replacement of nonconforming material incorporated in the work; and does not relieve the Contractor of the requirement to furnish samples for testing by the Government laboratory or for check testing by the Government in those instances where the technical specifications so prescribe.

3.9 STAMPS

Stamps used by the Contractor on the submittal data to certify that the submittal meets contract requirements shall be similar to the following:

(Firm Name)

__________ Approved

__________ Approved with corrections as noted on submittal data and/or attached sheets(s).

SIGNATURE: ____

TITLE: ____

DATE: ____

TRANSMITTAL OF SHOP DRAWINGS, EQUIPMENT DATA, MATERIAL SAMPLES, OR MANUFACTURER' S CERTIFICATES OF COMPLIANCE

(Read instructions on the reverse side prior to initiating this form)

DATE:

TRANSMITTAL NO.

SECTION I – REQUEST FOR APPROVAL OF THE FOLLOWING ITEMS *(This section will be initiated by the contractor)*

TO:	FROM:	CONTRACT NO.	CHECK ONE: ☐ THIS IS A NEW TRANSMITTAL ☐ THIS IS A RESUBMITTAL OF TRANSMITTAL ________________
SPECIFICATION SEC. NO. (Cover only one section with each transmittal)	PROJECT TITLE AND LOCATION		

ITEM NO. a.	DESCRIPTION OF ITEM SUBMITTED (Type size, model number/etc.) b.	MFG OR CONTR. CAT., CURVE DRAWING OR BROCHURE NO. (*See instruction, no. 8*) c.	NO. OF COPIES *d.*	CONTRACT CEFERENCE DOCUMENT		FOR CONTRACTOR USE CODE *g.*	VARIATION (See instruction No. 6) *h.*	FOR CE USE CODE i.
				SPEC. PARA.NO. *e.*	DRAWING SHEET NO f.			

REMARKS

I certify that the above submitted items have been reviewed In detail and are correct and in strict conformance with the Contract drawings and specifications except as other wise stated.

NAME AND SIGNATURE OF CONTRACTOR

SECTION II - APPROVAL ACTION

ENCLOSURES RETURNED (List by Item No)	NAME, TITLE AND SIGNATURE OF APPROVING AUTHORITY	DATE

SECTION 01351

SAFETY, HEALTH, AND EMERGENCY RESPONSE FOR HAZARDOUS, TOXIC AND RADIOACTIVE WASTE SITE ACTIVITIES AND UNDERGROUND STORAGE TANK (HTRW/UST)

TABLE OF CONTENTS

PAGE

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH-02 (1996) Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

A
NSI Z358.1 (1990) Emergency Eyewash and Shower Equipment

AMERICAN PETROLEUM INSTITUTE (API)

API Std 2015 (1994) Safe Entry and Cleaning of Petroleum Storage

Tanks

API Pub 2219 (1986) Safe Operation of Vacuum Trucks in Petroleum Service

API RP 1604 (1996) Closure Underground Petroleum Storage Tanks

CODE OF FEDERAL REGULATIONS (CFR)

10 CFR 20 Standards for Protection Against Radiation

29 CFR 1904 Recording and Reporting Occupational Injuries and Illnesses

29 CFR 1910 Occupational Safety and Health Standards

29 CFR 1926 Safety and Health Regulations for Construction

49 CFR 171 General Information, Regulations, and definitions

49 CFR 172 Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

ENGINEERING MANUALS

EM 385-1-1 (1996) U.S. Army Corps of Engineers Safety and Health Requirements Manual

ER 385-1-92 (2000) Safety and Occupational Document Requirements for Hazardous, Toxic, and Radioactive Waste (HTRW) Activities

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

NIOSH 85-115 (1985) Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities

1.2 DESCRIPTION OF WORK

This section provides additional requirements for implementing the accident prevention provisions of EM 385-1-1, and specifies a Site Safety and Health Plan (SSHP) which shall satisfy the requirements for submission of a separate Accident Prevention Plan (APP) as required by EM 385-1-1. This section shall apply to only work performed SAFETY, HEALTH, AND EMERGENCY RESPONSE for HAZARDOUS, TOXIC AND RADIOACTIVE WASTE SITE ACTIVITIES AND REMOVAL OF UNDERGROUND STORAGE TANK (HTRW/UST).

1.3 SUBMITTALS

Government approval is required for submittals with a “G” designation; submittals having an “FIO” designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-04 Drawings

Work Zones; GA.

Drawings shall include initial work zone boundaries: Exclusion Zone (EZ), including restricted and regulated areas; Contamination Reduction Zone (CRZ); and Support Zone (SZ).

Decontamination Facilities; GA.

Drawings shall show the layout of the personnel and equipment decontamination areas and facilities.

SD-09 Reports

Monitoring/Sampling Results; FIO.

Personnel exposure monitoring/sampling results.

Site Control Log; FIO.

Record of each entry and exit into the site, as specified.

1.4 REGULATORY REQUIREMENTS

Work performed under this contract shall comply with EM 385-1-1, USFK PAM 200-1, applicable Federal, state, and local safety and occupational health laws and regulations. This includes, but is not limited to, Occupational Safety and Health Administration (OSHA) standards, 29 CFR 1910, especially Section .120, "Hazardous Waste Site Operations and Emergency Response" and 29 CFR 1926, especially Section .65, "Hazardous Waste Site Operations and Emergency Response". Matters of interpretation of standards shall be submitted to the appropriate administrative agency for resolution before starting work. Where the requirements of this specification, applicable laws, criteria, ordinances, regulations, and referenced documents vary, the most stringent requirements shall apply.

1.5 PRECONSTRUCTION SAFETY CONFERENCE

Specify requirements to be addressed in the preconstruction safety conference. Contractor shall confer with Environment Officer of the construction area the contracting officer and Safety and Occupational Health Office representatives to make determination.

1.6 SAFETY AND HEALTH PROGRAM

OSHA Standards 29 CFR 1910, Section .120 (b) and 29 CFR 1926, Section.65 (b) require employers to develop and implement a written Safety and Health Program for employees involved in hazardous waste operations. The site specific program requirements of the OSHA Standards shall be integrated into one site-specific document, the Site Safety and Health Plan (SSHP). The SSHP shall interface with the employer's overall Safety and Health Program. Any portions of the overall Safety and Health Program that are referenced in the SSHP shall be included as appendices to the SSHP.

1.7 SITE SAFETY AND HEALTH PLAN

1.7.1 Preparation and Implementation

A Site Safety and Health Plan (SSHP) shall be prepared covering onsite work to be performed by the Contractor and all subcontractors. The Safety and Health Manager shall be responsible for the development, implementation and oversight of the SSHP. The SSHP shall establish, in detail, the protocols necessary for the anticipation, recognition, evaluation, and control of hazards associated with each task performed. The SSHP shall address site specific safety and health requirements and procedures based upon site specific conditions. The level of detail provided in the SSHP shall be tailored to the type of work, complexity of operations to be performed, and hazards anticipated. Details about some activities may not be available when the initial SSHP is prepared and submitted. Therefore, the SSHP shall address, in as much detail as possible, anticipated tasks, their related hazards and anticipated control measures. Additional details shall be included in the activity hazard analyses as described in paragraph ACTIVITY HAZARD ANALYSES.

1.7.2 Acceptance and Modifications

Prior to submittal, the SSHP shall be signed and dated by the Safety and Health Manager and the Site Superintendent. The SSHP shall be submitted for review 30 days prior to the Preconstruction Safety Conference. Deficiencies in the SSHP will be discussed at the preconstruction safety conference, and the SSHP shall be revised to correct the deficiencies and resubmitted for acceptance. Onsite work shall not begin until the plan has been accepted. A copy of the written SSHP shall be maintained onsite. As work proceeds, the SSHP shall be adapted to new situations and new conditions. Changes and modifications to the accepted SSHP shall be made with the knowledge and concurrence of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer. Should any unforeseen hazard become evident during the performance of the work, the Site Safety and Health Officer (SSHO) shall bring such hazard to the attention of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer, both verbally and in writing, for resolution as soon as possible. In the interim, necessary action shall be taken to re-establish and maintain safe working conditions in order to safeguard onsite personnel, visitors, the public, and the environment. Disregard for the provisions of this specification or the accepted SSHP shall be cause for stopping of work until the matter has been rectified.

1.7.3 Availability

The SSHP shall be made available in accordance with 29 CFR 1910, Section .120 (b)(1)(v) and 29 CFR 1926, Section .65 (b)(1)(v).

1.7.4 Elements

Topics required by 29 CFR 1910, Section .120 (b)(4) 29 CFR 1926, Section .65 (b)(4) and the Accident Prevention Plan as described in Appendix A of EM 385-1-1 and those described in this section shall be addressed in the SSHP. Where the use of a specific topic is not applicable to the project, the SSHP shall include a statement to justify its omission or reduced level of detail and establish that adequate consideration was given the topic.

1.8 SITE DESCRIPTION AND CONTAMINATION CHARACTERIZATION

1.8.1 Project/Site Conditions

The following information is a record of site contaminants and a description of the site. This information is provided to assist in preparing the SSHP. Additional sources of information are available as listed below.

1.8.1.1 Site Information

The contractor should confirm with the Environmental Officer for the area, or manager of the facilities to make the SSHP.

1.8.1.2 List of Available Documents

For further information, the contractor should contact with the area environmental office.

1.8.2 Plan Requirements

The SSHP shall include a site description and contamination characterization section that addresses the following elements:

a. Description of site location, topography, size and past uses of the site.

b. A list of contaminants which may present occupational health and safety hazards. This list shall be created by evaluating the analytical results in this section and by researching sources of information from past site investigation activities. Chemical names, radioisotopes, concentration ranges and strength of radiation fields and levels of radioactive contamination, media in which found, locations onsite, and estimated quantities/volumes to be impacted by site work shall be included if known. The contamination characterization shall be reviewed and revised if new chemicals are identified as work progresses.

1.9 HAZARD/RISK ANALYSIS

The SSHP shall include a safety and health hazard/risk analysis for each site task and operation to be performed. The hazard/risk analysis shall provide information necessary for determining safety and health procedures, equipment, and training to protect onsite personnel, the environment, and the public. Available site information shall be reviewed when preparing the “Hazard/Risk Analysis” section of the SSHP. The following elements, at a minimum, shall be addressed.

1.9.1 Site Tasks and Operations (Work plan)

The SSHP shall include a comprehensive section that addresses the tasks and objectives of the site operations and the logistics and resources required to reach those tasks and objectives. Based on the type of remediation required, the following is a list of anticipated major site tasks and operations to be performed. This is not a complete list of site tasks and operations; therefore, it shall be expanded and/or revised, during preparation of the SSHP as necessary.

1.9.2 Hazards

All potential hazards shall be included in the SSHP.

1.9.3 Action Levels

1.9.3.1 General

Action levels shall be established for the situations listed below, at a minimum. The action levels and required actions (engineering controls, changes in PPE, etc.) shall be presented in the SSHP in both text and tabular form.

a. Implementation of engineering controls and work practices.

b. Upgrade or downgrade in level of personal protective equipment.

c. Work stoppage and/or emergency evacuation of onsite personnel.

d. Prevention and/or minimization of public exposures to hazards created by site activities.

1.9.3.2 Confined Space Entry

Entry into and work in a confined space will not be allowed when oxygen readings are less than 19.5% or greater than 23.5% or if the Lower Flammable Limit (LFL) reading is greater than 10%, unless these conditions are adequately addressed in the confined space entry program. In addition, action levels for toxic atmospheres shall be determined.

1.10 ACTIVITY HAZARD ANALYSES

Prior to beginning each major phase of work, an Activity Hazard Analysis shall be prepared by the Contractor performing that work and submitted for review and acceptance. The format shall be in accordance with EM 385-1-1, figure 1-1. A major phase of work is defined as an operation involving a type of work presenting hazards not experienced in previous operations or where a new subcontractor or work crew is to perform. The analysis shall define the activities to be performed and identify the sequence of work, the specific hazards anticipated, and the control measures to be implemented to eliminate or reduce each hazard to an acceptable level. Work shall not proceed on that phase until the activity hazard analysis has been accepted and a preparatory meeting has been conducted by the Contractor to discuss its contents with everyone engaged in the activities, including the government onsite representatives. The activity hazard analyses shall be continuously reviewed and when appropriate modified to address changing site conditions or operations, with the concurrence of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer. Activity hazard analyses shall be attached to and become a part of the SSHP.

1.11 STAFF ORGANIZATION, QUALIFICATIONS, AND RESPONSIBILITIES

An organizational structure shall be developed that sets forth lines of authority (chain of command), responsibilities, and communication procedures concerning site safety, health, and emergency response. This organizational structure shall cover management, supervisors and employees of the Contractor and subcontractors. The structure shall include the means for coordinating and controlling work activities of subcontractors and suppliers. The SSHP shall include a description of this organizational structure as well as qualifications and responsibilities of each of the following individuals. The Contractor shall obtain Contracting Officer's acceptance before replacing any member of the Safety and Health Staff. Requests shall include the names, qualifications, duties, and responsibilities of each proposed replacement.

1.11.1 Site Superintendent

A Site Superintendent, who has responsibility to implement the SSHP, the authority to direct work performed under this contract and verify compliance, shall be designated.

1.11.2 Safety and Health Manager

1.11.2.1 Qualifications

The services of an Industrial Hygienist certified by the American Board of Industrial Hygiene or a safety professional certified by the Board of Certified Safety Professionals or certified by the Korean government shall be utilized. The name, qualifications (education summary and documentation, ABIH or BCSP certificate), and work experience summary shall be included in the SSHP. The Safety and Health Manager shall have the following additional qualifications:

a. A minimum of 3 years experience in developing and implementing safety and health programs at hazardous waste sites, in the hazardous waste disposal industry, in the chemical industry, in the petroleum processing industry or at underground storage tank removal projects.

b. Documented experience in supervising professional and technician level personnel.

c. Documented experience in developing worker exposure assessment programs and air monitoring programs and techniques.

d. Documented experience in the development of personal protective equipment programs, including programs for working in and around potentially toxic, flammable and combustible atmospheres and confined spaces.

e. Working knowledge of state and Federal occupational safety and health regulations.

1.11.2.2 Responsibilities

The Safety and Health Manager shall:

a. Be responsible for the development, implementation, oversight, and enforcement of the SSHP.

b. Sign and date the SSHP prior to submittal.

c. Conduct initial site-specific training.

d. Be present onsite during the first 3 days of remedial activities and at the startup of each new major phase.

e. Visit the site as needed and at least once per week for the duration of activities, to audit the effectiveness of the SSHP.

f. Be available for emergencies.

g. Provide onsite consultation as needed to ensure the SSHP is fully implemented.

h. Coordinate any modifications to the SSHP with the Site Superintendent, the SSHO, and the Contracting Officer.

i. Provide continued support for upgrading/downgrading of the level of personal protection.

j. Be responsible for evaluating air monitoring data and recommending changes to engineering controls, work practices, and PPE.

k. Review accident reports and results of daily inspections.

l. Serve as a member of the Contractor's quality control staff.

1.11.3 Site Safety and Health Officer (SSHO)

1.11.3.1 Qualifications of SSHO

An individual and one alternate shall be designated for the Site Safety and Health Officer (SSHO). The name, qualifications (education and training summary and documentation), and work experience of the Site Safety and Health Officer and alternate shall be included in the SSHP. The SSHO shall have the following qualifications:

a. A minimum of 2 years experience in implementing safety and health programs at hazardous waste sites, in the hazardous waste disposal industry, at underground storage tank removal projects, or in the chemical or petroleum processing industry where the required personal protective equipment was required and the required protective level was as this project or higher.

b. Documented experience in construction techniques and construction safety procedures.

c. Working knowledge of Federal and the Korean occupational safety and health regulations.

d. Specific training in personal and respiratory protective equipment program implementation, confined space program oversight, and in the proper use of air monitoring instruments, and air sampling methods.

1.11.3.2 Responsibilities of SSHO

The Site Safety and Health Officer shall:

a. Assist and represent the Safety and Health Manager in onsite training and the day to day onsite implementation and enforcement of the accepted SSHP.

b. Be assigned to the site on a full time basis for the duration of field activities. The SSHO shall have no duties other than Safety and Health related duties. If operations are performed during more than one work shift per day, a site Safety and Health Officer shall be present for each shift.

c. Have authority to ensure site compliance with specified safety and health requirements, Federal, state and OSHA regulations and all aspects of the SSHP including, but not limited to, activity hazard analyses, air monitoring, use of PPE, decontamination, site control, standard operating procedures used to minimize hazards, safe use of engineering controls, the emergency response plan, confined space entry procedures, spill containment program, and preparation of records by performing a daily safety and health inspection and documenting results on the Daily Safety Inspection Log.

d. Have authority to stop work if unacceptable health or safety conditions exist, and take necessary action to re-establish and maintain safe working conditions.

e. Consult with and coordinate any modifications to the SSHP with the Safety and Health Manager, the Site Superintendent, and the Contracting Officer.

f. Serve as a member of the Contractor’s quality control staff on matters relating to safety and health.

g. Conduct accident investigations and prepare accident reports.

h. Review results of daily quality control inspections and document safety and health findings into the Daily Safety Inspection Log.

i. In coordination with site management and the Safety and Health Manager, recommend corrective actions for identified deficiencies and oversee the corrective actions.

1.11.4 Occupational Physician (OP)

1.11.4.1 Qualifications of OP

The services of a licensed physician, who is certified in occupational medicine by the American Board of Preventative Medicine, or who, by necessary training and experience is Board eligible, shall be utilized. The physician shall be familiar with this site’s hazards and the scope of this project. The medical consultant’s name, qualifications, and knowledge of the site’s conditions and proposed activities shall be included in the SSHP.

1.11.4.2 Responsibilities of OP

The physician shall be responsible for the determination of medical surveillance protocols and for review of examination/test results performed in compliance with 29 CFR 1910, Section .120 (f) and 29 CFR 1926,Section .65 (f) and paragraph MEDICAL SURVEILLANCE.

1.11.5 Persons Certified in First Aid and CPR

At least two persons who are currently certified in first aid and CPR by the American Red Cross or other approved agency shall be onsite at all times during site operations. They shall be trained in universal precautions and the use of PPE as described in the Bloodborne Pathogens Standard of 29 CFR 1910, Section .1030. These persons may perform other duties but shall be immediately available to render first aid when needed.

1.11.6 Safety and Health Technicians

For each work crew in the exclusion zone, one person, designated as a Safety and Health technician, shall perform activities such as air monitoring, decontamination, and safety oversight on behalf of the SSHO. They shall have appropriate training equivalent to the SSHO in each specific area for which they have responsibility and shall report to and be under the supervision of the SSHO.

1.11.7 Certified Health Physicist (CHP)

The services of a health physicist certified by the American Board of Health Physics or certified by the Korean government shall be utilized. The CHP shall report to the Safety and Health Manager. The CHP shall be responsible for the problem, indicated on SSHP or CQC plan.

1.11.8 Certified Safety Professional (CSP)

The services of a safety professional certified by the Board of Certified Safety Professionals shall be utilized. The CSP shall report to the Safety and Health Manager. The CSP shall be responsible for problem indicated in the SSHP or CQC plan.

1.12 TRAINING

Personnel shall receive training in accordance with the Contractor’s written safety and health training program and 29 CFR 1910 Section 120, 29 CFR 1926 Section .65, and 29 CFR 1926 Section .21. The SSHP shall include a section describing training requirements.

1.12.1 General Hazardous Waste Operations Training Personnel entering the exclusion or contamination reduction zones shall have successfully completed 40 hours of hazardous waste instruction off the site; 3 days actual field experience under the direct supervision of a trained, experienced supervisor; and 8 hours refresher training annually. Onsite supervisors shall have completed the above training and 8 hours of additional, specialized training covering at least the following topics: the employer’s safety and health program, personal protective equipment program, spill containment program, and health hazard monitoring procedures and techniques. Copies of current training certification statements shall be submitted prior to initial entry onto the work site.

1.12.2 Site-specific Training

Site-specific training sessions shall be documented in accordance with Section 01.B.03.b of EM 385-1-1.

1.12.2.1 Initial Session (Pre-entry Briefing)

Prior to commencement of onsite field activities, all site employees, including those assigned only to the Support Zone, shall attend a site specific safety and health training session of at least 4 hours duration. This session shall be conducted by the Safety and Health Manager and the Site Safety and Health Officer to ensure that all personnel are familiar with requirements and responsibilities for maintaining a safe and healthful work environment. Procedures and contents of the accepted SSHP and Sections 01.B.02 and 28.D.03 of EM 385-1-1 shall be thoroughly discussed. The Contracting Officer shall be notified at least 5 days prior to the initial site-specific training session so government personnel involved in the project may attend.

1.12.2.2 Periodic Sessions

Periodic onsite training shall be conducted by the SSHO or Safety and Health Manager at least weekly or daily as required by the SSHP for personnel assigned to work at the site during the following week or day. The training shall address safety and health procedures, work practices, any changes in the SSHP, activity hazard analyses, work tasks, or schedule; results of previous week’s air monitoring, review of safety discrepancies and accidents. Should an operational change affecting onsite field work be made, a meeting prior to implementation of the change shall be convened to explain safety and health procedures. Site specific training sessions for new personnel, visitors, and suppliers shall be conducted by the SSHO using the training curriculum outlines developed by the Safety and Health Manager.

1.12.2.3 Other Training

The Safety and Health Manager shall provide training as specified by 29 CFR 1910 Section .146, for employees who are required to supervise, standby, or enter permit-required confined spaces, and persons involved in any aspect of the transportation of hazardous materials shall be trained in accordance with 49 CFR 172 Subpart H.

1.13 PERSONAL PROTECTIVE EQUIPMENT

1.13.1 General

In accordance with 29 CFR 1910 Section .120 (g)(5) and 29 CFR 1926 Section .65 (g)(5), a written Personal Protective Equipment (PPE) program which addresses the elements listed in that regulation, and which complies with respiratory protection program requirements of 29 CFR 1910 Section .134, is to be included in the employer’s Safety and Health Program. The Site Safety and Health Plan shall detail the minimum PPE ensembles (including respirators) and specific materials from which the PPE components are constructed for each site-specific task and operation to be performed, based upon the hazard/risk analysis. Components of levels of protection (B, C, D and modifications) must be relevant to site-specific conditions, including heat and cold stress potential and safety hazards. Only respirators approved by NIOSH shall be used. Onsite personnel shall be provided with appropriate personal protective equipment. Protective equipment and clothing shall be kept clean and well maintained. The PPE section of the SSHP shall include site-specific procedures to determine PPE program effectiveness and for onsite fit-testing of respirators, cleaning, maintenance, inspection, and storage of PPE.

1.13.2 Levels of Protection

The Safety and Health Manager shall establish appropriate levels of protection for each work activity based on review of historical site information, existing data, an evaluation of the potential for exposure (inhalation, dermal, ingestion, and injection) during each task, past air monitoring results, and a continuing safety and health monitoring program. The Safety and Health Manager shall also establish action levels for upgrade or downgrade in levels of PPE from the following specified minimum levels of protection. Protocols and the communication network for changing the level of protection shall be described in the SSHP. The PPE reassessment protocol shall address air monitoring results, potential for exposure, changes in site conditions, work phases, job tasks, weather, temperature extremes, individual medical considerations, etc.

1.13.2.1 Components of Levels of Protection

The items constitute minimum protective clothing and equipment ensembles to be utilized during this project. For guidance in determining appropriate components for levels of protection, utilize the following references: NIOSH, OSHA, USCG, EPA, Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, October 1985, NIOSH 85-115; EM 385-1-1, Section 5 and Appendix L; 29 CFR 1910 Section .120, Appendix B; and 29 CFR 1926

1.13.2.2 Initial Minimum Levels of PPE by Task

Based on available information, the initial minimum protective equipment requirements for each major task and operation shall be selected and listed. Available site information shall be reviewed and the list of tasks and operations and these levels of protection shall be expanded and/or revised during preparation of the SSHP.

1.13.3 PPE for Government Personnel

Requested number of clean sets of personal protective equipment and clothing (excluding air-purifying negative-pressure respirators and safety shoes, which will be provided by individual visitors), as required for entry into the Exclusion Zone and/or Contamination Reduction Zone, shall be available for use by the Contracting Officer or official visitors. The items shall be cleaned and maintained by the Contractor and stored in the clean room of the decontamination facility and clearly marked: “FOR USE BY GOVERNMENT ONLY.” The Contractor shall provide basic training in the use and limitations of the PPE provided, and institute administrative controls to check prerequisites prior to issuance. Such prerequisites include meeting minimum training requirements for the work tasks to be performed and medical clearance for site hazards and respirator use.

1.14 MEDICAL SURVEILLANCE

The Safety and Health Manager, in conjunction with the Occupational Physician, shall detail, in the employer’s Safety and Health Program and the SSHP, the medical surveillance program that includes scheduling of examinations, certification of fitness for duty, compliance with OSHA requirements, and information provided to the physician. Examinations shall be performed by or under the supervision of a licensed physician, preferably one knowledgeable in occupational medicine, and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place. Medical surveillance protocols and examination and test results shall be reviewed by the Occupational Physician. The medical surveillance program shall contain the requirements specified below. Personnel working in contaminated areas of the site shall have been examined as prescribed in 29 CFR 1910 Section .120, and 29 CFR 1926 Section .65, and determined medically fit to perform their duties.

1.14.1 Frequency of Examinations

Employees shall have been provided with medical examinations as specified, within the past 12 months and shall receive exams annually thereafter (if contract duration exceeds 1 year); on termination of employment; reassignment in accordance with 29 CFR 1910 Section .120 (f)(3)(i), and 29 CFR 1926 Section .65 (f)(3)(i)©; if the employee develops signs or symptoms of illness related to workplace exposures; if the physician determines examinations need to be conducted more often than once a year; and when an employee develops a lost time injury or illness during the period of this contract. The supervisor shall be provided with a written statement signed by the physician prior to allowing the employee to return to the work site after injury or illness resulting in a lost workday, as defined in 29 CFR 1904 Section .12 (f).

1.14.2 Content of Examinations

The following elements shall be included in the medical surveillance program. Additional elements may be included at the discretion of the occupational physician responsible for reviewing the medical surveillance protocols.

a. Complete medical and occupational history (initial exam only).

b. General physical examination of major organ systems.

c. Pulmonary function testing including FVC and FEV1.0.

d. CBC with differential.

e. Blood chemistry screening profile (e.g. SMAC 20/25).

f. Urinalysis with microscopic examination.

g. Audiometric testing (as required by Hearing Conservation Program).

h. Visual acuity.

i. Chest x-ray. (This test should be performed no more frequently than every 4 years, unless directed by Occupational Physician.)

j. Electrocardiogram (as directed by Occupational Physician).

k. Urine heavy metals (arsenic, cadmium, chromium, and mercury).

l. serum lead.

m. zinc protoporphyrin.

1.14.3 Information Provided to the Occupational Physician

The physician shall be furnished with the following:

a. Site information from paragraph, SITE DESCRIPTION AND CONTAMINATION CHARACTERIZATION.

b. Information on the employee’s antic ipated or measured exposure.

c. A description of any PPE used or to be used.

d. A description of the employee’s duties as they relate to the employee’s exposures (including physical demands on the employee and heat/cold stress).

e. A copy of 29 CFR 1910 Section .120, or 29 CFR 1926 Section 65.

f. Information from previous examinations not readily available to the examining physician.

g. A copy of Section 5.0 of NIOSH Pub No. 85-115.

h. Information required by 29 CFR 1910 Section .134.

1.14.4 Physician’s Written Opinion

Before work begins a copy of the physician’s written opinion for each employee shall be obtained and furnished to the Safety and Health Manager; and the employee. The opinion shall address the employee’s ability to perform hazardous remediation work and shall contain the following:

a. The physician’s recommended limitations upon the employee’s assigned work and/or PPE usage.

b. The physician’s opinion about increased risk to the employee’s health resulting from work; and

c. A statement that the employee has been informed and advised about the results of the examination.

Medical Records 1.14.5

Documentation of medical exams shall be provided as part of the Certificate of Worker or Visitor Acknowledgment. Medical records shall be maintained in accordance with 29 CFR 1910 Section .120, and 29 CFR 1926 Section .65.

1.15 RADIATION DOSIMETRY

A radiation protection and dosimetry program shall be described in the SSHP and implemented. Employees working within a radiologically restricted area shall receive appropriate dosimetry monitoring for radiation exposure.

1.15.1 Evaluation

Radiation dosimetry shall be evaluated by an individual or company holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP). Electronic dosimetry may be used to assign external dose if approved by the Contracting Officer.

1.15.2 Documentation

Employee exposure to external radiation shall be documented. This shall include reviewing each employee’s radiation exposure history in accordance with 10 CFR 20 Section .2104, for compliance with exposure standards prior to allowing the employee access to a restricted area. If the employee has no exposure history, the employee shall provide a signed written statement to that effect.

1.15.3 Bioassay

When the possibility of internal radioactive contamination exists, a bioassay program shall be implemented to determine internal exposure. The bioassay program shall provide sampling of employee nasal passages, urine and/or feces, or whole body counting, as appropriate to evaluate the suspected radionuclides.

1.15.4 Reporting

Reports of exposure to ionizing radiation shall be furnished to the Contracting Officer as soon as available and to each employee annually, upon termination, and within 30 days of any personal request.

1.16 EXPOSURE MONITORING/AIR SAMPLING PROGRAM

Specify methods, instrument, and equipment for both direct reading (real-time) monitoring and integrated (time weighted average) sampling. Direct reading instruments may include the following, as appropriate: instruments for specific chemicals (colorimetric tubes, direct reading badges, hazardous gas monitors, oxygen meters, gas chromatographs); survey type instruments for gases or vapors (PID, FID, IR), total and respirable dust, radiation, flammable gases or vapors, noise, etc. Integrated sampling equipment may include the following, as appropriate: pumps, collection media, badge-type passive samplers, etc. Some methods may require specific types of sampling equipment. Specify the use of NIOSH methods (from NIOSH Publication Number 84-100, NIOSH Manual of Analytical Methods) for personal exposure sampling. Samples collected using NIOSH methods are to be analyzed only by laboratories currently accredited by the American Industrial Hygiene Association (AIHA). Address procedures and record keeping requirements for calibration and maintenance of instruments and equipment. Do not specify brand names for instruments or equipment. Specify requirements for evaluation of results and implementation of appropriate actions based upon action levels established by the hazard/risk analysis. Include a paragraph for requirements for reporting and documentation. Documentation is to include the following information: date, type of equipment utilized, equipment I.D. number, monitoring results for each work location or monitoring station with time of readings, analytical results for personal exposure sampling, personnel or location monitored/sampled with description of activity being performed, sample numbers, weather conditions (wind direction, precipitation, temperature, etc.), and miscellaneous information related to monitoring/sampling performed. The Safety and Health Manager shall prepare and implement an exposure monitoring/air sampling program to identify and quantify safety and health hazards and airborne levels of hazardous substances in order to assure proper selection of engineering controls, work practices and personal protective equipment for affected site personnel. Minimum initial requirements for the program are delineated below. Available site information shall be reviewed and the exposure monitoring/air sampling program shall be expanded and/or revised for submittal as part of the SSHP.

1.17 HEAT AND COLD STRESS MONITORING

The Safety and Health Manager shall develop a heat stress and cold stress monitoring program for onsite activities. Details of the monitoring program, including schedules for work and rest, and physiological monitoring requirements, shall be described in the SSHP. Personnel shall be trained to recognize the symptoms of heat and cold stress. The SSHO and an alternate person shall be designated, in writing, to be responsible for the heat and cold stress monitoring program.

1.17.1 Heat Stress

Physiological monitoring shall commence when the ambient temperature is above 21.1 degrees C. (70 degrees F.) Monitoring frequency shall increase as the ambient temperature increases or as slow recovery rates are observed. An adequate supply of cool drinking water shall be provided for the workers. NIOSH Pub No. 85-115 may be consulted for guidance in determining protocols for prevention of heat stress.

1.17.2 Cold Stress

To guard against cold injury, appropriate clothing and warm shelter for rest periods shall be provided. Procedures to monitor and avoid cold stress shall be followed in accordance with the current TLVs for Cold Stress as recommended in ACGIH-02.

1.18 SAFETY PROCEDURES, ENGINEERING CONTROLS AND WORK PRACTICES

The SSHP shall describe the standard operating safety procedures, engineering controls and safe work practices to be implemented for the work covered. These shall include, but not be limited to, the following:

1.18.1 General Site Rules/Prohibitions

General site rules/prohibitions (buddy system, eating, drinking, and smoking restrictions, etc.).

1.18.2 Work Permit Requirements

Radioactive work, excavation, hot work, confined space, etc.

1.18.3 Material Handling Procedures

Soils, liquids, radioactive materials.

1.18.3.1 Spill and Discharge Control

Written spill and discharge containment/control procedures shall be developed and implemented. These procedures shall address radioactive wastes, shock sensitive wastes, laboratory waste packs, material handling equipment, and appropriate procedures for tank and vault entry as well as drum and container handling, opening, sampling, shipping and transport. These procedures shall describe prevention measures, such as building berms or dikes; spill control measures and material to be used (e.g. booms, vermiculite); location of the spill control material; personal protective equipment required to cleanup spills; disposal of contaminated material; and who is responsible to report the spill. Storage of contaminated material or hazardous materials shall be appropriately bermed, diked and/or contained to prevent any spillage of material on uncontaminated soil. If the spill or discharge is reportable, and/or human health or the environment are threatened, the National Response Center, the state, and the Contracting Officer shall be notified as soon as possible. Reporting requirements shall be in accordance with Section 02071 UNDERGROUND STORAGE TANK REMOVAL.

1.18.3.2 Materials Transfer Safety

Liquids and residues shall be removed from the tanks using explosion proof or air-driven pumps. Pump motors and suction hoses shall be bonded to the tank and grounded to prevent electrostatic ignition hazards. Use of a hand pump will be permitted to remove the last of the liquid from the bottom of the tanks. If a vacuum truck is used for removal of liquids or residues, the area of operation for the vacuum truck shall be vapor free. The truck shall be located upwind from the tank and outside the path of probable vapor travel. The vacuum pump exhaust gases shall be discharged through a hose of adequate size and length downwind of the truck and tank area. Vacuum truck operating and safety practices shall conform to API Publ2219. Tank residues shall be collected in drums, tanks, or tank trucks labeled according to 49 CFR 171 and 49 CFR 172 and disposed of as specified. After the materials have been transferred and the tanks have been exposed, fittings and lines leading to the tanks shall be disconnected and drained of their contents. The contents of the lines shall not spill to the environment during cutting or disconnecting of tank fittings. Materials drained shall be transferred into DOT-approved drums for storage and/or transportation. Only non-sparking or non-heat producing tools shall be used to disconnect and drain or to cut through tank fittings. Electrical equipment (e.g., pumps, portable hand tools, etc.) used for tank preparation shall be explosion-proof. Following cutting or disconnecting of the fittings, openings leading to the tanks shall be plugged.

1.18.4 Drum and Container Handling

Procedures and Precautions (opening, sampling, overpacking)

1.18.5 Confined Space Entry Procedures

1.18.6 Hot Work

Hot work shall not be permitted on or within the tanks except as outlined herein. Prior to conducting hot work, a hot work permit shall be prepared and submitted. An example format for a hot work permit shall be included in the SSHP. The permit shall describe compliance with the following procedures. After tank interiors have been decontaminated, hot work may be conducted only when the tank is inerted, and to the extent necessary to begin dismantling the tanks. After decontamination of tank interiors, hot work shall not be performed unless monitoring indicates atmospheres within and immediately surrounding the tanks are less than 8% oxygen inside the tank and less than 10% of the LFL outside the tank; continuous monitoring shall continue until the hot work is completed. The hot work prohibition includes welding, cutting, grinding, sawing, or other similar operations which could be expected to potentially generate combustion-producing temperatures or sparks, or which could produce potentially hazardous fumes or vapors. An individual at each hot work site shall be designated as a fire watch. This person’s sole responsibility shall be to monitor the hot work and have immediate access to the fire extinguisher located at each hot work site. A new permit shall be obtained at the start of each work shift during which hot work will be conducted.

1.18.7 Ignition Sources

1.18.8 Fire Protection and Prevention

1.18.9 Electrical Safety

1.18.10 Excavation and Trench Safety

1.18.11 Guarding of Machinery and Equipment

1.18.12 Lockout/Tagout

1.18.13 Fall Protection

1.18.14 Hazard Communication

1.18.15 Illumination

1.18.16 Sanitation

1.18.17 Engineering Controls

1.18.18 Process Safety Management

1.18.19 Signs and Labels

1.18.20 Waste Disposal

1.18.21 Tank Purging for Permit-Required Confined Space Entries

Tanks shall be purged for confined space entry. The flammable vapors shall be reduced to less than 10% of the LFL and the oxygen content shall be between 19.5% and 23.5%. Confined space entry into the tanks shall not be attempted unless absolutely necessary, as for example, to remove sludge from the tank. Flammable vapors may be exhausted from the tank by any of the methods from API RP 1604 listed below, or any method approved by the Contracting Officer. The SSHP shall specify the purging method to be used.

a. Ventilation by Eductor-Type Air Movers: The eductor-type air mover shall be properly bonded and grounded to prevent the generation and discharge of static electricity. When using this method, the fill (drop) tube shall remain in place to ensure ventilation at the bottom of the tank. Tanks equipped with fill (drop) tubes that are not removable shall be purged by this method. An eductor extension shall be used to discharge vapors a minimum of 3.7 meters (12 feet) above grade or 1 meter (3 feet) above adjacent roof lines, whichever is greater. If this is not possible, alternative methods shall be proposed and approved prior to purging. Noise levels generated by these devices as a result of high airflow may exceed OSHA PELs. Noise levels shall be evaluated and appropriate hearing protection shall be provided.

b. Ventilation by Diffused Air Blowers: When using this purging method, the air-diffusing pipe is properly bonded and grounded to prevent the discharge of a spark. Fill (drop) tubes shall be removed to allow proper diffusion of the air in the tank. Air supply shall be from a compressor that has been checked to ensure that Grade D breathing air is being supplied. Air pressure in the tank shall not exceed 34 kPa (5 psi) gauge to avoid tank failure.

c. Commercial Emulsifiers and Volatile Fuel Encapsulators: These products are completely miscible in water, aid in the elimination of flammable vapors, and are biodegradable. Regulatory requirements for treatment and disposal of the water shall be determined prior to using this method. Standing outside the tank, the operator shall rinse the tank with a 3-to-6 percent solution of the product using a pressure sprayer through a tank opening. Explosive concentrations shall be measured at several levels (top, middle, and bottom) within the tank. If readings are greater than 10% of the LFL, the tank shall be rinsed again. When LFL readings are acceptable, the water in the tank shall be pumped out for disposal.

1.18.22 Tank Inerting (No Entry)

Following the removal of tank contents but prior to excavation of the tanks and tank preparation activities, the tanks shall be inerted only by introducing an inert gas, carbon dioxide (CO_2) or liquid nitrogen (N_2), to remove flammable vapors. Before inerting, all openings in the tanks shall be plugged with threaded or expansion type plugs except the vent tube and the opening to be used for introducing the inert gas. Within 30 minutes prior to initiating any activities (e.g., excavating, preparation, removal, opening, demolition, transportation, or other similar activities) involving a tank which has been inerted, the inerted nature of the tank (oxygen levels less than 8%) shall be verified.

a. CO_2 fire extinguishers shall not be used for inerting the tank interiors. If a compressed gas (e.g., CO_2 or N_2) is introduced into the tank, the following requirements shall be met to prevent the buildup of static electricity:

(1) The UST and the compressed gas supply tank shall be bonded together and grounded.

(2) The compressed gas shall be supplied only at low flows.

(3) The liquid or gas shall be released at the tank bottom so that static electricity is not generated by liquid falling to the bottom of the tank. The tank shall be slowly filled from the bottom up.

b. Dry ice, which evolves CO_2 gas as it evaporates, if used, shall be introduced in the amount of at least 1.5 kg per 400 L (3 pounds per 100 gal) of tank capacity. Skin contact with dry ice shall be prevented by wearing heavy cloth gloves.

c. Sufficient quantities of inert gas (CO_2 or N_2) shall be introduced into the tanks to lower the oxygen content to less than 8%. Pressure inside the tank shall not exceed 34 kPa (5 psi). (5 psi.) Prior to proceeding with additional activities on the tank (e.g., excavating), the oxygen content of the tanks shall be monitored to confirm that it is less than 8%. Additional oxygen level monitoring shall be conducted at least hourly while activities involving the tanks are underway but prior to decontamination of tank interiors; at least daily during periods in which the tanks are not being disturbed but prior to decontamination of their interiors; or as directed by the Contracting Officer. If monitoring of tank interiors indicates that oxygen levels are not remaining below 8%, additional inert gas shall be introduced and more frequent oxygen monitoring shall be initiated.

d. During inerting procedures, an extension vent tube a minimum of 3.7 meters (12 feet) above grade or 1 meter (3 feet) above any adjacent (within 22.5 meters (75 feet)) roof lines, whichever is greater shall be used to discharge tank vapors. If this is not possible, alternative methods shall be proposed and approved prior to inerting. Continuous combustible gas/oxygen monitoring shall be conducted at the vent and inert gas introduction holes.

1.18.23 Tank Atmosphere Testing

The air within the storage tanks shall be monitored to ensure the space is either adequately purged and safe for personnel entry, or to ensure the tank has been adequately inerted and the oxygen content is less than 8%. In both instances, monitoring shall be performed at the top, bottom, and middle areas of the tanks to ensure stratification has not occurred. Monitoring results shall be reported to project personnel to ensure safe operations. Data shall be recorded as specified in paragraph EXPOSURE MONITORING/AIR SAMPLING PROGRAM.

1.18.23.1 Monitoring to Ensure Purging

When monitoring to ensure purging, both oxygen content and LFL readings are required. Prior to obtaining LFL readings, the Contractor shall monitor the oxygen content of the space and verify that the combustible gas indicators are operating within the oxygen limits identified by the CGI manufacturer. Personnel shall not be permitted to enter spaces with oxygen levels less than 19.5%, except in emergencies, and then only when equipped with the proper PPE and when following permit-required confined space entry procedures. Toxic air contaminants shall be monitored as specified in paragraph EXPOSURE MONITORING/ AIR SAMPLING PROGRAM.

1.18.23.2 Monitoring to Ensure Inerting

Inerted tanks shall be monitored to ensure oxygen readings remain below a maximum allowable percentage of 8% by volume.

1.18.24 Tank Lifting

Tanks shall be lifted using equipment with a rated capacity greater than the load to be lifted. Tanks shall be lifted by lifting eyes or by straps under the ends of the tanks. Tanks shall not be lifted by the manhole flange or by removing the bungs. Personnel shall be directed to remain away from the ends of the tanks and tanks shall be positioned, whenever possible, with the ends oriented away from occupied or traveled areas, due to potential for rupture. During transportation, the tanks shall be secured to prevent movement.

1.18.25 Tank Demolition

The tanks excavated as part of this project shall be demolished before being removed from the site unless they are transported directly to a state certified tank destruction facility. Demolition will not be permitted until a decontamination of the interiors and exteriors is complete. Demolition shall involve opening the tanks sufficiently to permanently prohibit further use as containers of liquids. Tanks shall be inerted and tested before they are opened. Plans and procedures, including a list of materials and supplies, for safely and effectively demolishing the tanks shall be submitted in the SSHP.

1.18.26 Tank Cleaning

Safety practices and procedures for the cleaning of the storage tanks shall conform to API Std 2015. Opening of the tanks to permit decontamination shall be conducted utilizing only methods approved in the SSHP. The interior and exterior of the tank shall be decontaminated prior to removing it from the work site unless the tank is being transported directly to a state certified tank destruction facility. Plans and procedures, including materials and supplies, for safely and effectively opening the tanks, cleaning surfaces of the interior and exterior of the tanks, and disposing of the decontamination fluids shall be submitted in the SSHP. Volatile organic solvents shall not be permitted to be utilized for decontamination procedures. Personnel shall not enter any of the storage tanks as a part of this project, except when following permit required confined space entry procedures. Decontamination fluids shall be collected and disposed. Upon completion of this project, written certification shall be made that the tank was properly decontaminated prior to being removed from the site.

1.19 SITE CONTROL MEASURES

In order to prevent the spread of contamination and control the flow of personnel, vehicles, and materials into and out of work areas, site control measures shall be established and described in the SSHP. The SSHP shall describe the methodology to be used by the Safety and Health Manager and SSHO in determining work zone designations and their modifications, and procedures to limit the spread of contamination. The SSHP shall include procedures for the implementation and enforcement of safety and health rules for all persons on the site, including employers, employees, outside Contractors, government representatives, and visitors.

1.19.1 Work Zones

Initial anticipated work zone boundaries are shown on the drawings. Utilizing this guidance, work zone boundaries (exclusion zone, including restricted and regulated areas; contamination reduction zone; and support zone) and access points shall be established and the boundary delineations shall be included on the drawings and in the SSHP. Delineation of work zone boundaries shall be based on the contamination characterization data and the hazard/risk analysis to be performed as described in paragraph: HAZARD/RISK ANALYSIS. As work progresses and field conditions are monitored, work zone boundaries may be modified with approval of the Contracting Officer. Work zones shall be clearly identified and marked in the field (using fences, tape, signs, etc.). A site map, showing work zone boundaries and locations of decontamination facilities, shall be posted in the onsite office. Work zones shall consist of the following:

a. Exclusion Zone (EZ): The exclusion zone is the area where hazardous contamination is either known or expected to occur and the greatest potential for exposure exists. Entry into this area shall be controlled and exit may only be made through the CRZ.

b. Contamination Reduction Zone (CRZ): The CRZ is the transition area between the Exclusion Zone and the Support Zone. The personnel and equipment decontamination areas shall be separate and unique areas located in the CRZ.

c. Support Zone (SZ): The Support Zone is defined as areas of the site, other than exclusion zones and contamination reduction zones, where workers do not have the potential to be exposed to hazardous substances or dangerous conditions resulting from hazardous waste operations. The Support Zone shall be secured against active or passive contamination. Site offices, parking areas, and other support facilities shall be located in the Support Zone.

1.19.2 Site Control Log

A log of personnel visiting, entering, or working on the site shall be maintained. The log shall include the following: date, name, agency or company, time entering and exiting site, time entering and exiting the exclusion zone (if applicable), and personal protective equipment utilized. Before visitors are allowed to enter the Contamination Reduction Zone or Exclusion Zone, they shall show proof of current training, medical surveillance and respirator fit testing (if respirators are required for the tasks to be performed) and shall fill out the Certificate of Worker or Visitor Acknowledgment. This visitor information, including date, shall be recorded in the log.

1.19.3 Communication

An employee alarm system that has adequate means of on and off site communication shall be provided and installed in accordance with 29 CFR 1910 Section.165. The means of communication shall be able to be perceived above ambient noise or light levels by employees in the affected portions of the workplace. The signals shall be distinctive and recognizable as messages to evacuate or to perform critical operations.

1.19.4 Site Security

The following site security shall be provided. Signs shall be printed in bold large letters on contrasting backgrounds in English and/or where appropriate, in the predominant language of workers unable to read English. Signs shall be visible from all points where entry might occur and at such distances from the restricted area that employees may read the signs and take necessary protective steps before entering.

1.20 PERSONAL HYGIENE AND DECONTAMINATION

Personnel entering the Exclusion or Contamination Reduction Zones or otherwise exposed or subject to exposure to hazardous chemical vapors, liquids, or contaminated solids shall adhere to the following personal hygiene and decontamination provisions. Decontamination shall be performed in the CRZ prior to entering the Support Zone from the Exclusion Zone. Chapter 10.0 of NIOSH Pub No. 85-115 shall be consulted when preparing decontamination procedures. A detailed discussion of personal hygiene and decontamination facilities and procedures to be followed by site workers shall be submitted as part of the SSHP. Employees shall be trained in the procedures and the procedures shall be enforced throughout site operations. Persons disregarding these provisions of the SSHP shall be barred from the site.

1.20.1 Decontamination Facilities

The following facilities shall be provided:

A personnel decontamination facility in the CRZ. This facility shall be used by both Contractor personnel and government representatives. The decontamination facility shall provide for separation of street clothing and contaminated PPE and shall be equipped with heating, lighting, ventilation, a change room and lockers, hot and cold water, shower facilities with hot and cold water, towels, soap in sufficient quantities for all anticipated personnel, and waste water storage facilities for controlling the disposal of used water. Laundry facilities or provisions of laundry service. If an offsite laundry service is used, they shall be notified, in writing, of the possibility and nature of contaminants expected on clothing.

1.20.2 Procedures

Minimum decontamination procedures are listed below. Available site information shall be reviewed and these procedures shall be expanded and/or revised for submittal as part of the SSHP.

1.21 EQUIPMENT DECONTAMINATION

Vehicles and equipment used in the EZ shall be decontaminated in the CRZ prior to leaving the site. The procedures for decontamination of vehicles and equipment shall be addressed in the SSHP.

1.21.1 Decontamination Facilities

A vehicle/equipment decontamination station shall be provided within the CRZ for decontaminating vehicles and equipment leaving the EZ. The decontamination station shall include the following: A traffic surface consisting of a concrete pad of sufficient strength to support traffic without cracking or a minimum of 12 inches thick of crushed rock as required for the traffic condition and condition of the contamination. The crushed rock shall be underlayed by a chemically resistant impermeable flexible membrane, such as HDPE, PVC or VLDPE with a minimum thickness of 1 mm The liner shall be protected from damage on top with a geotextile. The base layer of soil on which the membrane is placed shall be free of objects greater than 9.5 in diameter and any other materials which could puncture or damage the membrane. The pad shall be constructed to capture decontamination water, including overspray, and shall allow for collection and removal of the decontamination water using sumps, dikes and ditches as required. High pressure, low volume, water wash area for equipment and vehicles, a steam cleaning system for use after the mud and/or site material has been cleaned from the equipment or a designated “clean area” in the CRZ for performing equipment maintenance. This area shall be used when personnel are required by normal practices to come in contact with the ground, i.e., crawling under a vehicle to change engine oil. Equipment within the EZ or CRZ shall be decontaminated before maintenance is performed.

1.21.2 Procedures

Procedures for equipment decontamination shall be developed and utilized to prevent the spread of contamination into the SZ and off-site areas. These procedures shall address disposal of contaminated products and spent materials used on the site, including containers, fluids, oils, etc. Any item taken into the EZ shall be assumed to be contaminated and shall be inspected and/or decontaminated before the item leaves the area. Vehicles, equipment, and materials shall be cleaned and decontaminated prior to leaving the site. Construction material shall be handled in such a way as to minimize the potential for contaminants being spread and/or carried offsite. Prior to exiting the site, vehicles and equipment shall be monitored to ensure the adequacy of decontamination.

1.22 EMERGENCY EQUIPMENT AND FIRST AID REQUIREMENTS

The SSHP shall describe the emergency and first aid equipment to be available onsite. The following items, as a minimum, shall be maintained onsite and available for immediate use:

a. First aid equipment and supplies approved by the consulting physician.

b. Emergency eyewashes and showers which comply with ANSI Z358.1.

c. Emergency-use respirators. For escape purposes, 5- to 15 minute emergency escape masks shall be supplied. For rescue purposes, 2 positive pressure self-contained breathing apparatus (SCBA) shall be supplied. These shall be dedicated for emergency use only and maintained onsite in the Contamination Reduction Zone.

d. Fire extinguishers with a minimum rating of 20-A:120-B:C shall be provided at site facilities and in all vehicles and at any other site locations where flammable or combustible materials present a fire risk.

1.23 EMERGENCY RESPONSE AND CONTINGENCY PROCEDURES

An Emergency Response Plan, that meets the requirements of 29 CFR 1910 Section .120 (l) and 29 CFR 1926 Section .65 (l), shall be developed and implemented as a section of the SSHP. In the event of any emergency associated with remedial action, the Contractor shall, without delay, alert all onsite employees that there is an emergency situation; take action to remove or otherwise minimize the cause of the emergency; alert the Contracting Officer; and institute measures necessary to prevent repetition of the conditions or actions leading to, or resulting in, the emergency. Employees that are required to respond to hazardous emergency situations shall be trained in how to respond to such expected emergencies. The plan shall be rehearsed regularly as part of the overall training program for site operations. The plan shall be reviewed periodically and revised as necessary to reflect new or changing site conditions or information. Copies of the accepted SSHP and revisions shall be provided to the affected local emergency response agencies. The following elements, as a minimum, shall be addressed in the plan:

a. Pre-emergency planning. The local emergency response agencies shall be contacted and met with during preparation of the Emergency Response Plan. Agencies to be contacted include local fire, police, and rescue authorities with jurisdiction and nearby medical facilities that may be utilized for emergency treatment of injured personnel. At these meetings, the agencies shall be notified of upcoming site activities and potential emergency situations. The response agencies’ capabilities shall be ascertained and written response commitments obtained. The Contractor shall ensure the Emergency Response Plan for the site is compatible and integrated with the disaster, fire and/or emergency response plans of local, state, and Federal agencies.

b. Personnel roles, lines of authority, communications for emergencies.

c. Emergency recognition and prevention.

d. Site topography, layout, and prevailing weather conditions.

e. Criteria and procedures for site evacuation (emergency alerting procedures, employee alarm system, emergency PPE and equipment, safe distances, places of refuge, evacuation routes, site security and control).

f. Specific procedures for decontamination and medical treatment of injured personnel.

g. Route maps to nearest prenotified medical facility. Site-support vehicles shall be equipped with maps. At the beginning of project operations, drivers of the support vehicles shall become familiar with the emergency route and the travel time required.

h. Emergency alerting and response procedures including posted instructions and a list of names and telephone numbers of emergency contacts (physician, nearby medical facility, fire and police departments, ambulance service, Federal, state, and local environmental agencies; as well as Safety and Health Manager, the Site Superintendent, the Contracting Officer and/or their alternates).

i. Criteria for initiating community alert program, contacts, and responsibilities.

j. Procedures for reporting incidents to appropriate government agencies. In the event that an incident such as an explosion or fire, or a spill or release of toxic materials occurs during the course of the project, the appropriate government agencies shall be immediately notified. In addition, the Contracting Officer shall be verbally notified immediately and receive a written notification within 24 hours. The report shall include the following items:

(1) Name, organization, telephone number, and location of the Contractor.

(2) Name and title of the person(s) reporting.

(3) Date and time of the incident.

(4) Location of the incident, i.e., site location, facility name.

(5) Brief summary of the incident giving pertinent details including type of operation ongoing at the time of the incident.

(6) Cause of the incident, if known.

(7) Casualties (fatalities, disabling injuries).

(8) Details of any existing chemical hazard or contamination.

(9) Estimated property damage, if applicable.

(10) Nature of damage, effect on contract schedule.

(11) Action taken to ensure safety and security.

(12) Other damage or injuries sustained, public or private.

k. Procedures for critique of emergency responses and follow-up.

1.24 CERTIFICATE OF WORKER/VISITOR ACKNOWLEDGEMENT

A copy of a Contractor-generated certificate of worker/visitor acknowledgement shall be completed and submitted for each visitor allowed to enter contamination reduction or exclusion zones, and for each employee, following the example certificate at the end of this section.

1.25 INSPECTIONS

The SSHO shall perform daily inspections of the jobsite and the work in progress to ensure compliance with EM 385-1-1, the Safety and Health Program, the SSHP and other occupational health and safety requirements of the contract, and to determine the effectiveness of the SSHP. Procedures for correcting deficiencies (including actions, timetable and responsibilities) shall be described in the SSHP. Follow-up inspections to ensure correction of deficiencies shall be conducted and documented. Daily safety inspection logs shall be used to document the inspections, noting safety and health deficiencies, deficiencies in the effectiveness of the SSHP, and corrective actions taken. The SSHO’s Daily Inspection Logs shall be attached to and submitted with the Daily Quality Control reports. Each entry shall include the following: date, work area checked, employees present in work area, PPE and work equipment being used in each area, special safety and health issues and notes, and signature of preparer. In the event of an accident, the Contracting Officer shall be notified according to EM 385-1-1. Within 2 working days of any reportable accident, an Accident Report shall be completed on ENG Form 3394 and submitted.

1.26 SAFETY AND HEALTH PHASE-OUT REPORT

A Safety and Health Phase-Out Report shall be submitted within 10 working days following completion of the work, prior to final acceptance of the work. The following minimum information shall be included:

a. Summary of the overall performance of safety and health (accidents or incidents including near misses, unusual events, lessons learned, etc.).

b. Final decontamination documentation including procedures and techniques used to decontaminate equipment, vehicles, and onsite facilities.

c. Summary of exposure monitoring and air sampling accomplished during the project.

d. Signatures of Safety and Health Manager and SSHO.

EXAMPLE CERTIFICATE OF WORKER/VISITOR ACKNOWLEDGMENT

PROJECT NAME CONTRACT NO.

PROJECT ADDRESS

CONTRACTOR’S NAME

EMPLOYEE’S and VISITOR’S NAME

The contract for the above project requires the following: that you be provided with and complete formal and site-specific training; that you be supplied with proper personal protective equipment including respirators;

that you be trained in its use; and that you receive a medical examination to evaluate your physical capacity to perform your assigned work tasks, under the environmental conditions expected, while wearing the required personal protective equipment. These things are to be done at no cost to you. By signing this certification, you are acknowledging that your employer has met these obligations to you.

I HAVE READ, UNDERSTAND AND AGREE TO FOLLOW THE SITE SAFETY AND HEALTH PLAN FOR THIS SITE.

Name   Date

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FORMAL TRAINING: I have completed the following formal training courses that meet OSHA's requirements:

Date Completed

40 hour: ....________________

8 hour supervisory:...................________________

8 hour refresher:.....................________________

SITE-SPECIFIC TRAINING: I have been provided and have completed the site specific training required by this Contract. The Site Safety and Health Officer conducted the training. ______________

RESPIRATORY PROTECTION: I have been trained in accordance with the criteria in the Contractor's and my Employer's Respiratory Protection program. I have been trained in the proper work procedures and use and limitations of the respirator(s) I will wear. I have been trained in and will abide by the facial hair policy. ______________________

RESPIRATOR FIT-TEST TRAINING: I have been trained in the proper selection, fit, use, care, cleaning, and maintenance, and storage of the respirator(s) that I will wear. I have been fit-tested in accordance with the criteria in the Contractor's Respiratory Program and have received a satisfactory fit. I have been taught how to properly perform positive and negative pressure fit-check upon donning negative pressure respirators each time.________________

MEDICAL EXAMINATION: I have had a medical examination within the last twelve months which was paid for by my employer. The examination included: health history, pulmonary function tests and may have included an evaluation of a chest x-ray. A physician made determination regarding my physical capacity to perform work tasks on the project while wearing protective equipment including a respirator. I was personally provided a copy and informed of the results of that examination. My employer's industrial hygienist evaluated the medical certification provided by the physician and checked the appropriate blank below. The physician determined that there:

were no limitations to performing the required work tasks;

were identified physical limitations to performing the required work tasks.

Date medical exam completed

Employee's/Visitor's Signature ____

Date _________________________

Printed Name _____________________________

Social Security Number ______________________

Contractor's Site Safety and Health Officer Signature ____________________

Date _________________________

Printed Name _____________________________

Social Security Number ______________________

1.27 UNKNOWN HAZARDOUS MATERIAL

a. All unknown hazardous or regulated materials are indicated in the contract documents. In performance of the contract, if the contractor encounters material which the contract does not identify as hazardous, but may be dangerous to human health if disturbed during construction operation, the Contractor shall:

(1) Stop that portion of work immediately.

(2) Continue to work in other areas not in the vicinity of hazardous or regulated materials.

(3) Notify the Contracting Officer, immediately, identifying any hazardous or regulated materials not indicated in the contract documents.

The intent is to identify materials such as PCB, lead paint, mercury, petroleum products, and friable and non-friable asbestos. The Contractor shall not disturb asbestos material.

b. The Government, within 14 calendar days, will determine if the material is hazardous. If the material is not hazardous or poses no danger, the Government will direct the Contractor to proceed. If the material is hazardous or regulated and handling of the material is necessary to accomplish the work, the Contracting Officer shall arrange for removal of such hazardous or regulated material either by modification to the contract or otherwise. If the hazardous or regulated material removal is accomplished outside this contract the Contracting Officer shall notify the Contractor when it is permissible to resume work in the area where the hazardous or regulated material was discovered.

c. A revised delivery schedule may be negotiated depending on the length of the delay.

SECTION 01430

ENVIRONMENTAL PROTECTION

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specifications to the extent referenced. The publications are referred to in the text by basic designation only.

Code of Regulations

40 CFR 261	Identification and Listing of Hazardous Waste Engineering Manuals
EM 385-1-1	Army Corps of Engineers Safety and Health Requirements Manual
USFK Pamphlet	USFK Pam 200-1, Environmental Quality, Environmental Governing Standards, 15 July 1997

1.2 DEFINITIONS

This section covers prevention of environmental pollution and damage as the result of construction activities under this contract and for those measures set forth in other sections of the TECHNICAL SPECIFICATIONS. For the purpose of this specification, environmental pollution and damage is defined as the presence of chemical, physical, or biological elements or agents which adversely affect human health or welfare; unfavorably alter ecological balances of importance to human life; affect other species of importance to man. The control of environmental pollution and damage requires consideration of air, water, and land, and includes management of visual aesthetics, noise, solid waste, radiant energy, as well as other pollutants.

1.3 SUBMITTALS

The Contractor shall submit an environmental protection plan in accordance with provisions as herein specified.

1.3.1 Environmental Protection Plan shall include but not be limited to the following.

a. A List of USFK and ROK, Federal, local laws, regulations, Provincial and permits concerning environmental protection, pollution control and abatement that are applicable to the Contractor's proposed operations and the requirements imposed by those laws, regulations, and permits.

b. Methods for Protection of Features to be preserved within authorized work areas. The Contractor shall prepare a listing of methods to protect resources needing protection; i.e., trees, shrubs, vines, grasses and ground cover, landscape features, air and water quality and soil.

c. Procedures to be implemented to provide the required environmental protection and to comply with the applicable laws and regulations. The Contractor shall set out the procedures to be followed to correct pollution of the environment due to accident, natural causes, or failure to follow the procedure set out in accordance with the environmental protection plan.

d. Location of the solid waste disposal area.

e. Drawings Showing Locations of any proposed temporary excavations or embankments for haul roads, stream crossings, material storage areas, structures, sanitary facilities, and stockpiles of excess or spoil materials.

f. Environmental Monitoring Plans including land, water, air, and noise monitoring.

g. Traffic Control Plan including measures to r educe erosion of temporary roadbeds by construction traffic, especially during wet weather, and the amount of mud transported onto paved roads by vehicles or runoff.

h. Methods of Protecting surface and ground water during construction activities when specified.

i. Work Area Plan showing the proposed activity in each portion of the area and identifying the areas of limited use or nonuse. Plan should include measures for marking the limits of use areas.

j. Plan of Borrow Area(s).

k. Training for his personnel during the construction period.

l. List of Hazardous Materials: The contractor shall submit a list of any construction materials containing hazardous substance that has been determined to be capable of posing an unreasonable risk to health, safety, and property. The criteria for the storage, handling, transportation, and disposition of hazardous materials used by the contractor are included in USFK Pam 200-1, Chapter 5 and FAR 52.223-3.

1.3.2 Implementation

Within 15 calendar days after receipt of Notice to Proceed, the Contractor shall submit in writing the above environmental protection plan for approval of the Contracting Officer in accordance with the SPECIAL CONTRACT CLAUSES. Approval of the Contractor's plan will not relieve the Contractor of his responsibility for adequate and continuing control of pollutants and other environmental protection measures.

1.4 SUBCONTRACTORS

Assurance of compliance with this section by subcontractors will be the responsibility of the Contractor.

1.5 NOTIFICATION

The Contracting Officer will notify the Contractor in writing of any observed noncompliance with the aforementioned laws or regulations, permits, and other elements of the Contractor's environmental protection plan. The Contractor shall, after receipt of such notice, inform the Contracting Officer of proposed corrective action and take such action as may be approved. If the Contractor fails to comply promptly, the Contracting Officer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No time extensions shall be granted or costs or damages allowed to the Contractor for any such suspension.

PART 2. PRODUCTS (Not Applicable)

PART 3. EXECUTION

3.1 PROTECTION OF ENVIRONMENTAL RESOURCES

The environmental resources within the project boundaries and those affected outside the limits of permanent work under this contract shall be protected during the entire period of this contract. The Contractor shall confine his activities to areas defined by the drawings and specifications. Environmental protection shall be as stated in the following subparagraphs.

3.1.1 Protection of Land Resources

Prior to the beginning of any construction, the Contractor shall identify all land resources to the preserved within the Contractor's work area. Except in areas indicated on the drawings or specified to be cleared, the Contractor shall not remove, cut, deface, injure, or destroy land resources including trees, shrubs, vines, grasses, topsoil, and land forms without special permission from the Contracting Officer. No ropes, cables, or guys shall be fastened to or attached to any trees for anchorage unless specifically authorized. Where such special emergency use is permitted, the Contractor shall provide effective protection for land and vegetation resources at all times as defined in the following subparagraphs.

3.1.2 Work Area Limits

Prior to any construction, the Contractor shall mark the areas that are not required to accomplish all work to be performed under this contract. Isolated areas within the general work area that are to be saved and protected shall also be marked or fenced. Monuments and markers shall be protected before construction operations commence. Where construction operations are to be conducted during darkness, the markers shall be visible. The Contractor shall convey to his personnel the purpose of marking and/or protection of all necessary objects.

3.1.3 Protection of Landscape:

3.1.3.1 The Contractor shall be responsible for the protection of the tops, trunks and roots of all existing trees that are to be retained on the site. Protection shall be maintained until all work in the vicinity has been completed and shall not be removed without the consent of the Contracting Officer. If the Contracting Officer finds that the protective devices are insufficient, additional protection devices shall be installed.

3.1.3.2 Heavy equipment, vehicular traffic, or stockpiling of any materials shall not be permitted within the drip line of trees to be retained. 3.1.3.3 No toxic materials shall be stored within 30 meter (100 feet) from the drip line of trees to be retained.

3.1.3.3 Except for areas shown on the plans to be cleared, the Contractor shall not deface, injure, or destroy trees or shrubs, nor remove or cut them without special authority. Existing nearby trees shall not be used for anchorage unless specifically authorized by the Contracting Officer. Where such special emergency use is permitted, the Contractor shall first adequately protect the trunk with a sufficient thickness of burlap over which softwood cleats shall be tied.

3.1.3.4 No protective devices, signs, utility boxes or other objects shall be nailed to trees to be retained on the site.

3.1.4 Reduction of Exposure of Unprotected Erodible Soils

Earthwork brought to final grade shall be finished as indicated and specified. Side slopes and back slopes shall be protected as soon as practicable upon completion of rough grading. All earthworks shall be planned and conducted to minimize the duration of exposure of unprotected soils. Except in instances where the constructed feature obscures borrow areas, quarries, and waste material areas, these areas shall not initially be cleared in total. Clearing of such areas shall progress in reasonably sized increments as needed to use the areas developed as approved by the Contracting Officer.

3.1.5 Temporary Protection of Disturbed Areas

Such methods as necessary shall be utilized to effectively prevent erosion and control sedimentation, including but not limited to the following:

3.1.5.1 Retardation and Control of Runoff

Runoff from the construction site shall be controlled by construction of diversion ditches, benches, and berms to retard and divert runoff to protected drainage courses, and downstream lands and facilities.

3.1.5.2 Sediment Basins

Sediment from construction areas shall be trapped in temporary or permanent sediment basins in accordance with basin plans shown on the drawings. The basins shall accommodate the runoff of a local storm of a design frequency as indicated or 2 years if not specified. After each storm, the basins shall be pumped dry and accumulated sediment shall be removed as necessary to maintain basin effectiveness. Overflow shall be controlled by paved weir or by vertical overflow pipe, draining from the surface. The collected topsoil sediment shall be reused for fill on the construction site, and/or conserved/stockpiled for use at another site or sites. The Contractor shall institute effluent quality monitoring programs as required by Korean Provincial and local environmental authorities.

3.1.6 Erosion and Sedimentation Control Devices

The Contractor shall construct or install all temporary and permanent erosion and sedimentation control features as indicated on the drawings or directed. Temporary erosion and sediment control measures such as berms, dikes, drains, silt fences, sedimentation basins, grassing, and mulching shall be maintained until permanent drainage and erosion control facilities are completed and operative.

3.1.7 Location of Field Offices, Storage, and Other Contractor Facilities

The Contractors' Field offices, staging areas, stockpile storage, and temporary buildings shall be placed in areas designated on the drawings or as directed by the Contracting Officer. Temporary movement or relocation of Contractor facilities shall be made only on approval by the Contracting Officer.

3.1.8 Borrow Areas on U.S. Government Controlled lands shall be managed to minimize erosion and to prevent sediment from entering nearby waters.

3.1.9 Spoil Areas on U.S. Government controlled lands shall be managed and controlled to limit spoil to areas designated and prevent erosion of soil or sediment from entering nearby waters.

3.1.10 Temporary Excavations and Embankments for plant and/or work areas shall be controlled to protect adjacent areas from despoilment.

3.1.11 Disposal of Solid Wastes

Solid wastes (excluding clearing debris) shall be placed in containers, which are emptied on a regular schedule. All handling and disposal shall be conducted to prevent contamination. Segregation measures shall be employed such that no hazardous or toxic waste will become commingled with solid waste. The Contractor shall transport all solid waste off Government property and dispose of it in compliance with Korean National, Provincial and local requirements for solid waste disposal.

3.2 PROTECTION OF WATER RESOURCES

The Contractor shall keep construction activities under surveillance, management, and control to avoid pollution of surface and ground waters. Special management techniques as set out below shall be implemented to control water pollution by the listed construction activities, which are included in this contract. In particular, toxic or hazardous chemicals shall not be applied to soil or vegetation in a manner that may cause contamination of the fresh water reserves or sources. Toxic or Hazardous Chemicals include, but not be limited to, fuels, oils, bituminous, calcium chloride, and acid.

3.2.1 Washing and Curing Water

Waste waters directly derived from construction activities shall not be allowed to enter water areas. These waste waters shall be collected and placed in retention ponds where suspended material can be settled out or the water evaporates so that pollutants are separated from the water. Analysis shall be performed and results reviewed and approved before water in retention ponds is discharged.

3.2.2 Dewatering and Diversion Operations

The Contractor shall plan his operation and perform all work necessary to minimize adverse impact of violation of the water quality standards as may be designated by Korean governmental authorities. Construction operations for dewatering, and other relocated activities shall be controlled at all times to limit the impact of water turbidity on the habitat for wildlife and impacts on water quality for downstream use and to limit the impact on the safety of the adjacent structures and facilities caused from the ground water level draw down.

3.2.3 Stream Crossings shall be controlled during construction. Crossings shall provide movement of materials or equipment, which do not violate water pollution control standards of Korean National, Provincial or local government.

3.2.4 Monitoring of Water Areas Affected by Construction Activities shall be the responsibility of the Contractor. All water areas affected by construction activities shall be monitored by the Contractor.

3.3 PROTECTION OF AIR RESOURCES

The Contractor shall keep construction activities under surveillance, management and control to minimize pollution of air resources. All activities, equipment, processes, and work operated or performed by the Contractor in accomplishing the specified construction shall be in strict accordance with local U.S. and Korean governmental rules and regulations. Ambient Air Quality Standards as may be set by Korean governmental authorities shall be maintained for those construction operations and activities specified. Special management techniques as set out below shall be implemented to control air pollution by the construction activities which are included in the contract.

3.3.1 Particulates

Dust particles, aerosols, and gaseous by-products from all construction activities, processing and preparation of materials, such as from asphaltic and portland cement concrete, batch plants, shall be controlled at all times, including weekends, holidays and hours when work is not in progress.

3.3.1.1. Particulates Control

The Contractor shall maintain all excavations, stockpiles, haul roads, permanent and temporary access roads, plant sites, spoil areas, borrow areas, and all other work areas within or outside the project boundaries free from particulates which would cause the air pollution standards mentioned in paragraph Protection of Air Resources to be exceeded or which would cause a hazard or a nuisance. Sprinkling, chemical treatment of an approved type, light bituminous treatment, baghouse, scrubbers, electrostatic precipitators or other methods will be permitted to control particulates in the work area. Sprinkling, to be efficient, must be repeated at such intervals as to keep the disturbed area damp at all times. The Contractor must have sufficient competent equipment available to accomplish this task. particulate control shall be performed as the work proceeds and whenever a particulate nuisance or hazard occurs.

3.3.2 Hydrocarbons and Carbon Monoxide emissions from equipment shall be controlled to Korean governmental allowable limits at all times.

3.3.3 Odors shall be controlled at all times for all construction activities, processing and preparation of materials.

3.3.4 Monitoring of Air quality shall be the responsibility of the Contractor. The Contractor shall identify the air monitoring requirements in an activity hazard analysis in accordance with all pertinent provision of the latest version of U.S. Army Corps of Engineers Safety and Health Requirements Manual, EM 381-1-1. All air areas affected by the construction activities shall be monitored by the Contractor.

3.4 PROTECTION FROM SOUND INTRUSIONS

The Contractor shall keep construction activities under surveillance, and control to minimize damage to the environment by noise.

3.5 POST CONSTRUCTION CLEANUP

The Contractor shall clean up area(s) used for construction.

3.6 RESTORATION OF LANDSCAPE DAMAGE

Any trees or other landscape feature scarred or damaged by the Contractor’s operations shall be restored as nearly as possible to its original condition at the Contractor’s expense. The Contracting Officer will decide what method of restoration shall be used, and weather damaged trees shall be treated and healed or removed and disposed of. All scars made on trees, designated on the plans to remain, and all cuts for the removal of limbs larger than 25 mm (1 inch) in diameter shall be coated as soon as possible with an approved tree wound dressing. All trimming or pruning shall be performed in an approved manner by experienced workmen with saws or pruning shears. Tree trimming with axes will not be permitted. Where tree climbing is necessary, the use of climbing spurs will not be permitted. Trees that are to remain, either within or outside established clearing limits, that are subsequently damaged by the Contractor and area beyond saving in the opinion of the Contracting Officer, shall be immediately removed and replaced with a nursery-grown tree of the same species. Replacement trees shall measure no less than 50 mm (2 inches) in diameter at 150 mm (6 inches) above the ground level.

3.7 MAINTENANCE OF POLLUTION CONTROL FACILITIES

The Contractor shall maintain all constructed facilities and portable pollution control devices for the duration of the contract or for the length of time construction activities create the particular pollutant.

3.8 MEASUREMENT AND PAYMENT

No separate measurement or payment will be made for the environmental protection required under this contract, and all costs in connection therewith shall be considered a subsidiary obligation of the contractor.

SECTION 01451

CONTRACTOR QUALITY CONTROL

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 3740	(1996) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM E 329	(1995) Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

1.2 PAYMENT

Separate payment will not be made for providing and maintaining an effective Quality Control program, and all costs associated therewith shall be included in the applicable unit prices or lump-sum prices contained in the Bidding Schedule.

PART 2 PRODUCTS (NOT APPLICABLE)

PART 3 EXECUTION

3.1 GENERAL

The Contractor is responsible for quality control and shall establish and maintain an effective quality control system in compliance with the Contract Clause titled "Inspection of Construction." The quality control system shall consist of plans, procedures, and organization necessary to produce an end product which complies with the contract requirements. The system shall cover all construction operations, both onsite and offsite, and shall be keyed to the proposed construction sequence. The project superintendent will be held responsible for the quality of work on the job and is subject to removal by the Contracting Officer for non-compliance with quality requirements specified in the contract. The project superintendent in this context shall mean the individual with the responsibility for the overall management of the project including quality and production.

3.2 QUALITY CONTROL PLAN

3.2.1 General

The Contractor shall furnish for review by the Government, not later than 20 days after contract award, the Contractor Quality Control (CQC) Plan proposed to implement the requirements of the Contract Clause titled "Inspection of Construction." The plan shall identify personnel, procedures, control, instructions, test, records, and forms to be used. The Government will consider an interim plan for the first 5 days of operation. Construction will be permitted to begin only after acceptance of the CQC Plan or acceptance of an interim plan applicable to the particular feature of work to be started. Work outside of the features of work included in an accepted interim plan will not be permitted to begin until acceptance of a CQC Plan or another interim plan containing the additional features of work to be started.

3.2.2 Content of the CQC Plan

The CQC Plan shall include, as a minimum, the following to cover all construction operations, both onsite and offsite, including work by subcontractors, fabricators, suppliers, and purchasing agents:

a. A description of the quality control organization, including a chart showing lines of authority and acknowledgment that the CQC staff shall implement the three phase control system for all aspects of the work specified. The staff shall include a CQC System Manager who shall report to the project superintendent.

b. The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a CQC function.

c. A copy of the letter to the CQC System Manager signed by an authorized official of the firm which describes the responsibilities and delegates sufficient authorities to adequately perform the functions of the CQC System Manager, including authority to stop work which is not in compliance with the contract. The CQC System Manager shall issue letters of direction to all other various quality control representatives outlining duties, authorities, and responsibilities. Copies of these letters shall also be furnished to the Government.

d. Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, offsite fabricators, suppliers, and purchasing agents. These procedures shall be in accordance with Section 01330 SUBMITTAL PROCEDURES.

e. Control, verification, and acceptance testing procedures for each specific test to include the test name, specification paragraph requiring test, feature of work to be tested, test frequency, and person responsible for each test. Laboratory facilities will be approved by the Contracting Officer.

f. Procedures for tracking preparatory, initial, and follow-up control phases and control, verification, and acceptance tests including documentation.

g. Procedures for tracking construction deficiencies from identification through acceptable corrective action. These procedures shall establish verification that identified deficiencies have been corrected.

h. Reporting procedures, including proposed reporting formats.

i. A list of the definable features of work. A definable feature of work is a task which is separate and distinct from other tasks, has separate control requirements, and may be identified by different trades or disciplines, or it may be work by the same trade in a different environment. Although each section of the specifications may generally be considered as a definable feature of work, there are frequently more than one definable features under a particular section. This list will be agreed upon during the coordination meeting.

3.2.3 Acceptance of Plan

Acceptance of the Contractor's plan is required prior to the start of construction. Acceptance is conditional and will be predicated on satisfactory performance during the construction. The Government reserves the right to require the Contractor to make changes in his CQC Plan and operations including removal of personnel, as necessary, to obtain the quality specified.

3.2.4 Notification of Changes

After acceptance of the CQC Plan, the Contractor shall notify the Contracting Officer in writing of any proposed change. Proposed changes are subject to acceptance by the Contracting Officer.

3.3 COORDINATION MEETING

After the Preconstruction Conference, before start of construction, and prior to acceptance by the Government of the CQC Plan, the Contractor shall meet with the Contracting Officer or Authorized Representative and discuss the Contractor's quality control system. During the meeting, a mutual understanding of the system details shall be developed, including the forms for recording the CQC operations, control activities, testing, administration of the system for both onsite and offsite work, and the interrelationship of Contractor's Management and control with the Government's Quality Assurance. Minutes of the meeting shall be prepared by the Government and signed by both the Contractor and the Contracting Officer. The minutes shall become a part of the contract file.

3.4 QUALITY CONTROL ORGANIZATION

3.4.1 General

The requirements for the CQC organization are a CQC System Manager and sufficient number of additional qualified personnel to ensure contract compliance. The Contractor shall provide a CQC organization chart which shall be at the site at all times during progress of the work and with complete authority to take any action necessary to ensure compliance with the contract. All CQC staff members shall be subject to acceptance by the Contracting Officer.

3.4.2 CQC System Manager

The Contractor shall identify as CQC System Manager an individual within the onsite work organization who shall be responsible for overall management of CQC and have the authority to act in all CQC matters for the Contractor. The CQC System Manager shall have a BS degree in Engineering, Architecture, or Construction Management, with a minimum of 5 years of construction experience on similar construction contract for the Government. This CQC System Manager shall be on the site at all times during construction and shall be employed by the prime Contractor. The CQC System Manager shall be assigned as System Manager but may have duties as project superintendent in addition to quality control. An alternate for the CQC System Manager shall be identified in the plan to serve in the event of the System Manager's absence. The requirements for the alternate shall be the same as for the designated CQC System Manager.

3.4.3 CQC Personnel

In addition to CQC personnel specified elsewhere in the contract, the Contractor shall provide as part of the CQC organization specialized personnel to assist the CQC System Manager for the applicable areas: electrical, mechanical, civil, structural, environmental, architectural, materials technician, submittals clerk, and occupied family housing coordinator. These individuals may be employees of the prime or subcontractor; be responsible to the CQC System Manager; be physically present at the construction site during work on their areas of responsibility; have the necessary education and/or experience in accordance with the experience matrix listed herein. These individuals may perform other duties but must be allowed sufficient time to perform their assigned quality control duties as described in the Quality Control Plan. Experience Matrix Area Qualifications

a. BS degree in Civil Engineer with 2 years experience in the type of work being performed on this project or technician with 5 years related experience

b. BS degree in Mechanical Engineer with 2 years experience or person with 5 years related experience

c. BS degree in Electrical Engineer with 2 years related experience or person with 5 years related experience

d. BS degree in Structural Engineer with 2 years experience or person with 5 years related experience

e. BS degree in Architect with 2 years experience or person with 5 years related experience

f. BS degree in Environmental Engineer with 3 years experience

g. Submittal Clerk with 1 year experience

h. Occupied family housing Person, customer relations type, coordinator experience

i. Concrete, Pavements and Soils Materials Technician with 2 years experience for the appropriate area

3.4.3.1 Exception to Organization

The Contractor may maintain the CQC staff at partial strength depends upon the contract requirements, such as small contract amount with simple features of work. The Contractor shall provide the CQC organization specialized personnel to assist the CQC System Manager for the specific areas for applicable personnel as specified above paragraph. Contractor shall submit the CQC Plan to the Contracting Officer for acceptance.

3.4.4 Additional Requirement

In addition to the above experience and education requirements the CQC System Manager shall have completed the course entitled "Construction Quality Management for Contractors". This course is periodically offered by Regional Engineer Support Center, IMA-KORO.

3.4.5 Organizational Changes

The Contractor shall maintain the CQC staff at full strength at all times. When it is necessary to make changes to the CQC staff, the Contractor shall revise the CQC Plan to reflect the changes and submit the changes to the Contracting Officer for acceptance.

3.5 SUBMITTALS

Submittals shall be made as specified in Section 01330 SUBMITTAL PROCEDURES. The CQC organization shall be responsible for certifying that all submittals are in compliance with the contract requirements.

3.6 CONTROL

Contractor Quality Control is the means by which the Contractor ensures that the construction, to include that of subcontractors and suppliers, complies with the requirements of the contract. At least three phases of control shall be conducted by the CQC System Manager for each definable feature of work as follows:

3.6.1 Preparatory Phase

This phase shall be performed prior to beginning work on each definable feature of work, after all required plans/documents/materials are approved/accepted, and after copies are at the work site. This phase shall include:

a. A review of each paragraph of applicable specifications.

b. A review of the contract drawings.

c. A check to assure that all materials and/or equipment have been tested, submitted, and approved.

d. Review of provisions that have been made to provide required control inspection and testing.

e. Examination of the work area to assure that all required preliminary work has been completed and is in compliance with the contract.

f. A physical examination of required materials, equipment, and sample work to assure that they are on hand, conform to approved shop drawings or submitted data, and are properly stored.

g. A review of the appropriate activity hazard analysis to assure safety requirements are met.

h. Discussion of procedures for controlling quality of the work including repetitive deficiencies. Document construction tolerances and workmanship standards for that feature of work.

i. A check to ensure that the portion of the plan for the work to be performed has been accepted by the Contracting Officer.

j. Discussion of the initial control phase.

k. The Government shall be notified at least 48 hours in advance of beginning the preparatory control phase. This phase shall include a meeting conducted by the CQC System Manager and attended by the superintendent, other CQC personnel (as applicable), and the foreman responsible for the definable feature. The results of the preparatory phase actions shall be documented by separate minutes prepared by the CQC System Manager and attached to the daily CQC report. The Contractor shall instruct applicable workers as to the acceptable level of workmanship required in order to meet contract specifications.

3.6.2 Initial Phase

This phase shall be accomplished at the beginning of a definable feature of work. The following shall be accomplished:

a. A check of work to ensure that it is in full compliance with contract requirements. Review minutes of the preparatory meeting.

b. Verify adequacy of controls to ensure full contract compliance. Verify required control inspection and testing.

c. Establish level of workmanship and verify that it meets minimum acceptable workmanship standards. Compare with required sample panels as appropriate.

d. Resolve all differences.

e. Check safety to include compliance with and upgrading of the safety plan and activity hazard analysis. Review the activity analysis with each worker.

f. The Government shall be notified at least 48 hours in advance of beginning the initial phase. Separate minutes of this phase shall be prepared by the CQC System Manager and attached to the daily CQC report. Exact location of initial phase shall be indicated for future reference and comparison with follow-up phases.

g. The initial phase should be repeated for each new crew to work onsite, or any time acceptable specified quality standards are not being met.

3.6.3 Follow-up Phase

Daily checks shall be performed to assure control activities, including control testing, are providing continued compliance with contract requirements, until completion of the particular feature of work. The checks shall be made a matter of record in the CQC documentation. Final follow-up checks shall be conducted and all deficiencies corrected prior to the start of additional features of work which may be affected by the deficient work. The Contractor shall not build upon nor conceal non-conforming work.

3.6.4 Additional Preparatory and Initial Phases

Additional preparatory and initial phases shall be conducted on the same definable features of work if the quality of on-going work is unacceptable, if there are changes in the applicable CQC staff, onsite production supervision or work crew, if work on a definable feature is resumed after a substantial period of inactivity, or if other problems develop.

3.7 TESTS

3.7.1 Testing Procedure

The Contractor shall perform specified or required tests to verify that control measures are adequate to provide a product which conforms to contract requirements. Upon request, the Contractor shall furnish to the Government duplicate samples of test specimens for possible testing by the Government. Testing includes operation and/or acceptance tests when specified. The Contractor shall procure the services of a Corps of Engineers approved testing laboratory or establish an approved testing laboratory at the project site. The Contractor shall perform the following activities and record and provide the following data:

a. Verify that testing procedures comply with contract requirements.

b. Verify that facilities and testing equipment are available and comply with testing standards.

c. Check test instrument calibration data against certified standards.

d. Verify that recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.

e. Results of all tests taken, both passing and failing tests, shall be recorded on the CQC report for the date taken. Specification paragraph reference, location where tests were taken, and the sequential control number identifying the test shall be given. If approved by the Contracting Officer, actual test reports may be submitted later with a reference to the test number and date taken. An information copy of tests performed by an offsite or commercial test facility shall be provided directly to the Contracting Officer. Failure to submit timely test reports as stated may result in nonpayment for related work performed and disapproval of the test facility for this contract.

3.7.2 Testing Laboratories

3.7.2.1 Capability Check

The Government reserves the right to check laboratory equipment in the proposed laboratory for compliance with the standards set forth in the contract specifications and to check the laboratory technician's testing procedures and techniques. Laboratories utilized for testing soils, concrete, asphalt, and steel shall meet criteria detailed in ASTM D 3740 and ASTM E 329.

3.7.2.2 Capability Recheck

If the selected laboratory fails the capability check, the Contractor will be assessed a charge of $2,000.00 to reimburse the Government for each succeeding recheck of the laboratory or the checking of a subsequently selected laboratory. Such costs will be deducted from the contract amount due the Contractor.

3.7.3 Onsite Laboratory

The Government reserves the right to utilize the Contractor's control testing laboratory and equipment to make assurance tests and to check the Contractor's testing procedures, techniques, and test results at no additional cost to the Government.

3.7.4 Furnishing or Transportation of Samples for Testing

Costs incidental to the transportation of samples or materials shall be borne by the Contractor. Samples of materials for test verification and acceptance testing by the Government shall be delivered to the locations provided Contracting Officer. Coordination for each specific test, exact delivery location, and dates will be made through the Area Office.

3.8 COMPLETION INSPECTION

3.8.1 Punch-Out Inspection

Near the completion of all work or any increment thereof established by a completion time stated in the Special Clause entitled "Commencement, Prosecution, and Completion of Work," or stated elsewhere in the specifications, the CQC System Manager shall conduct an inspection of the work and develop a punch list of items which do not conform to the approved drawings and specifications. Such a list of deficiencies shall be included in the CQC documentation, as required by paragraph DOCUMENTATION below, and shall include the estimated date by which the deficiencies will be corrected. The CQC System Manager or staff shall make a second inspection to ascertain that all deficiencies have been corrected. Once this is accomplished, the

Contractor shall notify the Government that the facility is ready for the Government Pre-Final inspection.

3.8.2 Pre-Final Inspection

The Government will perform this inspection to verify that the facility is complete and ready to be occupied. A Government Pre-Final Punch List may be developed as a result of this inspection. The Contractor's CQC System Manager shall ensure that all items on this list have been corrected before notifying the Government so that a Final inspection with the customer can be scheduled. Any items noted on the Pre-Final inspection shall be corrected in a timely manner. These inspections and any deficiency corrections required by this paragraph shall be accomplished within the time slated for completion of the entire work or any particular increment thereof if the project is divided into increments by separate completion dates.

3.8.3 Final Acceptance Inspection

The Contractor's Quality Control Inspection personnel, plus the superintendent or other primary management person, and the Contracting Officer's Representative shall be in attendance at this inspection. Additional Government personnel including, but not limited to, those from Public Works, user groups, and major commands may also be in attendance. The final acceptance inspection will be formally scheduled by the Contracting Officer based upon results of the Pre-Final inspection. Notice shall be given to the Contracting Officer at least 14 days prior to the final acceptance inspection and shall include the Contractor's assurance that all specific items previously identified to the Contractor as being unacceptable, along with all remaining work performed under the contract, will be complete and acceptable by the date scheduled for the final acceptance inspection. Failure of the Contractor to have all contract work acceptably complete for this inspection will be cause for the Contracting Officer to bill the Contractor for the Government's additional inspection cost in accordance with the contract clause titled "Inspection of Construction".

3.9 DOCUMENTATION

The Contractor shall maintain current records providing factual evidence that required quality control activities and/or tests have been performed. These records shall include the work of subcontractors and suppliers and shall be on an acceptable form that includes, as a minimum, the following information:

a. Contractor/subcontractor and their area of responsibility.

b. Operating plant/equipment with hours worked, idle, or down for repair.

c. Work performed each day, giving location, description, and by whom. When Network Analysis (NAS) is used, identify each phase of work performed each day by NAS activity number.

d. Test and/or control activities performed with results and references to specifications/drawings requirements. The control phase should be identified (Preparatory, Initial, Follow-up). List deficiencies noted along with corrective action.

e. Quantity of materials received at the site with statement as to acceptability, storage, and reference to specifications/drawings requirements.

f. Submittals reviewed, with contract reference, by whom, and action taken.

g. Off-site surveillance activities, including actions taken.

h. Job safety evaluations stating what was checked, results, and instructions or corrective actions.

i. Instructions given/received and conflicts in plans and/or specifications.

j. Contractor's verification statement.

These records shall indicate a description of trades working on the project; the number of personnel working; weather conditions encountered; and any delays encountered. These records shall cover both conforming and deficient features and shall include a statement that equipment and materials incorporated in the work and workmanship comply with the contract. The original and one copy of these records in report form shall be furnished to the Government daily within 48 hours after the date covered by the report, except that reports need not be submitted for days on which no work is performed. As a minimum, one report shall be prepared and submitted for every 7 days of no work and on the last day of a no work period. All calendar days shall be accounted for throughout the life of the contract. The first report following a day of no work shall be for that day only. Reports shall be signed and dated by the CQC System Manager. The report from the CQC System Manager shall include copies of test reports and copies of reports prepared by all subordinate quality control personnel.

3.10 SAMPLE FORMS

Sample forms enclosed at the end of this section. Sample forms for recording QC operations, activities, and tests performed can be obtained from the Contracting Officer.

3.11 NOTIFICATION OF NONCOMPLIANCE

The Contracting Officer will notify the Contractor of any detected noncompliance with the foregoing requirements. The Contractor shall take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the work site, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, the Contracting Officer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to such stop orders shall be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

SECTION 01500

TEMPORARY CONSTRUCTION FACILITIES

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1 GENERAL REQUIREMENTS

1.1 Site Plan

The Contractor shall prepare a site plan indicating the proposed location and dimensions of any area to be fenced and used by the Contractor, the number of trailers to be used, avenues of ingress/egress to the fenced area and details of the fence installation. Any areas which may have to be graveled to prevent the tracking of mud shall also be identified. The Contractor shall also indicate if the use of a supplemental or other staging area is desired.

1.2 Identification of Employees

The Contractor shall be responsible for furnishing to each employee, and for requiring each employee engaged on the work to display, identification as approved and directed by the Contracting Officer. Prescribed identification shall immediately be delivered to the Contracting Officer for cancellation upon release of any employee. When required, the Contractor shall obtain and provide fingerprints of persons employed on the project. Contractor and subcontractor personnel shall wear identifying markings on hard hats clearly identifying the company for whom the employee works.

1.3 Employee Parking

Contractor employees shall park privately owned vehicles in an area designated by the Contracting Officer's Representative. This area will be within reasonable walking distance of the construction site. Contractor employee parking shall not interfere with existing and established parking requirements of the military installation.

2 AVAILABILITY AND USE OF UTILITY SERVICES

2.1 Utility Services

The Government will make all reasonably required utilities available to the Contractor from existing outlets and supplies, as specified in the contract. Unless otherwise provided in the contract, the amount of each utility service consumed shall not be charged to the Contractor. The Contractor shall carefully conserve any utilities furnished without charge.

2.2 Temporary Connections

The Contractor, at its expense and in a manner satisfactory to the Contracting Officer, shall provide and maintain necessary temporary electrical connections and distribution lines. The Contractor shall notify the Contracting Officer, in writing, 5 working days before final electrical connection is desired. The Contractor shall make the final hot connection after approval and under the supervision of the Government for the temporary installation.

2.3 Sanitation

The Contractor shall provide and maintain within the construction area minimum field-type sanitary facilities approved by the Contracting Officer. Government toilet facilities will not be available to Contractor's personnel.

2.4 Telephone

The Contractor shall make arrangements and pay all costs for telephone facilities desired.

3 PROJECT SIGN, AND PROJECT SAFETY SIGN

The requirements for the signs, their content, and location shall be as shown on the drawings at the end of this section. The signs shall be erected within 15 days after receipt of the notice to proceed. The data required by the safety sign shall be corrected daily, with light colored metallic or non-metallic numerals. Upon completion of the project, the signs shall be removed from the site.

4 PROTECTION AND MAINTENANCE OF TRAFFIC

During construction, the Contractor shall provide access and temporary relocated roads as necessary to maintain traffic. The Contractor shall maintain and protect traffic on all affected roads during the construction period except as otherwise specifically directed by the Contracting Officer. Measures for the protection and diversion of traffic, including the provision of watchmen and flagmen, erection of barricades, placing of lights around and in front of equipment and the work, and the erection and maintenance of adequate warning, danger, and direction signs, shall be as required by the local authorities having jurisdiction. The traveling public shall be protected from damage to person and property. The Contractor's traffic on roads selected for hauling material to and from the site shall interfere as little as possible with public traffic. The Contractor shall investigate the adequacy of existing roads and the allowable load limit on these roads. The Contractor shall be responsible for the repair of any damage to roads caused by construction operations.

4.1 Haul Roads

The Contractor shall, at its own expense, construct access and haul roads necessary for proper prosecution of the work under this contract. Haul roads shall be constructed with suitable grades and widths; sharp curves, blind corners, and dangerous cross traffic shall be avoided. The Contractor shall provide necessary lighting, signs, barricades, and distinctive markings for the safe movement of traffic. The method of dust control, although optional, shall be adequate to ensure safe operation at all times. Location, grade, width, and alignment of construction and hauling roads shall be subject to approval by the Contracting Officer. Lighting shall be adequate to assure full and clear visibility for full width of haul road and work areas during any night work operations. Upon completion of the work, haul roads designated by the Contracting Officer shall be removed.

4.2 Barricades

The Contractor shall erect and maintain temporary barricades to limit public access to hazardous areas. Such barricades shall be required whenever safe public access to paved areas such as roads, parking areas or sidewalks is prevented by construction activities or as otherwise necessary to ensure the safety of both pedestrian and vehicular traffic. Barricades shall be securely placed, clearly visible with adequate illumination to provide sufficient visual warning of the hazard during both day and night.

5 CONTRACTOR'S TEMPORARY FACILITIES

5.1 Administrative Field Offices

The Contractor shall provide and maintain administrative field office facilities within the construction area at the designated site subject to availability of space and COR approval. Government office and warehouse facilities will not be available to the Contractor's personnel.

5.2 Storage Area

The Contractor shall coordinate with the COR in coordination with the DPW for a temporary storage area at the minimum required space. The Contractor shall construct a temporary 1.8 m high chain link fence or solid metal fence around trailers and materials. Chain link fence shall include plastic strip inserts, colored green, so that visibility through the fence is obstructed. Fence posts may be driven, in lieu of concrete bases, where soil conditions permit. Equipment or materials shall not be exposed to public view with the exception of those items which are in support of ongoing work on any given day. Materials shall not be stockpiled outside the fence in preparation for the next day's work. Mobile equipment, such as tractors, wheeled lifting equipment, cranes, trucks, and like equipment, shall be parked within the fenced area at the end of each work day.

5.3 Supplemental Storage Area

Upon Contractor's request, the Contracting Officer’s Representative in coordination with the DPW may designate another or supplemental area for the Contractor's use and storage of trailers, equipment, and materials. This area may not be in close proximity of the construction site but shall be within the military boundaries. Fencing of materials or equipment will not be required at this site; however, the Contractor shall be responsible for cleanliness and orderliness of the area used and for the security of any material or equipment stored in this area. Utilities will not be provided to this area by the Government.

5.4 Appearance of Trailers

Trailers utilized by the Contractor for administrative or material storage purposes shall present a clean and neat exterior appearance and shall be in a state of good repair. Trailers which, in the opinion of the Contracting Officer, require exterior painting or maintenance will not be allowed on the military property.

5.5 Maintenance of Storage Area

Fencing shall be kept in a state of good repair and proper alignment. Should the Contractor elect to traverse, with construction equipment or other vehicles, grassed or unpaved areas which are not established roadways, such areas shall be covered with a layer of gravel as necessary to prevent rutting and the tracking of mud onto paved or established roadways; gravel gradation shall be at the Contractor's discretion. Grass located within the boundaries of the construction site shall be mowed for the duration of the project. Grass and vegetation along fences, buildings, under trailers, and in areas not accessible to mowers shall be edged or trimmed neatly.

5.6 New Building

In the event a new building is constructed for the temporary project field office, it shall be a minimum 3.6 m in width, 5 m in length and have a minimum of 2.1 m headroom. It shall be equipped with approved electrical wiring, at least one duplex convenience outlet and the required switches and fuses to provide 120 volts power. It shall be provided with a work table with stool, desk with chair, two additional chairs, and one legal size file cabinet that can be locked. The building shall be waterproof, shall be supplied with heater, shall have a minimum of two doors, electric lights, a telephone, a battery operated smoke detector alarm, a sufficient number of adjustable windows for adequate light and ventilation, and a supply of approved drinking water. Approved sanitary facilities shall be furnished. The windows and doors shall be screened and the doors provided with dead bolt type locking devices or a padlock and heavy duty hasp bolted to the door. Door hinge pins shall be non-removable. The windows shall be arranged to open and to be securely fastened from the inside. Glass panels in windows shall be protected by bars or heavy mesh screens to prevent easy access to the building through these panels. In warm weather, air conditioning capable of maintaining the office at 50 percent relative humidity and a room temperature 11 degrees C below the outside temperature when the outside temperature is 35 degrees C, shall be furnished. Any new building erected for a temporary field office shall be maintained by the Contractor during the life of the contract and upon completion and acceptance of the work shall become the property of the Contractor and shall be removed from the site. All charges for telephone service for the temporary field office shall be borne by the Contractor, including long distance charges up to a maximum of $75.00 per month.

5.7 Security Provisions

Adequate outside security lighting shall be provided at the Contractor's temporary facilities. The Contractor shall be responsible for the security of its own equipment; in addition, the Contractor shall notify the appropriate law enforcement agency requesting periodic security checks of the temporary project field office.

5.8 PLANT COMMUNICATION

Whenever the Contractor has the individual elements of its plant so located that operation by normal voice between these elements is not satisfactory, the Contractor shall install a satisfactory means of communication, such as telephone or other suitable devices. The devices shall be made available for use by Government personnel.

5.9 TEMPORARY PROJECT SAFETY FENCING

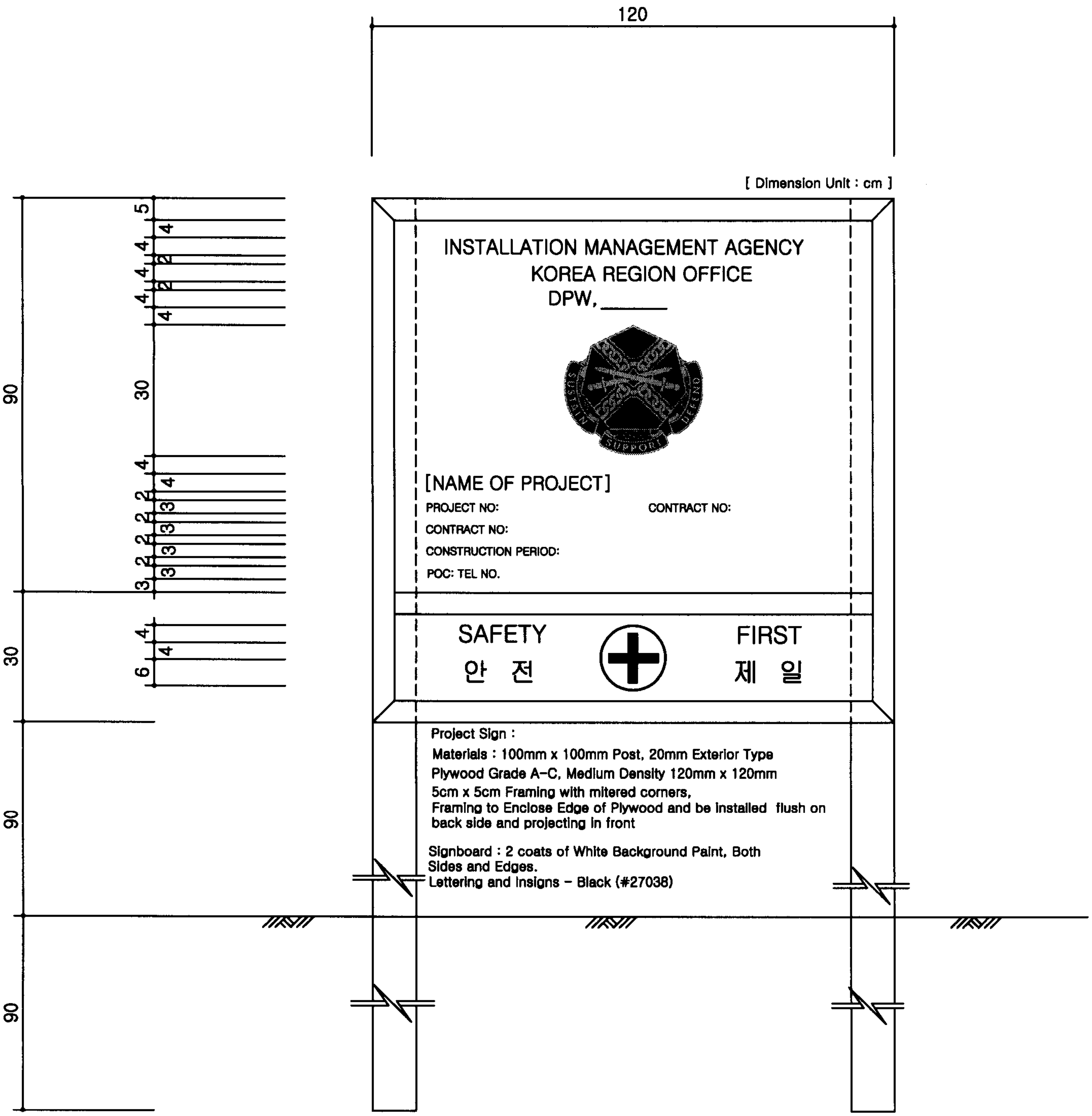
As soon as practicable, but not later than 15 days after the date established for commencement of work, the Contractor shall furnish and erect temporary project safety fencing at the work site. The safety fencing shall be a high visibility orange colored, high density polyethylene grid or approved equal, a minimum of 1.1 m high, supported and tightly secured to steel posts located on maximum 3 m centers, constructed at the approved location. The safety fencing shall be maintained by the Contractor during the life of the contract and, upon completion and acceptance of the work, shall become the property of the Contractor and shall be removed from the work site.

5.10 CLEANUP

Construction debris, waste materials, packaging material and the like shall be removed from the work site daily. Any dirt or mud which is tracked onto paved or surfaced roadways shall be cleaned away. Materials resulting from demolition activities which are salvageable shall be stored within the fenced area described above or at the supplemental storage area. Stored material not in trailers, whether new or salvaged, shall be neatly stacked when stored.

5.11 RESTORATION OF STORAGE AREA

Upon completion of the project and after removal of trailers, materials, and equipment from within the fenced area, the fence shall be removed and will become the property of the Contractor. Areas used by the Contractor for the storage of equipment or material, or other use, shall be restored to the original or better condition. Gravel used to traverse grassed areas shall be removed and the area restored to its original condition, including top soil and seeding as necessary.


120
[Dimension Unit : cm]
INSTALLATION MANAGEMENT AGENCY
KOREA REGION OFFICE
DPW, ______
[NAME OF PROJECT]
PROJECT NO:
CONTRACT NO:
CONTRACT NO:
CONSTRUCTION PERIOD:
POC: TEL NO.
SAFETY
FIRST
안 전
제 일
Project Sign :
Materials : 100mm x 100mm Post, 20mm Exterior Type
Plywood Grade A-C, Medium Density 120mm x 120mm
5cm x 5cm Framing with mitered corners,
Framing to Enclose Edge of Plywood and be installed flush on back side and projecting in front
Signboard : 2 coats of White Background Paint, Both Sides and Edges.
Lettering and Insigns - Black (#27038)
90
30
90
90

SECTION 01780

CLOSEOUT SUBMITTALS

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PART 1 GENERAL

1.1 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

As-Built Drawings; G

Drawings showing final as-built conditions of the project. The final CADD as-built drawings shall consist of one set of electronic CADD drawing files in the specified format, one set of mylar drawings, 2 sets of blue-line prints of the mylars, and one set of the approved working as-built drawings. The manually prepared drawings shall consist of 1 set of completed final as-built original transparency drawings, 2 sets of blue-line prints of the transparencies, and the approved marked working as-built prints.

SD-03 Product Data

As-Built Record of Equipment and Materials; G

Two copies of the record listing the as-built materials and equipment incorporated into the construction of the project.

Warranty Management Plan; G

One set of the warranty management plan containing information relevant to the warranty of materials and equipment incorporated into the construction project, including the starting date of warranty of construction. The Contractor shall furnish with each warranty the name, address, and telephone number of each of the guarantor's representatives nearest to the project location.

Warranty Tags; G

Two record copies of the warranty tags showing the layout and design.

Final Cleaning; G

Two copies of the listing of completed final clean-up items.

1.2 PROJECT RECORD DOCUMENTS

1.2.1 As-Built Drawings

This paragraph covers as-built drawings complete, as a requirement of the contract. The terms "drawings," "contract drawings," "drawing files," "working as-built drawings" and "final as-built drawings" refer to contract drawings which are revised to be used for final as-built drawings.

1.2.1.1 Government Furnished Materials

One set of mylar drawings revised to reflect all bid amendments will be provided by the Government at the preconstruction conference for projects requiring manually prepared as-built drawings. An electronic CADD file in the specified software and format revised to reflect all bid amendments will be provided by the Government at the preconstruction conference for projects requiring CADD file as-built drawings.

1.2.1.2 Working As-Built and Final As-Built Drawings

The Contractor shall revise 2 sets of paper drawings by red-line process to show the as-built conditions during the prosecution of the project. These working as-built marked drawings shall be kept current on a weekly basis and at least one set shall be available on the jobsite at all times. Changes from the contract plans which are made in the work or additional information which might be uncovered in the course of construction shall be accurately and neatly recorded as they occur by means of details and notes. Final as-built drawings shall be prepared after the completion of each definable feature of work as listed in the Contractor Quality Control Plan (Foundations, Utilities, Structural Steel, etc., as appropriate for the project). The working as-built marked prints and final as-built drawings will be jointly reviewed for accuracy and completeness by the COR and the Contractor prior to submission of each monthly pay estimate. If the Contractor fails to maintain the working and final as-built drawings as specified herein, the COR will deduct from the monthly progress payment an amount representing the estimated cost of maintaining the as-built drawings. This monthly deduction will continue until an agreement can be reached between the COR and the Contractor regarding the accuracy and completeness of updated drawings. The working and final as-built drawings shall show, but shall not be limited to, the following information:

a. The actual location, kinds and sizes of all sub-surface utility lines. In order that the location of these lines and appurtenances may be determined in the event the surface openings or indicators become covered over or obscured, the as-built drawings shall show, by offset dimensions to two permanently fixed surface features, the end of each run including each change in direction. Valves, splice boxes and similar appurtenances shall be located by dimensioning along the utility run from a reference point. The average depth below the surface of each run shall also be recorded.

b. The location and dimensions of any changes within the building structure.

c. Correct grade, elevations, cross section, or alignment of roads, earthwork, structures or utilities if any changes were made from contract plans.

d. Changes in details of design or additional information obtained from working drawings specified to be prepared and/or furnished by the Contractor; including but not limited to fabrication, erection, installation plans and placing details, pipe sizes, insulation material, dimensions of equipment foundations, etc.

e. The topography, invert elevations and grades of drainage installed or affected as part of the project construction.

f. Changes or modifications which result from the final inspection.

g. Where contract drawings or specifications present options, only the option selected for construction shall be shown on the final as-built prints.

h. If borrow material for this project is from sources on Government property, or if Government property is used as a spoil area, the Contractor shall furnish a contour map of the final borrow pit/spoil area elevations.

i. Systems designed or enhanced by the Contractor, such as HVAC controls, fire alarm, fire sprinkler, and irrigation systems.

j. Modifications (change order price shall include the Contractor's cost to change working and final as-built drawings to reflect modifications) and compliance with the following procedures.

(1) Directions in the modification for posting descriptive changes shall be followed.

(2) A Modification Circle shall be placed at the location of each deletion.

(3) For new details or sections which are added to a drawing, a Modification Circle shall be placed by the detail or section title.

(4) For minor changes, a Modification Circle shall be placed by the area changed on the drawing (each location).

(5) For major changes to a drawing, a Modification Circle shall be placed by the title of the affected plan, section, or detail at each location.

(6) For changes to schedules or drawings, a Modification Circle shall be placed either by the schedule heading or by the change in the schedule.

(7) The Modification Circle size shall be 12.7 mm diameter unless the area where the circle is to be placed is crowded. Smaller size circle shall be used for crowded areas.

1.2.1.3 Drawing Preparation

The as-built drawings shall be modified as may be necessary to correctly show the features of the project as it has been constructed by bringing the contract set into agreement with approved working as-built prints, and adding such additional drawings as may be necessary. These working as-built marked prints shall be neat, legible and accurate. These drawings are part of the permanent records of this project and shall be returned to the COR after approval by the Government. Any drawings damaged or lost by the Contractor shall be satisfactorily replaced by the Contractor at no expense to the Government.

1.2.1.4 Computer Aided Design and Drafting (CADD) Drawings

Only personnel proficient in the preparation of CADD drawings shall be employed to modify the contract drawings or prepare additional new drawings. Additions and corrections to the contract drawings shall be equal in quality and detail to that of the originals. Line colors, line weights, lettering, layering conventions, and symbols shall be the same as the original line colors, line weights, lettering, layering conventions, and symbols. If additional drawings are required, they shall be prepared using the specified electronic file format applying the same graphic standards specified for original drawings. The title block and drawing border to be used for any new final as-built drawings shall be identical to that used on the contract drawings. Additions and corrections to the contract drawings shall be accomplished using CADD files. The Contractor will be furnished "as-designed" drawings in Microstation format compatible with a Windows NT operating system. The electronic files will be supplied on compact disc, read-only memory (CD-ROM). The Contractor shall be responsible for providing all program files and hardware necessary to prepare final as-built drawings. The COR will review final as-built drawings for accuracy and the Contractor shall make required corrections, changes, additions, and deletions.

a. CADD colors shall be the "base" colors of red, green, and blue. Color code for changes shall be as follows:

(1) Deletions (red) - Deleted graphic items (lines) shall be colored red with red lettering in notes and leaders.

(2) Additions (Green) - Added items shall be drawn in green with green lettering in notes and leaders.

(3) Special (Blue) - Items requiring special information, coordination, or special detailing or detailing notes shall be in blue.

b. The Contract Drawing files shall be renamed in a manner related to the contract number (i.e., 03-C-0001.DGN) as instructed in the Pre-Construction conference. Marked-up changes shall be made only to those renamed files. All changes shall be made on the layer/level as the original item. There shall be no deletions of existing lines; existing lines shall be over struck in red. Additions shall be in green with line weights the same as the drawing. Special notes shall be in blue on layer #63.

c. When final revisions have been completed, the cover sheet drawing shall show the wording "RECORD DRAWING AS-BUILT" followed by the name of the Contractor in letters at least 5 mm high. All other contract drawings shall be marked either "AS-Built" drawing denoting no revisions on the sheet or

"Revised As-Built" denoting one or more revisions. Original contract drawings shall be dated in the revision block.

d. The submittal shall consist of one set of electronic files on compact disc, read-only memory (CD-ROM)], one set of mylars, two sets of blue-line prints and one set of the approved working as-built drawings. They shall be complete in all details and identical in form and function to the contract drawing files supplied by the Government. Any transactions or adjustments necessary to accomplish this is the responsibility of the Contractor. The Government reserves the right to reject any drawing files it deems incompatible with the customer's CADD system. Paper prints, drawing files and storage media submitted will become the property of the Government upon final approval. Failure to submit final as-built drawing files and marked prints as specified shall be cause for withholding any payment due the Contractor under this contract. Approval and acceptance of final as-built drawings shall be accomplished before final payment is made to the Contractor.

1.2.1.5 Manually Prepared Drawings

Only personnel proficient in the preparation of manually prepared drawings shall be employed to modify the original contract drawing or prepare additional new drawings. Additions and corrections to the contract drawings shall be neat, clean and legible, shall be done to the same level of detail, and shall match the adjacent existing line work, and lettering being annotated in type, density, size and style. Drafting work shall be done using the same medium (pencil, plastic lead or ink) that was employed on the original contract drawings and with graphite lead on paper base material. The COR will review as-built drawings for accuracy and conformance to the above specified drafting standards. Corrections, changes, additions, and deletions required shall meet these standards. The title block to be used for any new as-built drawings shall be similar to that used on the original drawings.

a. When final revisions have been completed, each drawing shall be lettered or stamped with the words "RECORD DRAWING AS-BUILT" followed by the name of the Contractor in letters at least 5 mm high. Original contract drawings shall be marked either "As-Built" drawings denoting no revisions on the sheet or "Revised As-Built" denoting one or more revisions All original contract drawings shall be dated in the revision block.

b. The submittal shall consist of the completed final as-built drawings, two blue-line prints of these drawings and the return of the approved marked as-built prints. The drawings shall be complete in all details. Paper prints and reproducible drawings will become the property of the Government upon final approval. Failure to submit final as-built drawings and marked prints, as required herein, will be cause for withholding any payment due the Contractor under this contract. Approval and acceptance of final as-built drawings shall be accomplished before final payment is made to the Contractor.

1.2.1.6 Payment

No separate payment will be made for as-built drawings required under this contract, and all costs accrued in connection with such drawings shall be considered a subsidiary obligation of the Contractor.

1.2.2 As-Built Record of Equipment and Materials

The Contractor shall furnish one copy of preliminary record of equipment and materials used on the project 15 days prior to final inspection. This preliminary submittal will be reviewed and returned 2 days after final inspection with Government comments. Two sets of final record of equipment and materials shall be submitted 10 days after final inspection. The designations shall be keyed to the related area depicted on the contract drawings. The record shall list the following data:

RECORD OF DESIGNATED EQUIPMENT AND MATERIALS DATA

Description	Specification Section	Manufacturer and Catalog, Model, and Serial Number	Composition and Size	Where Used

1.2.3 Final Approved Shop Drawings

The Contractor shall furnish final approved project shop drawings 30 days after transfer of the completed facility.

1.2.4 Construction Contract Specifications

The Contractor shall furnish final as-built construction contract specifications, including modifications thereto, 30 days after transfer of the completed facility.

1.2.5 Real Property Equipment

The Contractor shall furnish a list of installed equipment furnished under this contract. The list shall include all information usually listed on manufacturer's name plate. The "EQUIPMENT-IN-PLACE LIST" shall include, as applicable, the following for each piece of equipment installed: description of item, location (by room number), model number, serial number, capacity, name and address of manufacturer, name and address of equipment supplier, condition, spare parts list, manufacturer's catalog, and warranty. A draft list shall be furnished at time of transfer. The final list shall be furnished 30 days after transfer of the completed facility.

1.3 WARRANTY MANAGEMENT

1.3.1 Warranty Management Plan

The Contractor shall develop a warranty management plan which shall contain information relevant to the clause Warranty of Construction. At least 30 days before the planned pre-warranty conference, the Contractor shall submit the warranty management plan for Government approval. The warranty management plan shall include all required actions and documents to assure that the Government receives all warranties to which it is entitled. The plan shall be in narrative form and contain sufficient detail to render it suitable for use by future maintenance and repair personnel, whether tradesmen, or of engineering background, not necessarily familiar with this contract. The term "status" as indicated below shall include due date and whether item has been submitted or was accomplished. Warranty information made available during the construction phase shall be submitted to the COR for approval prior to each monthly pay estimate. Approved information shall be assembled in a binder and shall be turned over to the Government upon acceptance of the work. The construction warranty period shall begin on the date of project acceptance and shall continue for the full product warranty period. A joint 4 month and 9 month warranty inspection shall be conducted, measured from time of acceptance, by the Contractor, COR and the Customer Representative. Information contained in the warranty management plan shall include, but shall not be limited to, the following:

a. Roles and responsibilities of all personnel associated with the warranty process, including points of contact and telephone numbers within the organizations of the Contractors, subcontractors, manufacturers or suppliers involved.

b. Listing and status of delivery of all Certificates of Warranty for extended warranty items, to include roofs, HVAC balancing, pumps, motors, transformers, and for all commissioned systems such as fire protection and alarm systems, sprinkler systems, lightning protection systems, etc.

c. A list for each warranted equipment, item, feature of construction or system indicating:

1. Name of item.

2. Model and serial numbers.

3. Location where installed.

4. Name and phone numbers of manufacturers or suppliers.

5. Names, addresses and telephone numbers of sources of spare parts.

6. Warranties and terms of warranty. This shall include one-year overall warranty of construction. Items which have extended warranties shall be indicated with separate warranty expiration dates.

7. Cross-reference to warranty certificates as applicable.

8. Starting point and duration of warranty period.

9. Summary of maintenance procedures required to continue the warranty in force.

10. Cross-reference to specific pertinent Operation and Maintenance manuals.

11. Organization, names and phone numbers of persons to call for warranty service.

12. Typical response time and repair time expected for various warranted equipment.

d. The Contractor's plans for attendance at the 4 and 9 month post-construction warranty inspections conducted by the Government.

e. Procedure and status of tagging of all equipment covered by extended warranties.

f. Copies of instructions to be posted near selected pieces of equipment where operation is critical for warranty and/or safety reasons.

1.3.2 Performance Bond

The Contractor's Performance Bond shall remain effective throughout the construction period.

a. In the event the Contractor fails to commence and diligently pursue any construction warranty work required, the Contracting Officer will have the work performed by others, and after completion of the work, will charge the remaining construction warranty funds of expenses incurred by the Government while performing the work, including, but not limited to administrative expenses.

b. In the event sufficient funds are not available to cover the construction warranty work performed by the Government at the Contractor's expense, the Contracting Officer will have the right to recoup expenses from the bonding company.

c. Following oral or written notification of required construction warranty repair work, the Contractor shall respond in a timely manner. Written verification will follow oral instructions. Failure of the Contractor to respond will be cause for the Contracting Officer to proceed against the Contractor.

1.3.3 Pre-Warranty Conference

Prior to contract completion, and at a time designated by the Contracting Officer’ Representative (COR), the Contractor shall meet with the COR to develop a mutual understanding with respect to the requirements of this section. Communication procedures for Contractor notification of construction warranty defects, priorities with respect to the type of defect, reasonable time required for Contractor response, and other details deemed necessary by the COR for the execution of the construction warranty shall be established/reviewed at this meeting. In connection with these requirements and at the time of the Contractor's quality control completion inspection, the Contractor shall furnish the name, telephone number and address of a licensed and bonded company which is authorized to initiate and pursue construction warranty work action on behalf of the Contractor. This point of contact will be located within the local service area of the warranted construction, shall be continuously available, and shall be responsive to Government inquiry on warranty work action and status. This requirement does not relieve the Contractor of any of its responsibilities in connection with other portions of this provision.

1.3.4 Contractor's Response to Construction Warranty Service Requirements

Following oral or written notification by the Contracting Officer or COR, the Contractor shall respond to construction warranty service requirements in accordance with the "Construction Warranty Service Priority List" and the three categories of priorities listed below. The Contractor shall submit a report on any warranty item that has been repaired during the warranty period. The report shall include the cause of the problem, date reported, corrective action taken, and when the repair was completed. If the Contractor does not perform the construction warranty within the timeframes specified, the Government will perform the work and backcharge the construction warranty payment item established.

a. First Priority Code 1. Perform onsite inspection to evaluate situation, and determine course of action within 4 hours, initiate work within 6 hours and work continuously to completion or relief.

b. Second Priority Code 2. Perform onsite inspection to evaluate situation, and determine course of action within 8 hours, initiate work within 24 hours and work continuously to completion or relief.

c. Third Priority Code 3. All other work to be initiated within 3 work days and work continuously to completion or relief.

d. The "Construction Warranty Service Priority List" is as follows:

Code 1-Air Conditioning Systems

(1) Recreational support.
(2) Air conditioning leak in part of building, if causing damage.
(3) Air conditioning system not cooling properly.

Code 1-Doors

(1) Overhead doors not operational, causing a security, fire, or safety problem.
(2) Interior, exterior personnel doors or hardware, not functioning properly, causing a security, fire, or safety problem.

Code 3-Doors

(1) Overhead doors not operational.
(2) Interior/exterior personnel doors or hardware not functioning properly.

Code 1-Electrical

(1) Power failure (entire area or any building operational after 1600 hours).
(2) Security lights
(3) Smoke detectors

Code 2-Electrical

(1) Power failure (no power to a room or part of building).
(2) Receptacle and lights (in a room or part of building).

Code 3-Electrical

Street lights.

Code 1-Gas

(1) Leaks and breaks.
(2) No gas to family housing unit or cantonment area.

Code 1-Heat

(1). Area power failure affecting heat.
(2). Heater in unit not working.

Code 2-Kitchen Equipment

(1) Dishwasher not operating properly.
(2) All other equipment hampering preparation of a meal.

Code 1-Plumbing

(1) Hot water heater failure.
(2) Leaking water supply pipes.

Code 2-Plumbing

(1) Flush valves not operating properly.
(2) Fixture drain, supply line to commode, or any water pipe leaking.
(3) Commode leaking at base.

Code 3 -Plumbing

Leaky faucets.

Code 3-Interior

(1) Floors damaged.
(2) Paint chipping or peeling.
(3) Casework.

Code 1-Roof Leaks

Temporary repairs will be made where major damage to property is occurring.

Code 2-Roof Leaks

Where major damage to property is not occurring, check for location of leak during rain and complete repairs on a Code 2 basis.

Code 2-Water (Exterior)

No water to facility.

Code 2-Water (Hot)

No hot water in portion of building listed.

Code 3-All other work not listed above.

1.3.5 Warranty Tags

At the time of installation, each warranted item shall be tagged with a durable, oil and water resistant tag approved by the COR. Each tag shall be attached with a copper wire and shall be sprayed with a silicone waterproof coating. The date of acceptance and the QC signature shall remain blank until project is accepted for beneficial occupancy. The tag shall show the following information.

a. Type of product/material _____________________________________.

b. Model number ____.

c. Serial number ____.

d. Contract number ____.

e. Warranty period ___________from ___________to __________________.

f. Inspector's signature _______________________________________.

g. Construction Contractor _____________________________________.

Address ____.

Telephone number ____.

h. Warranty contact ____.

Address ____.

Telephone number ____.

i. Warranty response time priority code _________________________.

j. WARNING - PROJECT PERSONNEL TO PERFORM ONLY OPERATIONAL MAINTENANCE DURING THE WARRANTY PERIOD.

1.4 MECHANICAL TESTING, ADJUSTING, BALANCING, AND COMMISSIONING

Prior to final inspection and transfer of the completed facility; all reports, statements, certificates, and completed checklists for testing, adjusting, balancing, and commissioning of mechanical systems shall be submitted to and approved by the COR as specified in applicable technical specification sections.

1.5 OPERATION AND MAINTENANCE MANUALS

Operation and maintenance manuals shall be submitted as specified. Operation and maintenance manuals provided in a common volume shall be clearly differentiated and shall be separately indexed.

1.6 FINAL CLEANING

The premises shall be left broom clean. Stains, foreign substances, and temporary labels shall be removed from surfaces. Carpet and soft surfaces shall be vacuumed. Equipment and fixtures shall be cleaned to a sanitary condition. Filters of operating equipment shall be replaced. Debris shall be removed from roofs, drainage systems, gutters, and downspouts. Paved areas shall be swept and landscaped areas shall be raked clean. The site shall have waste, surplus materials, and rubbish removed. The project area shall have temporary structures, barricades, project signs, and construction facilities removed. A list of completed clean-up items shall be submitted on the day of final inspection.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

DIVISION 02 SITE CONSTRUCTION

SECTION 02050

DEMOLITION

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ENGINEERING MANUALS (EM)

EM 385-1-1 (1996) U.S. Army Corps of Engineers Safety and Health Requirements Manual

1.2 GENERAL REQUIREMENTS

The work includes demolition, salvage of identified items and materials, and removal of resulting rubbish and debris. Rubbish and debris shall be removed from Government property daily, unless otherwise directed, to avoid accumulation at the demolition site. Materials that cannot be removed daily shall be stored in areas specified by the Contracting Officer. In the interest of occupational safety and health, the work shall be performed in accordance with EM 385-1-1, Section 23, Demolition, and other applicable Sections. In the interest of conservation, salvage shall be pursued to the maximum extent possible; salvaged items and materials shall be disposed of as specified.

1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES.

SD-18 Records

Work Plan; GA.

The procedures proposed for the accomplishment of the work. The procedures shall provide for safe conduct of the work, careful removal and disposition of materials specified to be salvaged, protection of property which is to remain undisturbed, coordination with other work in progress, and timely disconnection of utility services. The procedures shall include a detailed description of the methods and equipment to be used for each operation, and the sequence of operations in accordance with EM 385-1-1.

1.4 DUST CONTROL

The amount of dust resulting from demolition shall be controlled to prevent the spread of dust to occupied portions of the construction site and to avoid creation of a nuisance in the surrounding area. Use of water will not be permitted when it will result in, or create, hazardous or objectionable conditions such as ice, flooding and pollution.

1.5 PROTECTION

1.5.1 Protection of Personnel

During the demolition work the Contractor shall continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the demolition site. No area, section, or component of floors, roofs, walls, columns, pilasters, or other structural element will be allowed to be left standing without sufficient bracing, shoring, or lateral support to prevent collapse or failure while workmen remove debris or perform other work in the immediate area.

Floors, roofs, walls, columns, pilasters, and other structural components that are designed and constructed to stand without lateral support or shoring, and are determined to be in stable condition, may be allowed to remain standing without additional bracing, shoring, of lateral support until demolished. The Contractor shall ensure that no elements determined to be unstable are left unsupported and shall be responsible for placing and securing bracing, shoring, or lateral supports as may be required as a result of any cutting, removal, or demolition work performed under this contract.

Protection of Existing Property

Before beginning any demolition work, the Contractor shall survey the site and examine the drawings and specifications to determine the extent of the work. The Contractor shall take necessary precautions to avoid damage to existing items to remain in place, to be reused, or to remain the property of the Government; any damaged items shall be repaired or replaced as approved by the Contracting Officer. The Contractor shall coordinate the work of this section with all other work and shall construct and maintain shoring, bracing, and supports as required. The Contractor shall ensure that structural elements are not overloaded and shall be responsible for increasing structural supports or adding new supports as may be required as a result of any cutting, removal, or demolition work performed under this contract.

Protection From the Weather

The interior of buildings to remain and salvageable materials and equipment shall be protected from the weather at all times.

1.5.4 Protection of Trees

Trees within the project site which might be damaged during demolition and which are indicated to be left in place shall be protected by a 1.83 m (6 foot) high fence. The fence shall be securely erected a minimum of 1.5 m (5 feet) from the trunk of individual trees or follow the outer perimeter of branches or clumps of trees. Any tree designated to remain that is damaged during the work under this contract shall be replaced in kind or as approved by the Contracting Officer.

1.5.5 Environmental Protection

The work shall comply with the requirements of Section 02051, ASBESTOS REMOVAL and the requirements of OSHA.

1.5.6 Oil Contaminated Soil

The work shall comply with the requirement of section 02071, Underground Fuel Oil Storage Tank Removal and section 01351, Safety, Health and Emergency Response (HTRW/UST).

1.6 BURNING

The use of burning at the project site for the disposal of refuse and debris will not be permitted.

1.7 USE OF EXPLOSIVES

Use of explosives will not be permitted.

AVAILABILITY OF WORK AREAS

Areas in which the work is to be accomplished will be scheduled by the contracting officer.

PART 2 PRODUCTS

Not Applicable

PART 3 EXECUTION

3.1 EXISTING STRUCTURES

Existing structures indicated shall be removed to the depth indicated on the drawings and as directed by the Contracting Officer. Basement slabs shall be broken up to permit drainage. Sidewalks, curbs, gutters and street light bases shall be removed as indicated on the drawings and as directed by the Contracting Officer.

3.2 UTILITIES

Disconnection of utility services, with related meters and equipment, are specified in Section 02660 AND DIVISION 16 ELECTRICAL. Existing utilities shall be removed as indicated. When utility lines are encountered that are not indicated on the drawings, the Contracting Officer shall be notified prior to further work in that area.

3.3 FILLING

Holes, open basements and other hazardous openings shall be filled in accordance with Section 02210.

3.4 DISPOSITION OF MATERIAL

Title to material and equipment to be demolished, except Government salvage and historical items, is vested in the Contractor upon receipt of notice to proceed. The Government will not be responsible for the condition, loss or damage to such property after notice to proceed.

3.4.1 Title to materials

Title to all fixtures (installed property) and equipment to be removed during construction shall remain with the U. S. Government.

3.4.2 Designation of Government Salvage, Unsalvageable Property or Rubble

All fixtures and equipment desired by the Government for salvage shall be designated as "Government Salvage". All remaining materials and equipment not designated as salvage are "Unsalvageable Material" or "Rubble". Designation will be made by Contracting Officer after consultation with DPW.

3.4.3 Joint Inventory

The Contractor upon receipt of NTP is required to contact Contracting Officer to have a joint inventory with DPW.

3.4.4 Disposition of Government Salvage

Government salvage will be removed, disassembled, collected, stored and transported with sufficient care to prevent loss or damage. The Contractor shall maintain an inventory of all items specifically designated as Government Salvage. Items damaged during removal or storage shall be repaired or replaced to match existing.

3.4.5 Historical Items

Historical items shall be removed in a manner to prevent damage. The following historical items shall be delivered to the Government for disposition: Corner stones, contents of corner stones, and document boxes wherever located on the site.

3.4.6 TURN-IN Item

Items Designated for TURN-IN to the DPW will be placed at the designated location within 10 days of complete removal from the existing facility. All fixtures turned-in will be inventoried and received by DPW as designated in this contract.

3.4.7 Disposition of Unsalvageable Material

The Contractor shall remove all unsalvageable property from the contract work area. The unsalvageable materials removed from the work shall be disposed of by the Contractor outside limits of the Government property (Military Installation) at the Contractor’s responsibility and expense.

3.4.8 Disposition of Rubble

Rubble shall be removed from the installation unless otherwise directed. Contractor vehicles must be inspected and provided with a duly authorized USFK Form 211 prior to departing the installation.

3.5 CLEAN UP

3.5.1 Debris and Rubbish

Debris and rubbish shall be removed from basement and similar excavations.

3.5.2 Debris Control

Debris shall be removed and transported in a manner that prevents spillage on streets or adjacent areas.

3.5.3 Regulations

Local regulations regarding hauling and disposal shall apply.

3.6 PAVEMENTS

Existing pavements designated for removal shall be saw cut and removed in accordance with the details shown on the drawings and the limits and depths indicated on the drawings.

3.7 CONTRACTOR QUALITY CONTROL

The Contractor shall establish and maintain a quality control procedure to assure compliance of the demolition and removal work with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced of corrected in an approved manner. Quality control shall include, but not be limited to, the following:

a. Procedures: Safety Measures, protection of property, environmental protection, coordination of work, disconnection of utility services, and dust control.

b. Salvaging: Removal and preparation of materials for storage.

c. Demolition: Extent of demolition and disposition of materials.

3.7.1 Contractor’s Quality Control (CQC) Procedure

The CQC procedure for demolition and removal work shall be submitted to the Contracting Officer for approval to the start of demolition and removal work.

SECTION 02051

ASBESTOS REMOVAL

TABLE OF CONTENTS

PART 1 GENERAL

1.1 WARNINGS

1.1.1 THE CONTRACTOR IS WARNED THAT EXPOSURE TO AIRBORNE ASBESTOS FIBERS HAS BEEN ASSOCIATED WITH FOUR DISEASES: LUNG CANCER, CERTAIN GASTROINTESTINAL CANCERS, PLEURAL OR PERITONEAL MESOTHELIOMA, AND ASBESTOSIS. Studies indicate that there are significantly increased health hazards to persons exposed to asbestos fibers who smoke and to family members and other persons who become indirectly exposed as a result of a contaminated worker bringing asbestos-laden work clothing home to be laundered.

1.1.2 The Contractor is advised that friable and/or nonfriable asbestos containing material has been identified in the area(s) where work is to be performed. Care must be taken to avoid releasing, or causing to be released, asbestos fibers into the atmosphere where they may be inhaled or ingested. Uncontrolled abrading, sanding, drilling, cutting, machining, removal, renovation, demolition or similar activities may result in the release of asbestos fibers in excess of permissible exposure limits.

1.1.3 When the contract work activities are carried out in locations where the potential exists for exposure to airborne asbestos fibers as described in 1.1.2, or where asbestos waste will be generated, the Contractor shall assure that all measures necessary to provide effective protection to persons from exposure to asbestos fibers and prevention of contamination to property, materials, supplies, equipment, and the internal and external environment are effectively instituted.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

CODE of FEDERAL REGULATIONS (CFR)

29 CFR 1910.20	Access to Employee Exposure and Medical Records
1910.134	Respiratory Protection
1910.145	Specifications for Accident Prevention Signs & Tags
1926.58	Asbestos, Tremolite, Anthophylite, & Actinolite

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z88.2	(1992) Practices for Respiratory Protection

U.S. ENVIROMENTAL PROTECTION AGENCY (EPA)

EPA 560	Guidance for Controlling Asbestos Containing Materials
5-85-024	in Buildings

U.S. ARMY CORPS of ENGINEERS

EM 385-1-1	U.S. Army Corps of Engineers Safety and Health as Revised Requirements Manual

COMMERCIAL PUBLICATIONS

Asbestos Abatement Worker's Training Manual

Controlling Asbestos Contamination With Negative Air Filtration Systems

Asbestos Removal And Control: An Insider's Guide To The Business

ROK ENVIROMENTAL PROTECTION AGENCY (EPA)

ROK Environmental Protection Law 3505

1.3 DEFINITIONS

1.3.1 Amended water is water containing a wetting agent or surfactant.

1.3.2 Action level is an airborne concentration of 0.1 asbestos fibers per cubic centimeter (f/cc) of air calculated as an eight (8) hour time-weighted average (TWA).

1.3.3 Aggressive Sampling

Aggressive sampling is a term applied to the procedure of intentionally trying to suspend the maximum number of asbestos fibers in the air in order to determine if an area is "clean". The procedure involves using forced air equipment such as a l hp leaf blower against all the walls, ceilings, floors, ledges and other surfaces in a recently cleaned area and then placing 20" fans (1 per 10k cf) around the area pointing towards the ceiling while running at slow speed prior to starting the sampling pumps. Airborne sampling pumps, usually high volume, are strategically placed around the area and samples taken to determine if the area is safe for re-occupation. THIS METHOD IS EMPLOYED ONLY AFTER AN AREA HAS BEEN THOROUGHLY CLEANED. ALL EMPLOYEES ENTERING THE AREA MUST BE WEARING THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.

1.3.4 Air Lock

Air lock is a dead air space created by fastening two 0.1016 mm (4-mil) polyethylene plastic sheets opposite one another in a doorway or opening. Together they form a double flap or barrier.

1.3.5 Air Monitoring

Air monitoring is the method used to determine the quantity of airborne asbestos fibers in the air.

1.3.5.1 Area (Environmental) Air Monitoring

Area (Environmental) air monitoring is a method used for determining the number of asbestos fibers suspended in the air in a general area inside or outside the asbestos control area. Area or environmental air monitoring samples are taken at locations specified in the air monitoring strategy plan. These areas include general work area, areas immediately adjacent to the work area, at the exhaust duct outlet for the negative air filtration system, and in the clean or change room.

1.3.5.2 Ambient Air Monitoring

Ambient air monitoring is the method used for determining the existing ambient levels of asbestos in a work area or the area immediately surrounding the work area prior to the start of work. In some cases, it may be used as the acceptable clean-up level criteria.

1.3.5.3 Final or Clean-Up Air Monitoring

Final or clean-up air monitoring is the method used for determining if an area where asbestos work has been completed is "clean". The definition of "clean" is - the area must contain less than 0.01 f/cc or less than the ambient levels sampled prior to the start of work. The aggressive sampling technique is employed to perform this form of sampling.

1.3.5.4 Initial Air Monitoring

Initial air monitoring is the method used for determining the level of asbestos fibers being generated by the work when the work first begins. If initial monitoring indicates that the exposure levels are below the PEL then periodic monitoring is not required. Initial air monitoring may also be used to determine the level of respiratory protection required.

1.3.5.5 Periodic Air Monitoring

Periodic air monitoring is the method used on a daily basis to determine the representative exposure of each employee who is assigned to work within regulated areas. Periodic air monitoring can include both environmental and personal air monitoring.

1.3.5.6   Personal Air Monitoring

Personal air monitoring is a method used for determining the number of asbestos fibers suspended in the air in a worker’s breathing zone (BZ).

1.3.6   Air Monitoring Plan

Air monitoring plan is a plan developed by a Certified Industrial Hygienist to include a list of the equipment to be used, pump calibration procedures and records, date and method of last calibration, name of the person performing the calibration, pump numbers, sampling strategies (locations, sampling rates and numbers of samples to be taken) and the name(s) of the qualified person(s) taking the samples. The plan shall also include a description of how the samples will be shipped to an accredited laboratory, the name, address and qualifications of the laboratory performing the sample analysis, the analysis method employed and an explanation of how the contractor intends to maintain the chain of custody.

1.3.7   Asbestos

Asbestos is the general term used to describe a group of fibrous mineral forms including chrysotile, emosite, crocidolite, tremolite, anthophyllite, actiolite and any of these minerals that have been chemically treated and/or altered.

1.3.8   Asbestos Abatement Plan

Asbestos abatement plan is a detailed plan of the work procedures and materials to be used in the removal and/or demolition of asbestos containing materials (ACM). The plan shall be prepared and signed by a Certified Industrial Hygienist. The plan shall specify the locations, types (enclosed or non-enclosed) and boundaries of asbestos control areas, layout and sketches of the decontamination facilities and asbestos control areas, decontamination protocol, type of wetting agent, emergency evacuation and first aid treatment procedures, fire protection/prevention plan, air monitoring plan, credentials of the laboratory analyzing the air samples, respiratory protection program, personal protective clothing to be used, employee indoctrination and training plan, medical surveillance program and employee medical examination records, negative-air filtration system plan, qualifications of the competent person, sequencing of asbestos related work, and method for securing the area. This plan must be submitted to the Contracting Officer for review and acceptance at least 15 days after receipt of the notice to proceed. The contractor and industrial hygienist shall meet with the Contracting Officer to discuss the details of the plan and other safety procedures prior to start of work. Work shall not commence until the Contracting Officer has accepted the plan in writing.

1.3.9   ASBESTOS CONTAINING MATERIAL (ACM)

Asbestos containing material (ACM) is material containing more than 1% asbestos by weight, either alone or mixed with other fibrous or non-fibrous materials.

1.3.9.1 Friable Asbestos

Friable asbestos is asbestos containing material that can be crumbled, pulverized, or reduced to powder by hand pressure when dry.

1.3.9.2 Non-Friable Asbestos

Non-Friable Asbestos is asbestos containing materials that do not release airborne asbestos fibers during routine handling and end-use.

1.3.10 Asbestos Control (Regulated) Area

Asbestos control (Regulated) area is an area where the Action Level (0.1 f/cc) of asbestos may be exceeded and which is isolated by physical boundaries to prevent the spread of asbestos dust, fibers, or debris during asbestos removal operations.

1.3.11 Authorized Person

Authorized person means any person authorized by the Contracting Officer and required by work duties to be present in asbestos control (regulated) areas.

1.3.12 Certified Industrial Hygienist (CIH)

Certified industrial hygienist (CIH) is an industrial hygienist certified by the American Board of Industrial Hygiene.

1.3.13 Certificate of Disposal

Certificate of disposal is a document used to assure the Contractor is disposing of asbestos in accordance with current Korean law. The certificate will establish a chain of custody between our contractor and a licensed disposal contractor. The certificate will be prepared in the same format as the sample provided in Appendix C. The certificate will contain the date the material is physically transferred to the disposal contractor, the name of the Resident/Project Office where the work is being done, the name and address of the contractor performing the removal work, the contract number, the project name, the name and address of the removal contractor's project manager and KID number, the name and address of the disposal contractor, the license number of the disposal contractor, the quantity of material transferred to the disposal contractor, the name and KID number of the person physically receiving the ACM on behalf of the disposal contractor, and a statement signed by a company officer (disposal contractor) certifying that the ACM will be disposed of in accordance with current Korean law and regulation. The certificate will be attached to the industrial waste disposition card (see appendix B) provided by the disposal contractor and kept as a permanent part of the contract record.

1.3.14 Competent Person

Competent person means one who is capable of identifying existing asbestos hazards in the workplace and who has the authority to take prompt corrective measures. He/she must have been trained in all aspects of asbestos abatement practices. Such training must be obtained from a comprehensive course such as a course conducted by an Environmental Protection Agency Asbestos Training Center or an equivalent course. He/she must also have at least one year of asbestos experience and have participated in at least three separate abatement projects.

1.3.15 Decontamination Facility

Decontamination facility means an enclosed area adjacent and connected to the asbestos control (regulated) area and consisting of an equipment room, shower room, and clean room which is used for the decontamination of workers, materials and equipment contaminated with asbestos. The facility must be equipped with air locks between the work area and the equipment room, equipment room and shower room and the shower room and clean (change) room (see Appendix A). The entrance shall be secured by a guard during working hours and a guard or positive barriers (doors, padlocks, etc.) to prevent public access during non-working hours.

1.3.15.1 Clean (Change) Room

Clean (Change) room is an uncontaminated room having facilities for the storage of employees street clothing and other uncontaminated equipment. A clean room is the first section of a decontamination facility a worker enters when accessing an asbestos control area and the area where personal protective equipment/clothing is donned.

1.3.15.2 Shower Room

Shower room is a room usually located in the center of the decontamination facility between the clean room and change room. It should be equipped with tempered (heated) water and a means to collect the asbestos waste washed off the workers and equipment. Waste water must be disposed of as contaminated material or filtered through a system with a 5.0 micron particle size collection capacity prior to disposal into a sanitary sewer or septic tank. Filters will be disposed of as contaminated material. This room must be supplied with impermeable containers for the disposal of filter cartridges.

1.3.15.3 Equipment Room

Equipment room is a room assumed to be contaminated with asbestos. It is located adjacent to the work area. This room is supplied with impermeable bags or containers for disposal of contaminated protective clothing and equipment. Workers will use this room to remove all contaminated clothing WITH THE EXCEPTION OF RESPIRATORS and place it in the waste disposal containers. RESPIRATORS WILL BE WORN INTO THE SHOWER AND NOT REMOVED UNTIL THE WORKER AND THE RESPIRATOR HAVE BEEN THOROUGHLY WASHED. The wetted respirator filters will be placed in a container provided in the shower room. IF POSSIBLE, ALL ASBESTOS WASTE CONTAINERS WILL BE CLEANED AND DISPOSED OF DAILY. THE CONTAINERS WILL NOT BE BROUGHT THROUGH THE CLEAN ROOM OF THE DECONTAMINATION FACILITY, BUT SHALL BE REMOVED THROUGH THE WASTE DISPOSAL PORT - SEE APPENDIX A.

1.3.16 Emergency Medical Plan

Emergency medical plan is a plan that explains how the Contractor intends to handle medical emergencies that may arise in a contaminated area, availability of first aid kits, names of employees certified in first aid & CPR, and emergency phone numbers.

1.3.17 Fire Protection/Prevention Plan

Fire protection/prevention plan is a plan that explains how the Contractor intends to protect the contaminated area from fire. As a minimum, it must contain an emergency evacuation drawing showing the means of egress, locations of exit signs, locations and types of fire extinguishers, fire department phone numbers, and the name of the person responsible for fire protection/prevention on the site.

1.3.18 Encapsulant

Encapsulant is a liquid sealant used to coat ACM. It controls the release of asbestos fibers by either creating a membrane over the surfaces or by penetrating into the material and binding its components together.

1.3.19 Glove Bags

Glove bags are plastic bags made of 0.1524 mm (6 mil) polyethylene with two long-sleeve gloves projecting into the bag to permit the user to work on small-scale, short duration asbestos removal jobs (usually pipe insulation) while limiting the asbestos fibers released to the contents of the bag. Once the work is complete, the bag is sealed and disposed of as asbestos waste.

1.3.20 Glove Bag Technique

Glove bag technique is a method used for removing limited amounts of ACM from HVAC ducts, short piping runs, valves, joints, showers, other short-duration maintenance or renovation activities where other types of asbestos removal is not required. The procedure involves cutting the sides of the glove bag to fit the size of the area to be enclosed and then attaching it around the removal area by folding the open edges together and securely sealing them with tape. All openings in the glove bag must be sealed with duct tape and the sides and bottom seams of the bag taped to prevent possible leakage. Tools such as razor knives, nips, wire brushes and wire cutters, etc., shall be placed in the tool pouch inside the bag prior to attachment. The pre-cut side part can be used to insert an airless sprayer to thoroughly wet the area to be removed with amended water, or, a small spray bottle containing amended water may be placed in the tool poach and used to wet down the ACM. Once the material has been thoroughly wetted, it can be removed by cutting through the painted canvas and peeling it away. It may be necessary to wet that material if it was not adequately soaked during this initial spraying. If the ACM is covered with wire-mesh, then wire cutters can be used. IT IS IMPORTANT TO REMEMBER THAT ALL ACM SHOULD REMAIN THOROUGHLY SOAKED DURING THE ENTIRE REMOVAL OPERATION. After the ACM has been removed from the desired area, a wire brush and water may be used to remove the remaining ACM. No visible traces of ACM should remain after the brushing. Any remaining raw edges of ACM that will be exposed when the bag is removed shall be covered with a bridging encapsulant to assure the edges do not release any fibers into the air when the bag is removed. Once the removal and encapsulation operations are complete, a hose from a HEPA filter vacuum cleaner shall be inserted into the side port to remove any air in the bag that may contain asbestos fibers.

Once the air has been removed from the bag, it should be squeezed tight as close to the top of the bag (but below the pipe or area that was cleaned) as possible, twisted, and sealed with tape. Once the bag has been sealed, the HEPA filter vacuum cleaner hose may be removed from the side port and the glove bag disposed of as asbestos waste by placing it inside a properly labeled disposal bag. Tools may be left in the bag and disposed of as asbestos waste or removed from the bag by bringing them through the glove sleeves. Tool removal via the glove sleeves is a risky procedure that may result in a spill if not properly and precisely carried out. The glove sleeves often break during this operation thus contaminating the area. This procedure requires the tools be brought first into one sleeve, turned inside out, twisted, taped, and cut and then the same procedure on the other. Care must be taken when cutting the sleeves to assure they have been securely taped and will not release fibers when they are cut. Once the sleeves are cut, the tools are kept in it until they can be taken to an area and decontaminated. It is often wise to place another piece of plastic under the bag just in case it tears. AN APPROVED RESPIRATOR AND PROTECTIVE CLOTHING MUST BE WORN DURING GLOVE BAG REMOVAL OPERATIONS. HEATING SYSTEMS SHOULD BE SHUT DOWN, IF POSSIBLE DURING REMOVAL OPERATIONS. GLOVE BAGS SHALL NEVER BE USED ON HOT PIPES HAVING A TEMPERATURE OF 65.5 DEGREES C.(150 DEGREES F)OR GREATER.

1.3.21 Hepa Filter Vacuum Cleaner

Hepa filter vacuum cleaner is a three stage HEPA filter vacuum cleaner specifically designed to vacuum asbestos fibers without re-dispersing them into the air.

1.3.22 High-Efficiency Particulate Absolute (HEPA) Filter

High-efficiency particulate absolute (HEPA) filter means a filter capable of trapping and retaining at least 99.97% of all monodispersed particles of 0.3 micrometers in diameter or larger. Used in air purifying respirators, asbestos vacuum cleaners, and negative filtration system.

1.3.23 Lockdown

Lockdown is the procedure of applying a protective coating to a surface from which asbestos-containing material has been removed.

1.3.24 Medical Surveillance Program

Medical surveillance program is a program designed to determine if an employee is able to work in an asbestos environment, to determine the workers baseline physical condition, and to monitor adverse lung conditions that may develop in the future. A more detailed explanation of a medical surveillance program is contained in 29.CFR 1926.58(m).

1.3.25 Negative-Pressure Air Filtration System

Negative-pressure air filtration system is a system that has been designed to maintain a differential of minus 0.508 mm (0.02 inches) of water column in the asbestos control area as relative to adjacent, unsealed areas. The intent of the system is to assure the environment and people outside the asbestos control area are not exposed to asbestos that could escape from the control area.

1.3.26 Non-Occupational Exposure Limit

Non-occupational exposure limit is the maximum number of asbestos fibers to which a non-asbestos worker may be exposed. 0.01 f/cc has been established as the non-occupational exposure limit and the level to which an area must be cleaned after asbestos removal and prior to re-occupancy. However, there is no known safe level of exposure to asbestos.

1.3.27 Personal Protective Clothing

Personal protective clothing shall consist of disposable coveralls, hoods, foot coverings, gloves, and goggles.

1.3.28 Permissible Exposure Limit (PEL)

Permissible exposure limit is the maximum legal number of asbestos fibers a worker may be exposed to as measured in terms of f/cc over an 8 hour TWA. The current maximum PEL established by OSHA is 0.2f/cc.

1.3.29 Respirators

Respirators are devices designed to filter out harmful levels of contaminants from the air before they can enter the wearer's lungs. Respirators must be Mine Safety and Health Administration (MSHA) and National Institute for Occupational Safety and Health (NI0SH) approved for the type of hazard encountered.

1.3.30 Respirator Protection Factor

Respirator protection factor each type of respirator is assigned a protection factor based on its ability to filter out contaminants. The protection factor determines the quantity of contaminants to which the person wearing that respirator may be exposed. For example, a respirator having a protection factor of 10 would permit the wearer to be exposed to 10 times the PEL of a contaminant. In the case of asbestos, that would mean 10 x 0.2 f/cc or 2 f/cc. Better respirators have higher protection factors.

1.3.31 Respiratory Protection Program

Respiratory protection program contains information on respirator selection, maintenance, cleaning, employee training, fit testing, etc. The plan must be developed in accordance with ANSI Z88.2 and 29 CFR 1910.134.

1.3.32 Single Use Respirator

Single use respirator is a respirator intended to be used only one time. Many look like masks warn by doctors. Others have the outward appearances of negative-pressure, air-purifying respirators. Unfortunately, even though some have been approved for asbestos exposures by NIOSH/MSHA in the past, they do not provide the protection necessary and ARE NOT ACCEPTABLE FOR USE ON CORPS OF ENGINEERS ASBESTOS REMOVAL PROJECTS. AS A MINIMUM, ONLY AIR-PURIFYING RESPIRATORS EQUIPPED WITH HEPA FILTERS ARE ACCEPTABLE.

1.3.33 Testing Laboratory (Accredited)

Testing laboratory (Accredited) is a laboratory that is currently enrolled and has successfully participated in NIOSH Proficiency Analytical Testing (PATs) 7400 Method program for asbestos airborne sampling and the EPA Research Triangle Institute (RTI) program for bulk sampling. See paragraphs, 1.5.2.1 and 1.5.2.2.

1.3.34 Training Plan

Training plan is a plan developed by the contractor to inform his employees of the hazards associated with working in an asbestos environment and the safety measures that must be taken to prevent injury. The minimum basic requirements for an acceptable training program is contained in 29 CFR 1926.58(k)(3).

1.3.35 Visual Inspection Procedure

Prior to performing "cleanup" air monitoring but after the Contractor has removed all gross contamination, vacuumed, and wet wiped the area, all surfaces should be checked for ACM and/or dust. Special attention should be given to pipes, beams, tops of suspended light fixtures and irregular surfaces that may have corners and hard-to-reach areas. A damp cloth should be run across the exposed surfaces and the cloth then inspected for any evidence of dust. A more sensitive test for dust is to darken the room and shine a flashlight so that the beam glances any smooth horizontal surface. Run your finger across the illuminated area. If a line is left on the surface, or airborne particles shine in the light, dust is still present and additional cleaning is necessary.

1.4 DESCRIPTION OF WORK

The work covered by this section includes the removal, handling, and disposal of friable/non-friable asbestos containing material identified in (locations specified by A-E studies) and the ancillary procedures necessary to protect workers, area occupants, and others that may be exposed to the contaminated area. All work must be performed in accordance with 29 CFR 1926.58 and the requirements specified herein.

1.4.1 Title to Materials

All asbestos containing materials removed by the work shall become the property of the Contractor and shall be disposed of as specified herein.

1.4.2 Protection of Existing Work

The work shall be performed without damage or contamination of adjacent areas. When such areas are damaged or contaminated, the Contractor shall be responsible for restoring them to the original condition.

1.5 SUBMITTALS

The following items shall be submitted to and accepted by the Contracting Officer prior to the start of any work involving asbestos removal:

1.5.1 Equipment and Materials

The Contractor shall submit a list, description and certificates of compliance (when applicable) for equipment that will be used for asbestos removal to the Contracting Officer for acceptance. As a minimum, the list shall include:

Respirators

Respirator filters

Respirator fit test kits

Respirator maintenance kits

Personal protective clothing - disposable coveralls, hoods, foot covers, eye protection, and gloves

Negative-filtration system equipment - exhaust fan, HEPA filters, ducts,and other ancillary equipment (if required)Monometer for continuous monitoring of the negative filtration system(if required) HEPA filter vacuum cleaners replacement filters, liners, and disposal tags

Decontamination facility to include shower and waste-water containment

Air monitoring pumps - high volume, tubes, fittings, etc.

Air monitoring filter cassettes

Air monitoring pump calibration equipment

Kurz meter, bubble burrette

Warning signs, tapes, etc.

Fiberous Aerosal Monitor (if required)

Wetting agent or surfactant

Encapsulant

Glove bags

Disposal bags

Disposal drums

Sprayers for applying surfactants

0.1524 mm (6-mil) polyethylene plastic sheeting

0.1026 mm (4-mil) polyethylene plastic sheeting

Tape

1.5.2   Testing Laboratories

The Contractor shall submit the name, address and qualifications of the laboratory that will be performing the asbestos analysis, and certification that the persons counting the samples are qualified.

1.5.2.1 Laboratory Qualifications - Airborne Sampling Analysis

To be considered acceptable, person(s) in the laboratory must have been judged proficient in airborne asbestos analysis by the successful participation in at least one round of the NIOSH Proficiency Analytical Testing (PAT) Program within the last year. Participation scores shall be submitted as part of the Asbestos Abatement Plan. To be considered successful, the laboratory must have scored at least 3 correct out of 4 in a round.

1.5.2.2 Laboratory Qualifications - Bulk Sample Analysis

If it becomes necessary for the Contractor to perform bulk sample asbestos analysis, the Contractor shall use a laboratory that has been judged proficient in asbestos bulk sample analysis by successful participation in at least two rounds of the Environmental Protection Agency (EPA) Research Triangle Institute program in the last year. Participation scores shall be submitted as a part of the Asbestos Abatement Plan. To be considered successful, the laboratory must have scored at least 3 out of 4 in a round.

1.5.3 Certified Industrial Hygienist (CIH)

The Contractor shall submit the name, academic credentials, asbestos abatement experience and certification number of the industrial hygienist that will be overseeing the work. This information shall be submitted as part of the Asbestos Abatement Plan.

1.5.4 Competent Person

The Contractor shall submit the name of the person who will be designated as the competent person on the job site; the name of the asbestos abatement course that person attended, the date the person attended, and the name and address of the organization providing the course. This information shall be submitted as part of the Asbestos Abatement Plan.

1.5.5 Asbestos Abatement Plan

The Contractor shall submit an asbestos abatement plan as described in the definitions of this document to the Contracting Officer for acceptance prior to the commencement of asbestos removal work. Asbestos removal work shall not start until the Contracting Officer has evaluated and accepted the plan in writing.

1.5.6 Fire Protection and Emergency Medical Treatment Plans

The Contractor shall submit a fire protection and emergency treatment plan as described in the definitions section of this document prior to the commencement of asbestos removal work. The plans shall be submitted as part of the Asbestos Abatement Plan.

1.5.7 Air Monitoring Plan

The Contractor shall perform air monitoring in the work area before, during and after the removal of asbestos. The monitoring shall be accomplished in accordance with current OSHA, EPA, and NI0SH sampling methods. The Contractor shall develop and submit an air monitoring plan as described in the definitions section of this document to the Contracting Officer for acceptance prior to initial airborne sampling and the commencement of any asbestos removal work. This plan shall be submitted as part of the Asbestos Abatement Plan.

1.5.8 Air Monitoring Results

The results of the pre-work ambient airborne asbestos fiber level monitoring will be submitted to the Contracting Officer prior to completion of cleanup airborne fiber sampling; the results of the personal and environmental (area) airborne samples taken in the asbestos removal work area during removal operations will be submitted to the Contracting Officer for review not later than 36 hours after the completion of the sampling period if a testing laboratory in-country is utilized, or, not later than ten (10) calendar days if a laboratory out of country is utilized. The results of the airborne samples taken during the cleanup stage of the work will be submitted within 36 hours after the completion of the sampling period if a testing laboratory in-country is utilized, or, not later than ten (10) calendar days if a laboratory out of country is utilized. The results of the samples will be expressed in terms of fibers per cubic centimeter (f/cc) and will be tied to the date, time, location, name of sampler, volume sampled, number of the pump used to take the sample, and its last calibration date. The CIH will take immediate and appropriate actions to abate any asbestos hazards to the workers or the public when such a hazard is so indicated by the sample result. The Contractor will immediately verbally notify the Contracting Officer of the nature of the hazard. In addition to verbal notifications, the CIH will submit a written analysis of the impact of the results of all samples on employees working in the asbestos control area and the adjacent environments and certify the asbestos control area as "clean" when indicated by the sample results.

1.5.9 Certificate of Compliance

The CIH submit a certificate of compliance to the Contracting Officer guaranteeing that each asbestos control area has been tested in accordance with established procedures and that the airborne concentration of asbestos fibers is less than the non-occupational exposure level of 0.01f/cc or the initial ambient levels sampled prior to the start of work, whichever is less. The CIH will affix his seal and certification number to the certificate. The Contracting Officer will not accept the work area for turn-over until this certificate has been received.

1.5.9.1 Certificate of Disposal

The Contractor shall submit a certificate of disposal as described in the definitions section of this document to the Contracting Officer for every load of asbestos containing material removed from the work site. The certificate shall be given to the Contracting Officer not later than one (1) working day after the ACM waste has been removed from the site.

1.5.9.2 Medical Surveillance Program

The Contractor shall submit a copy of their medical surveillance program as described in the definitions section of this specification to the Contracting Officer prior to the start of work. The program shall be submitted as a part of the Asbestos Abatement Plan.

1.5.9.3 Physician's Written Opinion

The Contractor shall submit a copy of a licensed physician's signed, written opinion to the Contracting Officer that each employee who will be exposed to the Action Level is medically able to wear a respirator and work in an asbestos contaminated environment without incurring a health impairment; detailing any recommended limitations on the employee or on the use of respirators; a statement that the employee has been informed of the results of the examination and any medical conditions that might result from exposure to asbestos; and that the medical examination has been performed in accordance with 29 CFR 1926.58 (m)(2)(ii). The written opinions will be submitted as part of the Asbestos Abatement Plan and will be made a permanent part of the contract record.

1.5.9.4 Respiratory Protection Program

The Contractor shall submit a copy of his respiratory protection program as described in 29 CFR.1910 134 and ANSI Z88.2 to the Contracting Officer for acceptance prior to the start of asbestos removal. This plan shall be submitted as part of the Asbestos Abatement Plan.

1.5.9.5 Certificate of Training

The Contractor shall submit a certificate of training for each employee who will be exposed to levels of asbestos that exceed the Action Level to the Contracting Officer prior to the start of asbestos removal work. The document shall certify that the exposed employee(s) has received training in the proper removal, handling and disposal of asbestos containing material as required by 29 CFR 1926.58(k)(3), understands the health hazard implications associated with exposure to asbestos, understands the use and limits of the respiratory equipment to be used; understands the results of airborne monitoring of asbestos as related to health and respiratory equipment; and understands the engineering and other hazard control techniques and procedures. A separate certificate will be prepared for each employee who will be exposed. The CIH shall sign and affix his seal and certification number to each training certificate. The certificates shall be written in Korean and English. Training shall be conducted in Korean. A copy of the certificate will be retained as a permanent part of the contract file.

1.6 PRE-ASBESTOS REMOVAL PREPARATIONS

The Contractor shall make every reasonable effort to remove all furniture and other movable items from the work area prior to the commencement of asbestos removal work. Items that cannot be removed from the worksite shall be covered completely with 0.1524 mm (6 mil) thick polyethylene plastic sheeting before the work begins. The work shall be accomplished without damage or contamination to adjacent areas. Other workers or building occupants in the area shall be warned of the asbestos hazard and advised to stay away from the asbestos control area. Any portion of the building HVAC system passing through or connecting with the asbestos controlled area shall be shut down and sealed off in such a positive fashion to assure no entry of contaminated material into the system. If practical, the permanent electrical system in the asbestos controlled area shall be disconnected and replaced with a temporary system designed for wet locations and equipped with ground-fault circuit interruption protection. If it is necessary to use the permanent electrical system, it must be equipped with a ground-fault circuit interruption system.

1.7 EMPLOYEE TRAINING

Prior to the start of work, the Contractor shall provide all employees that are expected to be exposed to concentrations of asbestos fibers that exceed the Action Level (0.1f/cc) with at least 8 hours of asbestos abatement training as described herein unless it can be confirmed that the employee has received equivalent training within the previous 6 months. The training shall be provided in a manner that the employee is able to understand and, as a minimum, shall contain information on methods of recognizing asbestos, health effects associated with asbestos, the relationship between smoking and asbestos in producing lung cancer, the purposes, proper use, fit testing instruction, and limitations of respirator, the nature of operations that could result in exposure to asbestos, the importance of protective controls to minimize exposure, the appropriate protection for performing an asbestos removal job, and explanation of the medical surveillance program and a review of 29 CFR 1925.58.

1.8 MEDICAL SURVEILLANCE PROGRAM

The Contractor shall establish a medical surveillance program in accordance with the provisions specified in 29 CFR 1926.58(m) for all employees who are or who may reasonably be expected to be engaged in work involving levels of asbestos at or above the Action Level or who are required to wear negative pressure respirators. Examinations are not required for employees whose records indicate that they have been examined in accordance with this specification within the last 6 months.

1.8.1 Medical Examinations

The physician shall provide each worker who will be exposed to the Action Level (0.1 f/cc) of asbestos a medical examination consistent with the provisions setforth in 29 CFR 1926.58(m)(2)(ii).

1.8.2 Information Provided to the Physician

The Contractor shall provide the examining physician the following information. A copy of 29 CFR 1926.58 and Appendices D, E, and I; a description of the employee's duties as they relate to the exposure; the anticipated employee exposure level; a description of any personal protective and respiratory equipment that will be used; and previous medical examination information.

1.9 RESPIRATORY PROTECTION PROGRAM

The Contractor shall develop a respiratory protection program consistent with the requirements specified in ANSI Z88.2 and 29 CFR 1910.134. The respiratory protection program as a minimum shall address the selection, fitting, use, and maintenance of the respirators that will be used.

1.9.1 Respirators

All employees that are exposed to or can reasonably be expected to be exposed to airborne concentrations of asbestos above the Permissible Exposure Limit (PEL) 0.2 f/cc shall wear an approved respirator. All respirators shall be approved by the Mine Safety and Health Administration (MSHA) and the National Institute for Occupational Safety and Health (NI0SH) for asbestos environments and shall have the appropriate NI0SH approved number. Single-use respirators or negative-pressure air purifying respirators WITHOUT HEPA filters will NOT BE APPROVED FOR ASBESTOS WORK ON IMA-KORO PROJECTS.

1.9.2 Respirator Selection

Respirators shall be selected in accordance with the criteria setforth in ANSI Z88.2 and when in accordance with the following table.

AIRBORNE FIBERS		REQUIRED RESPIRATOR
Not in excess of 2 f/cc. (Protection Factor of at least 10 x 0.2 f/cc PEL)	1.	Half mask air-purifying respirator equipped with HEPA filters. or
	2.	Any powered air respirator equipped with HEPA filters. or
	3.	A type C supplied-air, continuous flow or positive pressure demand mode respirators.*
Not in excess of 10 f/cc (Protection Factor of at least 50 x 0.2 f/cc PEL)	1.	Full facepiece air-purifying equipped with HEPA filters. or
	2.	Any powered air respirator equipped with HEPA filters. or
	3.	A type C supplied-air, continuous flow or positive pressure demand mode respirators.*
Not in excess of 20 f/cc	1.	Any powered air purifying

(Protection Factor of at least 100 x 0.2 f/cc PEL)		respirator with HEPA filters. or
	2.	A type C supplied-air, continuous flow or positive pressure demand mode respirators.*
Not in excess of 200 f/cc (Protection Factor of at least 1000 x 0.2 f/cc)	1.	Type C full-facepiece supplied-air respirator-operated in pressure demand mode.* or
	2.	Self-contained breathing apparatus (SCBA) operated in the positive pressure demand mode.*
Greater than 200 f/cc or an unknown concentration	1.	Type C full-facepiece supplied-air respirator operated in positive pressure demand mode.* or
	2.	Type C self-contained breathing apparatus (SCBA) operated in the pressure demand mode.*

* Certified Grade D air must be provided for Type C supplied-air and SCBA respirators. Supplied air respirators with emergency escape HEPA filters are preferable.

1.9.3   Respirators Furnished to Government Representative

The Contractor shall furnish approved powered-air purifying respirator(s) for use by the government representative. If a higher level of respiratory protection is used by the contractor, such as supplied air, this shall be furnished for use by the government representative, if requested.

1.10   PROTECTIVE CLOTHING

The Contractor shall furnish all employees exposed to asbestos fibers with disposable protective clothing. The protective clothing shall consist of coveralls, head covers or hoods, foot coverings, safety boots, and eye protection. At least 4 complete sets of protective clothing shall be provided for each employee/day he is exposed to asbestos. Additional sets shall be provided when necessary - i.e. torn or ripped clothing. During warm weather, no other clothing aside from underwear shall be worn under the protective clothing. During cooler weather, additional clothing may be worn under the protective clothing for comfort, but it must be removed and thoroughly laundered by the Contractor each day. ALL CLOTHING, REGARDLESS OF WHETHER OR NOT IT WAS WORN UNDER THE PROTECTIVE CLOTHING, SHALL BE REMOVED IN THE DECONTAMINATION FACILITY AND PLACED IN IMPERMEABLE SEALED BAGS AND LABELED WITH WARNING SIGNS. IF IT IS DEEMED DISPOSABLE, IT SHALL BE DISPOSED OF AS ASBESTOS WASTE. IF IT IS DEEMED NON-DISPOSABLE, IT SHALL BE LAUNDERED DAILY IN ACCORDANCE WITH 29 CFR 1926.58(i)(2).

1.10.1 Laundering Procedures

The Contractor shall assure all non-disposable clothing is placed in impermeable bags and an asbestos warning sign is affixed to the container. The Contractor shall inform the party providing the laundering service of the hazards associated with asbestos and advise him that the clothes should be laundered separate from other laundry and in a manner so as to prevent the release of asbestos fibers.

1.10.2 Protective Clothing Furnished the Government Representative

The Contractor shall furnish protective clothing for use by the government representative.

1.10.3 Eye Protection

The Contractor shall provide each worker goggles (prescription where necessary) to wear with half-mask respirators. When full-face piece respirators are used and prescription eyewear is required, the Contractor shall provide respirators specifically designed for spectacles. Under no circumstances will spectacle spatulas be permitted to extend through the face seal of the mask. Contact lens shall not be worn by workers in an asbestos contaminated areas.

1.11 WORK METHODS

The Contractor shall identify asbestos removal work areas based on the information supplied by the A-E studies. If a suspect material is encountered during the work that has not been identified by the A-E surveys, the Contractor shall notify the Contracting Officer and take a sample for analysis, or at the option of the Contracting Officer, make the assumption that the suspect material does contain asbestos and treat it in the required manner. The Contractor shall determine the extent of the asbestos hazard and provide the Contracting Officer a written opinion of the types of protective measures that should be employed. The written opinion shall be submitted with the Asbestos Abatement Plan. The Contracting Officer may either accept or reject the Contractor's opinion.

1.11.1 Engineering Controls and Work Practices

The Contractor shall make every reasonable effort to employ engineering controls and work methods to reduce the amount of asbestos fibers generated into the air. As a minimum, the Contractor shall use any one or combination of the following control methods to achieve that end: Negative-pressure exhaust ventilation systems, local exhaust ventilation systems designed for use on powered cutting saws, grinder, drills, etc.; HEPA filter vacuum cleaners, enclosure and isolation processes; wet methods; removal encapsulants; and prompt disposal of wastes in leak tight containers.

1.11.2 Prohibited Activities

Eating, drinking, smoking, chewing tobacco or, gum, applying cosmetics, running high speed abrasive disk saws that are not equipped with HEPA filter local exhaust systems, dropping asbestos materials, and using compressed air to remove asbestos are prohibited.

1.11.3 Asbestos Control (Regulated) Area Requirements

The Contractor shall provide an area designed to control the release of asbestos fibers. Depending on the magnitude of the hazard, the Contractor shall provide an area that complies with one of the three asbestos control area criteria listed herein.

1.11.4 Negative-Pressure Enclosure

When the airborne concentration of asbestos fibers exceeds or is expected to exceed the PEL (0.2 f/cc), a negative-pressure enclosure meeting the requirements specified herein shall be constructed. Prior to the start of construction all movable objects such as desks, chairs, rugs, light fixtures, etc. shall be removed from the work area. If the movable objects or the work area are contaminated or suspected of being contaminated, they shall be vacuumed with a HEPA filter vacuum cleaner and cleaned with amended water unless they are made of material that will be damaged by the wetting agent or water. In those cases where the wetting agent will damage the material, plain water may be used. Those objects that cannot be removed from the work area shall be covered and sealed in 0.1524 mm (6-mil) thick, polyethylene plastic sheeting. When all objects have been removed from the work area or covered, all penetrations in the floors, walls, and ceiling shall be covered with the 0.1524 mm (6-mil) thick plastic sheeting. Windows and unnecessary doors shall be locked, covered and sealed in the plastic sheeting. All other surfaces such as support columns, ledges, pipes, and other surfaces shall also be covered with the plastic sheeting before the walls are covered. All HVAC ducts shall be shut down and locked out, and covered with plastic and sealed with tape. If it is not possible to shut down the system, all intake and supply ducts shall be sealed with sheet metal and plastic. All electrical systems in the area should be shut down and locked-out and a temporary system protected by ground-fault circuit interrupters provided. If it is not possible to shut down the permanent system, it shall be protected with ground-fault circuit interrupters. Electrical equipment shall be protected from the effects of the water. Care shall be taken to assure that the measures taken do not cause the equipment protected to overheat. The enclosure shall be equipped with a negative-pressure air filtration exhaust system and a decontamination facility.*

1.11.5 Floor Coverings

After openings such as windows, doors, duct openings, etc. have been covered, the floor must be covered with 0.1524 mm (6-mil) polyethylene sheets of plastic. Several sheets with at least 300 mm (12") overlap seams can be taped together. Blue or red carpenter's chalk should be placed beneath the seam line to detect water leaks. The chalk will darken when exposed to water. Leaks shall be cleaned-up immediately. The floor coverings must be cut to match the dimensions of the floor plus an extension of 600 mm (24") up the wall all the way around the room. The plastic covering must be flush with the walls to prevent damage. The edges must be taped to the wall with 76.2 mm (3") duct tape. After the first layer of plastic has been secured in place, a second layer should be installed over the first with the seams slightly offset from the first and the edges secured with 76.2 mm (3") duct tape a few inches above the edges of the first layer.

1.11.6 Wall Coverings

Next, a nail board should be attached not less than 100 mm (4") from the top of all walls surrounding the enclosed work area close to the wall-ceiling interface and a layer of the 0.1026 mm (4-mil) thick plastic sheeting stuck to the nails and taped. All seams must be over-lapped at least 150 mm (6") and sealed with adhesive and tape. All interior walls shall be covered in the same manner. The wall sheeting is extended out across the floor area at least 600 mm (24") from the edge of the wall where it is taped to the floor covering with 76.2 mm (3") duct tape.

1.11.7 Negative-Pressure Air Filtration Exhaust Ventilation System

The Contractor shall provide a positive means of assuring that all asbestos fibers generated from the work process are contained within the control enclosure. To accomplish this the Contractor shall procure and install a HEPA filter exhaust ventilation system for the enclosure. The exhaust system shall be installed and operated in such a fashion as to create a pressure of minus 0.508 mm (0.02 inches) of water column within the enclosure with respect to adjacent areas. The system installed must be capable of providing an air exchange rate of at least 4 times per hour. The air exhausted from the enclosure shall be clean of asbestos fibers to a level of 0.01 f/cc. The exhaust system shall be operated continuously 24 hours a day and the pressure differential recorded by a continuous readout manometer monitor equipped with a strip tape. The monitor shall be equipped with a minor scale division of 0.508 mm (0.02 inches) of water and shall have an accuracy of plus or minus 1%. The monometer shall be calibrated daily or as recommended by the manufacturer. The competent person and the CIH shall monitor the monometer several times each day to assure the integrity of the work area is being maintained. Work will cease immediately if there is a variance in the pressure differential which could cause exposure to adjacent areas at or in excess of the Action Level.

1.11.8 Decontamination Facility

In addition to the enclosed area, the Contractor shall construct a decontamination facility. It shall consist of a clean room, a shower, and equipment room. If possible, the decontamination facility shall be adjacent to the negative-pressure enclosure. If placement of the facility next to the enclosure is not feasible, a polyethylene plastic tunnel shall be constructed from the work area to the facilities. If a tunnel is necessary, a double-flapped door shall be constructed at the entrance to the tunnel and the entrance into the equipment room. The clean room shall be used to enter the enclosure and to remove and store street clothing and don protective clothing and respirators. Lockers shall be provided to store street clothes. The shower room shall be located next to the clean room. It shall have warm water, soap, etc. It shall also be equipped with a 5-micron particle filtration system to filter out asbestos fibers washed off equipment and workers or a waste-water container. Filtered waste water may be disposed of into a sewer. Unfiltered waste-water shall be disposed of as asbestos waste. The equipment room shall be the last room next to the work area. It shall be used to remove disposable clothing and clean equipment prior to entering the shower room or exiting the enclosure. The equipment room shall have a HEPA filter vacuum cleaner to vacuum the gross contamination off those entering the room and impermeable waste disposal bags. The disposal bags shall be removed and disposed of as asbestos waste daily.

1.11.9 Integrity Test

An integrity test shall be performed on all enclosed areas prior to the start of work to assure there are no leaks in the enclosure. The test shall be conducted by placing smoke bombs in the enclosed area and observing any leaks. Positive steps shall be taken to assure the smoke bombs do not present a fire hazard. Fire extinguishers and a fire guard will be provided during the test. The test shall be witnessed by the QAR and the results recorded in his log book. If any leaks are observed in the enclosure, work shall not commence until the appropriate repairs have been made and the area re-tested. The smoke shall be exhausted via the negative filtration system.

1.11.10 Low-Hazard, Small-Scale, Short-Duration Asbestos Control (Regulated) Areas

In work areas where the airborne concentration of asbestos does not or is not expected to exceed the Permissible Exposure Limit (PEL), a limited asbestos control area may be developed. Such operations may include the removal of non-friable ACM or small-scale operations that can be controlled by the use of glove bags. In such cases, the asbestos control area shall be roped off by a 6 m (20 foot) perimeter around the area where the asbestos handling operations are being performed. The perimeter shall be signed with asbestos warnings in both English and Korean. In addition, personal and area air monitoring shall be taken at least every four hours during the work shift. If the concentration of airborne fibers exceeds the lesser of 2 times the background or Action Level, all personnel in adjacent areas shall be evacuated and that area cleaned. Employees working in limited control areas shall wear the appropriate respiratory protection equipment and protective clothing. When the work is complete, the work area must be cleaned to the non-occupational or initial ambient fiber level.

1.11.11 Mini-Enclosures

In some instances, such as the removal of asbestos from a small ventilation system or from a short length duct, a glove bag may not be either large enough or of the proper shape to enclose the work area. In such cases, the Contractor may elect to construct a mini-enclosure around the area where the small-scale, short-duration asbestos work will be performed. Such an enclosure shall be constructed of 0.1524 mm (6-mil)-thick polyethylene plastic sheeting and may be small enough to restrict entry to the work area to one worker. A mini-enclosure shall be constructed in much the same way as a full-scale negative-pressure asbestos control enclosure. Plastic sheeting shall be affixed to the walls and floors and all penetrations in the walls and floors shall be sealed. A negative-pressure exhaust system shall be installed if possible. In some cases, HEPA filter vacuum cleaners will provide an adequate negative pressure in a small area. A small single-room change room may be constructed instead of the 3-room decontamination facility. The change room shall be directly adjacent to the work area. Workers shall wear protective clothing and respirators and shall vacuum off and remove them before leaving the enclosure. All clothing and respirator filters shall be disposed of as asbestos waste. Workers should take showers prior to putting on their street clothes.

1.11.12 Access

Access to asbestos controlled areas shall be limited only to authorized persons. The Contractor shall provide a positive means for securing the control area. During work hours, the entrance to the control area shall be signed with an asbestos warning sign; and, in areas of easy public access, a guard shall be placed at the entrance. During non-work hours, entrance to the control area must be controlled by a substantial barrier such as a padlocked door or a guard.

1.11.13 Emergency Egress

The Contractor shall provide emergency and fire exits at the asbestos removal areas. Where possible at least two clear choices of exits remote from one another shall be provided.

1.12 WARNING SIGNS

The Contractor shall post warning signs around the perimeter of the asbestos control area where airborne concentrations of asbestos are expected to exceed the PEL. The warning signs shall be in English and Korean and posted at such a distance that personnel may read them and take the necessary protective steps required prior to entering the control area. The warning signs shall contain the following information:

DANGER

ASBESTOS

CANCER AND LUNG DISEASE HAZARD

AUTHORIZED PERSONNEL ONLY

RESPIRATORS AND PROTECTIVE

CLOTHING ARE REQUIRED IN THIS AREA

1.13 AIR MONITORING

The Contractor shall determine asbestos exposure levels by air monitoring. Employee exposures shall be determined on the basis of one or more daily samples representing a full shift exposure for employees in each work area. As a minimum, the Contractor shall comply with the requirements specified in 29 CFR 1926.56(1).

1.13.1 Initial Monitoring

The Contractor shall perform initial air monitoring at the start of each asbestos removal operation to determine the concentration level of asbestos fibers to which the employees are exposed. Personal samples will be taken in the breathing zone (BZ) of the workers while they are engaged in the removal process. Low volume air sampling pumps calibrated to between 0.5 and 2.5 liters per minute will be used to take the samples. A 25 mm cassette with a 50 mm extension cowl shall be attached to the worker near the BZ - i.e. collar, etc. The samples shall be analyzed by a laboratory accredited under the NIOSH PATs program using the NIOSH Method 7400. The results of the samples will be submitted to the Contracting Officer and made a part of the permanent contract record. The results of the initial monitoring may be used to determine the degree of respiratory protection required.

1.13.2 Ambient Area Monitoring

Prior to the start of work and the sealing operations, the Contractor shall perform air monitoring to establish a reference baseline for adjacent areas outside the asbestos control area. The samples shall be taken not more than 1 day prior to the start of work. At least 3,000 liters of air shall be taken per sample. 25mm cassettes with 50 mm extension cowls will be used to collect the samples and NIOSH Method 7400 will be used to analyze the samples. The set-up and start-up of the monitoring must be witnessed by the Contracting Officer and the CIH. A diagram indicating the exact location of the pumps shall be submitted to the Contracting Officer to be included as a permanent part of the contract record. WARNING: IF THERE IS ANY EVIDENCE TO INDICATE THAT THE ASBESTOS LEVELS IN THE AREAS WHERE THE SAMPLES ARE BEING TAKEN IS CONTAMINATED OR MAY EXCEED THE ACTION LEVELS (DAMAGED PIECES OF ASBESTOS ON THE FLOORS ETC.), PERSONAL PROTECTIVE EQUIPMENT MUST BE WORN DURING SAMPLING. Although not a requirement, the use of high volume air pump samplers will expedite this procedure.

1.13.3 Periodic Air Monitoring

The Contractor shall conduct daily personal and area air monitoring inside and outside the work area at specified locations to assure that the respiratory protection factor is not being exceeded, that the control methods being implemented are effective, and that asbestos fibers exceeding the Action Level are not being expelled outside the control area. Personal samples shall be taken in the BZ. Area samples shall be collected inside the asbestos control area; outside the perimeter of the control area; in the clean room; and in any areas where other employees or members of the public may be working adjacent to the control area; at the exhaust opening of the negative-pressure air filtration system; and any other areas deemed appropriate by the CIH.

1.13.4 Exception to the Periodic Personal Air monitoring Requirement

If all employees within the asbestos controlled area are equipped with supplied-air or SCBA respirators operated in the positive-pressure demand mode, the Contractor may dispense with the daily personal monitoring in the breathing zone requirements. But all other monitoring requirements will still be in force.

1.13.5 Final Clean-up Monitoring

Upon completion of final clean-up procedures and after the site has passed the visual (dust) inspection test, the Contractor shall conduct at least 3 aggressive area samplings per 141.5 cubic meter (5,000 cubic feet) in an asbestos control (or at least one sample per room) area prior to removing the control enclosure. At least 3,000 liters of air will be sampled. The sample shall be sent to an accredited laboratory as defined in the specification and analyzed in accordance with the NIOSH Method 7400. To be considered "clean" and released for occupancy, the sample results for an area shall be less than 0.01 f/cc or less than the baseline established by the ambient air monitoring if these requirements cannot be met. Then the area shall be recleaned and sampled again until that criteria can be met. The enclosures and warning signs shall not be removed until the Contracting Officer has confirmed that the clean-up sample results meet the non-occupational or initial ambient air exposure level. The industrial hygienist shall certify that the area has been cleaned to the non-occupational exposure level (0.01 f/cc) or initial ambient exposure level. The certificate shall be signed, sealed and given to the Contracting Officer for approval prior to releasing the area for unrestricted reentry. After clean-up confirmation has been received, the Contractor shall remove all existing filters in the asbestos work area and shall provide new filters and restart the HVAC systems. The filters shall be disposed of as contaminated material.

1.13.6 Air Monitoring Results

Samples will be labeled, logged, and immediately sent to a certified laboratory for analysis. The results of the samples shall be completed and returned to the CIH for analysis not later than 36 hours after the completion of the sampling if a testing laboratory in-country is utilized, or not later than ten (10) calendar days if a laboratory out of country is utilized. If the results of the samples indicate that the protection factor of a respirator is being exceeded in a work area, employees will be evacuated from the work area and respirators having a higher protection factor provided prior to the recommencement of work or positive measures taken to assure that level is not exceeded again. If monitoring outside the asbestos control area shows airborne concentrations have reached the Action Level, a stop work order will be issued and measures taken to correct the problem implemented prior to the recommencement of the work. The written results of all air monitoring shall be provided to the Contracting Officer within ten (10) working days after the sampling cycle. The results of the samples should be made a permanent part of the contract record. In addition to the sampling pumps, fibrous aerosol monitors should be set up in and outside the work area to provide continuous monitoring of the airborne level of asbestos. Although this device often overstates the actual level of asbestos fibers in the air and is not considered to be a legal measurement of asbestos fibers, it does provide the Contractor an early warning system that will give immediate readouts and allow corrective action to be taken on the spot instead of waiting until the next shift.

1.14 HOUSEKEEPING

Asbestos containing material shall be removed by means that prevent, to the maximum extent possible, the release of asbestos dust into the air. The Contractor shall keep surfaces in the asbestos control areas free from accumulations of asbestos debris during removal operations. Cementitious type asbestos insulation shall be removed using the glove bag technique where possible. However, where the use of glove bags is not feasible, it shall be removed with single-point cutting tools. If saws or abrasive cutting devices are used they shall be equipped with HEPA filter local exhaust systems. Prior to removal, the surface of the insulation shall be thoroughly soaked with a low pressure spray of amended water in a way that does not cause the dust to rise from the impingement of the water on the surface. Non-absorbent cementitious surfaces shall be punctured and amendment water injected into the opening until the underlaying material becomes saturated. The saturated material shall then be carefully removed in small pieces. It shall not be permitted to fall to the ground or thrown or tossed to the ground or into disposal bags, but shall be carefully lowered and immediately placed in disposal bags while still wet. Sheets of asbestos board will NOT be broken just to place them in bags. Instead, they shall be enclosed in 0.1524 mm (6-mil) plastic, labeled and disposed of as asbestos waste. Slurries of waste materials that fall must be immediately placed in the disposal bags while still wet. HEPA filter vacuum cleaners approved for use on asbestos shall be used to collect the remaining asbestos dust from all work surfaces. The vacuums must operate at a noise level below 85 dBA; have a flow rate of at least 1 cubic meter/min (35 CFM) through a 38 mm (1-1/2 inch) inside diameter hose at 127 mm (5") of static water pressure, and have a minimum of 1270 mm (50") of water as a maximum static water pressure. Compressed air shall never be used on asbestos.

1.15 DISPOSAL

The Contractor shall collect all asbestos waste, scrap debris, contaminated filters, protective clothing, slurries and water, and place them in impermeable plastic bags and seal the bags in drums affixed with warning labels.

1.15.1 Asbestos Waste Removal Port

Where possible, an asbestos waste removal port shall be provided in the asbestos control area. The port when utilized shall be a separate room, but a part of the negative-pressure enclosure. It shall be equipped with air locks between the work area and the outside collection area. A means for decontaminating the disposal bags, drums and other contaminated items that pass through its doors (i.e. HEPA filter vacuum cleaners and wet wiping) shall be provided in the room. A system for collecting the asbestos waste that is washed off the bags, equipment, etc. will be provided - wastewater collection container or a filtration system like the one specified for the shower room in the decontamination facility. An area designed for the collection and pickup of the bags, shall be roped off and posted with asbestos warning signs. The trucks provided for transportation of the waste material to the landfill shall enter the roped off area for loading. Truck drivers shall either stay in their vehicles or leave the roped off area until the loading is complete. ALL PERSONNEL LOADING THE WASTE MATERIAL AND/OR IN THE ROPED-OFF AREA SHALL WEAR APPROVED RESPIRATORS AND PROTECTIVE CLOTHING. UNDER NO CIRCUMSTANCES WILL ANYONE BE PERMITTED TO USE THE PORT AS AN ENTRANCE TO OR EXIT FROM THE ASBESTOS CONTROL AREA. THE ROPED-OFF AREA WILL BE CONSIDERED A PART OF THE ASBESTOS CONTROL AREA. Trucks used to transport asbestos waste to a landfill shall have an enclosed carrying compartment sufficient to contain the waste. Vehicles using compactors to reduce the volume of the waste shall not be used.

1.15.2 Disposal Bags and Drums

The disposal bags shall be of 0.1524 mm (6-mil) thick polyethylene plastic. The drums shall be constructed of fiber board with a plastic or metal lining and should have sealable lids. Both bags and drums shall be posted with asbestos warning labels. Once the bags are half full, the excess air shall be removed and the bag sealed and placed in a second bag. Both shall then be taken to the asbestos waste removal port, vacuumed, wet wiped taken to the "roped-off area" and placed in drums. The drums shall be sealed and stored in that area for removal. All drums shall be removed from the roped-off area daily. DRUMS CONTAINING ASBESTOS WASTE WILL NOT BE PERMITTED TO REMAIN OVERNIGHT.

1.15.3 Warning Labels

All asbestos disposal bags and drums shall be affixed with a warning label containing the following information in English and Korean:

DANGER

CONTAINS ASBESTOS FIBERS

AVOID BREATHING DUST

CANCER AND LUNG DISEASE HAZARD

1.15.4 Disposal Procedure

The Contractor shall acquire the services of a qualified industrial waste disposal company licensed by the Korean Environmental Protection Agency to dispose of all of the asbestos waste generated by the work on the site. A list of qualified industrial waste disposal contractors is available from The Korean Industrial Wastes Association, #77-9, Munredong 3 Ga, Yongdeungpo-Ku, Seoul, Korea; Telephone number: 678-1276 or 678-4680. The Contractor must submit a copy of the disposal contractor's license (see Appendix D) from the Korean Government to the Contracting Officer for acceptance prior to the delivery of any ACM. Once the license has been accepted in writing by the Contracting Officer, the ACM, properly bagged and signed, will be delivered at the construction site to the disposal contractor. Upon receipt of the ACM, the disposal contractor shall provide the Contracting Officer via the Contractor, a Hazardous Waste Conveyance/Disposal Report Form (see Appendix B)for the material received. The report form must be signed by authorized representatives of the conveyance and disposal companies. The conveyance and the disposal contractors shall be responsible for removing the ACM received from the Contractor and conveying and disposing of it in accordance with Korean law.

1.15.5 Certificate of Disposal

In addition to the Industrial Waste Disposition Card required in Section 1.15.4, the Contractor will prepare and submit a Certificate of Disposal (see Appendix C) containing the following information in English to the Contracting Officer: Date of Transaction, Name and Address of the Contractor, Contract Number, Name of the Project, Name and KID Number of the Contract Manager, Name and KID Number of receiver, Signature, Description of the Material received, Quantity of Material received - weight or volume in cubic feet, and a statement signed by officers of the conveyance and the disposal contractors' companies indicating that the material received is being conveyed and disposed of in accordance with current Korean laws and regulations. The Certificate of Disposal will then be attached to the Hazardous Waste Conveyance/Disposal Report Form and kept as a permanent part of the contract file.

1.16 CONTRACTOR QUALITY CONTROL

The Contractor shall establish and maintain a quality control procedure to assure compliance of the installed asbestos removal with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to, the following:

1.16.1 Contractor's Quality Control (CQC) Procedure

The CQC procedure for asbestos removal installation shall be submitted to the Contracting Officer for approval prior to the start of asbestos removal work.

SECTION 02071

UNDERGROUND FUEL OIL STORAGE TANK REMOVAL

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

This guide specification covers the requirements for removal and disposal of underground, non-hardened tanks used to store Petroleum products, waste oils or hazardous wastes. This guide specification is to be used in the preparation of project specifications in accordance with ER 1110-345-720. The project contractor should obtain the available as-built drawings and should conduct a field verification investigation for the tank prior to the work start.

The publications listed below form a part of this section to the extent referenced. The publications are referenced in the text by basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API Publ 2217A	(1997) Guidelines for Wood in Inert Confined Spaces in the Petroleum Industry

API Publ 2219	(1999) Safe Operation of Vacuum Trucks in Petroleum Service, 2nd Edition
API RP 1604	(1996) Closure of Underground Petroleum Storage Tanks
API RP 2003	(1998) Protection Against Ignitions Arising out of Static, Lightning and Stray Currents
API Std 2015	(1994) Safe Entry and Cleaning of Petroleum Storage Tanks

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 1556	(1990; R 1996el) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(1998) Laboratory Compaction Characteristics of Soil Using the Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu.m.)
ASTM D 2167	(1994) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2487	(1998) Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2922	(1996el) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017	(1988; R 1996el) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

CODE OF FEDERAL REGULATIONS (CFR)

40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 266	Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities
40 CFR 268	Land Disposal Restrictions
40 CFR 279	Standards for the Management of Used Oil
40 CFR 280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)

1.2 MEASUREMENT AND PAYMENT

Compensation for removal of contaminated soil and pumpable liquids shall be paid as a unit cost. This unit cost includes testing, excavation, stockpiling, transportation and disposal of the contaminated soil and backfilling with non-contaminated soil. Payment for all other work shall be under the base bid for the tank removal and shall constitute full payment for all work defined in the contract documents including testing of the contents, excavation and disposal of the tank, and testing of the underlying soil.

1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation, submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with SECTION: 01330 SUBMITTAL PROCEDURES.

SD-01 Data

Work Plan; GA.

The Work Plan shall be submitted within 30 days after notice to proceed. The Contractor shall allow 30 days in the schedule for the Government's review and approval. No adjustment for time or money will be made for re-submittals required as a result of non-compliance.

SD-08 Statements

Qualifications; GA.

A document indicating that the Contractor meets the specified requirements.
SD-09 Reports

Backfill Material; GA.

Tank Contents Verification; GA.

Contaminated Water Disposal; GA.

Soil Examination, Testing, and Analysis; GA.

The reports shall include the chain-of-custody records.

Backfilling: GA.

Copies of all laboratory and field test reports.

Tank Closure Report; GA.

5 copies of the report for each UST site opened, prepared in a standard three ring binder, within 14 days of completing work at each site. Each binder shall be labeled with contract number, project name, location and tank number; each binder shall be indexed. A copy of the report shall be furnished to the Installation Environmental Coordinator.

SD-18 Records

Salvage Rights; FIO.

A record of the disposition of salvaged materials at the end of the contract.

1.4 QUALIFICATIONS

The Contractor shall have a minimum of 2 years of tank removal experience Contractor shall be licensed and permitted by the ROK government for tank removal work.

1.4.1 Laboratory Services

For laboratory services the Contractor shall be validated in accordance with state certification requirements and Section 01450: CHEMICAL DATA QUALITY CONTROL.

1.4.2 Support Staff

The Contractor shall identify all staff involved for the various components, including personnel collecting and shipping samples. The qualifications of these staff members shall be detailed by the Contractor.

1.5 REGULATORY REQUIREMENTS

1.5.1 Permits and Licenses

The Contractor, as required or as directed by the Contracting Officer, shall obtain local, state, or federal permits and licenses that directly impact the Contractor's ability to perform the work prior to commencing removal operations.

1.5.2 Statutes and Regulations

Tank closures shall be carried out in accordance with 40 CFR 280, 40 CFR 262, 40 CFR 264, and 40 CFR 265 as well as the applicable local regulations. Hazardous material and hazardous waste shall be transported in accordance with ROK EPA regulations.

1.6 PROJECT/SITE CONDITIONS

The work shall consist of removal, decontamination and disposal of underground storage tanks and associated piping and ancillary equipment. Residue remaining in the tank is considered a special or hazardous waste. Subsurface conditions shall be examined at the site during the work. The Contractor shall verify the actual conditions prior to submitting a bid. The site shall be treated as a hazardous waste site and shall be given special consideration due to the nature of the materials and hazards present until closure activities are complete.

1.6.1 Sequencing and Scheduling

The Contractor shall notify the Installation Environmental Coordinator and the Contracting Officer 40 days prior to tank removal. The Contractor Installation Environmental Coordinator will decide who is responsible for contacting the Implementation Agency (IA) in accordance with the applicable reporting requirements.

1.6.2 Work Plan

The Contractor shall develop, implement, maintain, and supervise as part of the work, a comprehensive plan for tank removal and related operations. As a minimum the plan shall include, but not be limited to, excavation, removal, and ultimate disposal of the tank, its contents, and any contaminated materials. The Work Plan shall be based on work experience, on the requirements of this specification, and on the following references:

a. API RP 1604.
b. API Std 2015.
c. API RP 2003.
d. API Publ 2217A.
e. API Publ 2219.

No work at the site, with the exception of site inspections and mobilization, shall be performed until the Work Plan is approved. At a minimum the Work Plan shall include:

a. Discussion of the removal approach, tank cleaning, and tank cutting procedures.

b. A Sampling and Analysis Plan prepared in accordance with Section 01450: CHEMICAL DATA QUALITY CONTROL.

c. Methods to be employed for product, sludge, vapor, and pumpable liquid removal; purging and inerting; and storage methods proposed for control of surface water.

d. Treatment options.

e. Identification of waste, tank and contaminated soil transporters and means of transportation.

f. Treatment, disposal, and alternate facilities, and means of treatment, disposal or remediation.

g. Borrow source.

h. Spill prevention plan.

i. Spill contingency plan.

j. Decontamination procedures, shoring plan, and safety measures in accordance with Section: 01110 SAFETY, HEALTH, AND EMERGENCY RESPONSE (HTRW/UST).

PART 2 PRODUCTS

2.1 BACKFILL MATERIAL

Backfill material shall be obtained from the location indicated on the drawings or off-site. Backfill shall be classified in accordance with ASTM D 2487 as GW, GP, GM, GC, SW, SP, SM, SC, MH, CL, or CH and shall be free from roots and other organic matter, trash, debris, snow, ice or frozen materials. If off-site materials are used, soil classification test results shall be approved prior to bringing the material onsite. The testing frequency for backfill material shall be one per 1000 cubic meters (yards) or a minimum of one test. Non-contaminated material removed from the excavation shall be used for backfill in accordance with Paragraph BACKFILLING.

PART 3 EXECUTION

3.1 GENERAL

3.1.1 Safety Guidelines

Personnel shall abide by the safety guidelines specified in Section 01110 SAFETY, HEALTH, AND EMERGENCY RESPONSE (HTRW/UST).

3.1.2 Burning and Explosives

Use of explosives or burning debris will not be allowed.

3.1.3 Protection of Existing Structures and Utilities

The Contractor shall take all necessary precautions to avoid damage to existing structures, their appurtenances, monitoring wells, or utilities that may be affected by work activities. Any damage to utilities or monitoring wells resulting from the Contractor's operations shall be repaired at no expense to the Government. The Contractor shall coordinate with the installation to locate underground utilities prior to beginning construction. Utilities encountered which were not previously shown or otherwise located shall not be disturbed without approval from the Contracting Officer.

3.1.4 Shoring

Shoring requirements shall be provided in accordance with Section 01110: SAFETY, HEALTH, AND EMERGENCY RESPONSE (HTRW/UST).

3.2 TANK CONTENTS VERIFICATION

Sampling and analysis shall be conducted in accordance with the approved Sampling and Analysis Plan and Section 01450 CHEMICAL DATA QUALITY CONTROL. Contractor shall coordinate with the installation environmental coordinator to determined the items to be analyzed and verified for the tank.

3.2.1 Sampling

Contaminated water shall be sampled and analyzed both prior to and after treatment. Contaminated water produced from excavation operations and tank pumping treated onsite, shall be analyzed for pH; benzene, ethylbenzene, toluene, and xylene (BETX); total lead; oil and grease; total petroleum hydrocarbons (TPH). Sampling and analysis shall be performed prior to discharge to the installation sanitary sewer or disposal for every 200,000 L of contaminated water treated. Analyses for contaminated water to be taken to an off-site treatment facility shall conform to the requirements of the treatment facility with documentation of all analyses performed furnished to the Contracting Officer in accordance with paragraph RECORDS. Contaminated water shall be contained, stored onsite, and analyzed prior to being transported to the approved treatment, storage and disposal facility The Contractor shall provide approved containers, vehicles, equipment, labor, signs, labels, placards and manifests and associated land disposal notices and notifications, necessary for accomplishment of the work. Sampling and analyses of contaminated water and treated water and the Contractor and laboratory quality assurance program shall be in accordance with Section 01450: CHEMICAL QUALITY CONTROL.

3.2.2 Analysis

Tank contents shall be tested by the contractor for the parameters listed herein. Analyses shall include total petroleum hydrocarbons (TPH)] benzene, ethylbenzene, toluene and xylene (BETX) lead and others designated by the contracting officer.

3.2.3 Characterization

Prior to removing any of the tank contents, the contents shall be characterized to determine if the tank contents must be in a special manner based on local, state, and Federal disposal regulations. Tank product, pumpable liquids, and sludge shall be characterized in accordance with 40 CFR 261 and 40 CFR 279. The waste contents determination and accompanying test results for each phase present in the tank shall be submitted to the Contracting Officer. The Contractor shall be responsible for any additional requirements identified by the disposal facility. The tank contents shall not be removed until approval is given by the Contracting Officer.

3.3 CLEARING, GRUBBING AND REMOVALS

Clearing and grubbing shall be in accordance with Section: 02110 CLEARING AND GRUBBING. Areas designated for clearing and grubbing as required and directed by the Contracting Officer shall be cleared of all trees, stumps, down timber, brush, rubbish, roots larger than 75 mm (3 inches) in diameter, and matted roots prior to commencing operations. Concrete or asphalt pavement shall be saw cut at the limits of removal, broken and removed with the resulting debris disposed off Government.

3.4 TOPSOIL

Topsoil shall meet the requirements in Section 02210: GRADING.

3.5 PREPARATIONS FOR EXCAVATION

Before excavating, the Contractor shall drain product piping back to the tank, remove residual liquids trapped in the product lines, remove all product from the tank, and the tank shall be purged and vented in accordance with API RP 1604 and as specified herein.

3.5.1 Removal of Product, Pumpable Liquids, and Sludge

Tank product, pumpable liquids, and sludge shall be contained, and stored onsite, prior to disposal. Contaminated water shall be treated as specified. Tank product, pumpable liquids, and sludge shall be analyzed and segregated to recover reusable products by the Contractor prior to being transported to the designated location. Tank product, pumpable liquids, and sludge shall be removed and disposed of by the Contractor. No Government facilities shall be used for permanent storage or disposal of the wastes. Temporary storage on Government facilities shall be allowed only until testing is complete, manifests (if necessary) are complete, and transportation is arranged. The Contractor shall be responsible for obtaining all required permits. Usable product shall be the property of the Government. The Contractor shall provide approved containers, vehicles, equipment, labor, signs, labels, placards and manifests and associated land disposal restriction notices and notifications, necessary for accomplishment of the work, including materials necessary for cleaning up spills that could occur from tank removal operations.

3.5.2 Contaminated Water Disposal

3.5.2.1 General

Contaminated water shall be sampled and analyzed both prior to and after treatment. Contaminated water produced from excavation operations and tank pumping treated onsite, shall be analyzed for pH; benzene, ethylbenzene, toluene, and xylene (BETX); total lead; oil and grease; total petroleum hydrocarbons (TPH). Sampling and analysis shall be performed prior to discharge to the installation sanitary sewer for every 20,000 L of contaminated water treated. Where off site treatment is required, analyses for contaminated water to be taken to an off-site treatment facility shall conform to the requirements of the treatment facility with documentation of all analyses performed furnished to the Contracting Officer in accordance with paragraph RECORDS. Contaminated water shall be contained, stored onsite, and analyzed prior to being transported to the approved treatment, storage and disposal facility and disposed of by the Contractor in accordance with applicable Federal and State disposal regulations. The Contractor shall provide approved containers, vehicles, equipment, labor, signs, labels, placards and manifests and associated land disposal notices and notifications, necessary for accomplishment of the work. Sampling and analyses of contaminated water and treated water and the Contractor and laboratory quality assurance program shall be in accordance with Section: 01450 CHEMICAL DATA QUALITY CONTROL.

3.5.2.2 Treatment

Contaminated water shall be treated onsite or off-site by means as approved by the Contracting Officer. If contaminated water is to be treated onsite, the proposed treatment shall be specified in the Work Plan and submitted for approval. Temporary storage and treatment equipment shall be installed at a location approved by the Contracting Officer. Treated effluent shall be sampled and analyzed and the results approved by the Contracting Officer before discharge to existing sewer or drainage systems. Effluent shall be treated and discharged in accordance with the discharge permit.

3.6 PURGING AND INERTING

After the tank and piping contents have been removed, but prior to excavation beyond the top of the tank, the Contractor shall disconnect all the piping (except the piping needed to purge or inert the tank). Flammable and toxic vapors shall be purged from the tank or the tank made inert in accordance with API RP 1604, with the exceptions that filling with water shall not be used and, if dry ice is employed, the Contractor shall use a minimum of 1.8 kg per 500 L (3 pounds per 100 gallons) of tank volume. The tank atmosphere shall be continuously monitored for combustible vapors if the tank is purged, or continuously monitored for oxygen if the tank is inerted.

3.7 EXCAVATION

Excavation areas, as well as work near roadways, shall be marked in accordance with Section: 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE (HTRW/UST).

3.7.1 Exploratory Trenches

Exploratory trenches shall be excavated as necessary to determine the tank location, limits and the location of ancillary equipment.

3.7.2 Tank Excavation

Excavation around the perimeter of the tank shall be performed limiting the amount of potentially petroleum contaminated soil that could be mixed with previously uncontaminated soil. Petroleum contaminated soil shall be segregated in separate stockpiles. The Contractor shall maintain around the tank an excavation of sufficient size to allow workers ample room to complete the work, but also protect the workers from sliding or cave-ins. Sheeting, bracing, or shoring shall be installed in the absence of adequate side slopes if there is a need for workers to enter the excavated area. Surface water shall be diverted to prevent direct entry into the excavation. Dewatering of the excavation may require a discharge permit by the State and shall be limited to allow adequate access to the tank and piping, to assure a safe excavation, and to ensure that compaction and moisture requirements are met during backfilling. Dewatering may result in the production of petroleum contaminated water and/or free product. Free product shall be recovered from the groundwater only as part of necessary dewatering.

3.7.3 Piping Excavation

Excavation shall be performed as necessary to remove tank piping and ancillary equipment in accordance with paragraphs: SHORING, TANK EXCAVATION, and OPEN EXCAVATIONS.

3.7.4 Open Excavations

Open excavations and stockpile areas shall be secured while awaiting confirmation test results from the soil beneath the tank. The excavation shall be backfilled as soon as possible after tank and contaminated soil removals have been completed and confirmation samples have been taken. The Contractor shall divert surface water around excavations to prevent water from directly entering into the excavation.

3.7.5 Stockpiles

Uncontaminated excavated soil and petroleum contaminated soil that is not a state-regulated hazardous waste shall be stockpiled and used for backfill in the tank excavation prior to using borrow material. Excavated material that is regulated by the state as a hazardous waste which is visibly stained or which has an obvious petroleum odor or as required by implementing agency shall be considered contaminated and shall be placed in containers such as drums, roll-offs or dumpsters for sampling in accordance with paragraph Stockpiled Material Sampling. Uncontaminated soil shall be stockpiled separately from the contaminated soil, a safe distance away from, but adjacent to, the excavation. Allowable stockpiles of contaminated soil shall be placed on an impermeable geomembrane a minimum of 3 layers, each 0.8 thick, and covered with a 0.8 mm sheet of geomembrane or the method as directed by the COR. The geomembrane shall be placed to prevent the stockpiled soil from coming into contact with surface water run-off. The geomembrane or container cover shall prevent rain or surface water from coming into contact with the contaminated soil, as well as limit the escape of the volatile constituents in the container or in the stockpile.

3.8 REMOVAL OF PIPING, ANCILLARY EQUIPMENT, AND TANK

3.8.1 Piping and Ancillary Equipment

All piping and ancillary equipment shall be disconnected from the tank. The piping shall be removed completely (interior and exterior of the tank) or as directed by the Contracting Officer. All tank ancillary equipment and piping connections shall be capped, except those connections necessary to inert the tank within the excavation zone. The piping exterior and ancillary equipment shall be cleaned to remove all soil and inspected for signs of corrosion and leakage. The Contractor shall ensure no spillage of the piping contents occurs, as specified in the Work Plan, and as required in paragraph SPILL RESPONSIBILITY. If the soil under and around the tank pad is not contaminated, the tank pad shall remain in place.

3.8.2 Tank

The tank shall be removed from the excavation and the exterior cleaned to remove all soil and inspected for signs of corrosion, structural damage, or leakage. All materials coming into contact with the tank, or in the vicinity of the excavation such as shovels, slings and tools shall be of the non-sparking type. After removal from the excavation, the tank shall be placed on a level surface at an approved location and secured with wood blocks to prevent movement.

3.8.3 Contaminated Soil, Tank and Piping Excavation Examination

After the tank has been removed from the ground, the adjacent and underlying soil shall be examined for any evidence of leakage. The soil shall be visually inspected for staining after removal of all obviously contaminated soil, then screened for the presence of volatile and/or semi-volatile contamination using a real time vapor monitoring instrument. Uncontaminated soil or petroleum contaminated soil not regulated by the state as hazardous waste shall be stockpiled onsite per paragraph STOCKPILES or transported off-site for disposal as directed by the COR. Contaminated soil or suspected contaminated soil shall be containerized, or, if the site is a RCRA-designated CAMU, stockpiled until further disposition. The Contracting Officer shall determine the extent of the contaminated soil to be removed from each . The Contractor shall report any evidence indicating that the amount of contaminated soil may exceed the individual site limit specified, to the Installation's Environmental Coordinator and Contracting Officer the same day it is discovered. If minimal additional excavation is required, the Contracting Officer may allow the Contractor to proceed. If extensive contamination is encountered, the excavation shall be sampled and backfilled in accordance with paragraph BACKFILLING. After the known contaminated soil is removed, the excavation shall be sampled and analyzed in accordance with Section 01450: CHEMICAL DATA QUALITY CONTROL.

3.9 TANK CLEANING

3.9.1 Exterior

Soil shall be removed from the exterior of the tank, piping, and associated equipment to eliminate soil deposition on roadways during transportation to a temporary storage area, ensure markings will adhere to the surfaces, and simplify tank cutting. Soil shall be removed using non-sparking tools. Removed uncontaminated soil and soil not regulated by the state as a hazardous waste shall be recovered and used as backfill in the former tank excavation or disposed of the location as directed by the COR. Soil believed to be contaminated shall be removed and containerized, or if the site is a RCRA designated CAMU, collected on 3 layers of 0.8 mm impermeable geomembrane and stockpiled with other contaminated soil removed from the excavation.

3.9.2 Temporary Storage

If the tank is stored after the tank exterior is cleaned and ancillary equipment is removed, and prior to being cut into sections, the tank shall be labeled as directed in API RP 1604, placed on blocks, and temporarily stored at the location designated by the COR. Prior to cleaning the tank interior the tank atmosphere shall be monitored for combustible vapors and purged or inerted if combustible vapors are detected.

3.9.3 Interior

The tank interior shall be cleaned using a high pressure (greater than 3.45 MPa (500 psi)), low volume (less than 0.13 L/s (2 gpm)) water spray or steam cleaned until all loose scale and sludge is removed, and contamination, in the form of a sheen, is no longer visible in the effluent stream. The interior surfaces of piping shall also be cleaned, to the extent possible, using the same method used for cleaning the tank. Contaminated water generated from interior cleaning operations (of both piping and tank) shall not exceed the following quantities for each UST cleaned:

UST VOLUME (LITERS)	PERCENT OF UST VOLUME
3,785 or less	5
37,850 or less	5 or 378 L, whichever is less
75,700 or less	1 or 568 L, whichever is less
greater than 75,700	1 or 946 L, whichever is less

UST VOLUME (GALLONS)	PERCENT OF UST VOLUME
1,000 or less	5
10,000 or less	5 or 100 gal., whichever is less
20,000 or less	1 or 150 gal., whichever is less
greater than 20,000	1 or 250 gal., whichever is less

All contaminated water resulting from cleaning operations shall be discharged to the installation sanitary sewer after passing through an oil-water separator. Cleaning shall be accomplished eliminating, to the greatest extent possible, the need for personnel to enter the tank. Cleaning shall be done using specially designed tank cleaning equipment which allows the tank to be cleaned prior to cutting into sections without requiring personnel to enter the tank or, if less specialized equipment is used, the tank shall be partially dissected to overcome confined space entry hazards. This work shall be accomplished in accordance with Section 01110: SAFETY, HEALTH, AND EMERGENCY RESPONSE (HTRW/UST).

3.10 SOIL EXAMINATION, TESTING, AND ANALYSIS

3.10.1 General

After soil known to be contaminated has been removed or after soil excavation is complete, the excavation shall be sampled with procedures, number, location, and methodology in accordance with state regulations and Section 01450: CHEMICAL DATA QUALITY CONTROL. Samples may be obtained from the pits using a backhoe with a Shelby tube attached to the bucket. Sample preservation and analytical procedures shall conform to Section 01450 CHEMICAL DATA QUALITY CONTROL.

3.10.2 Stockpiled Material Sampling

Stockpiled contaminated soil shall be sampled and preserved in accordance with the approved Sampling and Analysis Plan, and Section 01450.

CHEMICAL DATA QUALITY CONTROL

3.10.3 Analysis

Soil samples from the excavation and stockpiled material shall be tested in accordance with the approved Sampling and Analysis Plan, and Section 01450 CHEMICAL DATA QUALITY CONTROL for the following parameters: total petroleum hydrocarbon (TPH) benzene, ethylbenzene, toluene, xylene (BETX) toxicity characteristic leaching procedure (TCLP). Copies of all test results shall be provided to the Contracting Officer.

3.11 BACKFILLING

The tank area and any other excavations shall be backfilled only after the soil test results have been approved. Contaminated soil removal shall be complete after the bottom of the tank excavation is determined to have soil contamination levels below the state standards of 100 ppm TPH. The excavation shall be dewatered if necessary. Stockpiled material subjected to chemical confirmation testing shall be used as backfill if it is found to conform to the requirements of clean fill per appropriate state regulations contain less than 100 ppm of total petroleum hydrocarbons (TPH). Backfill consisting of clean fill shall be placed in layers with a maximum loose thickness of 200 mm, 8 inches,) and compacted to 90 percent maximum density for cohesive soils and 95 percent maximum density for cohesionless soils. Density tests shall be performed by an approved commercial testing laboratory or by facilities furnished by the Contractor. Test results shall be attached to contractor's Quality Control Report. A minimum of one density test shall be performed on each lift. Laboratory tests for moisture density relations shall be determined in accordance with ASTM D 1557, Method B, C, or D, or ASTM D 3017. A mechanical tamper may be used provided that the results are correlated with those obtained by the referenced hand tamper. Field in-place density shall be determined in accordance with ASTM D 1556, ASTM D 2922, or ASTM D 2167.

3.12 DISPOSAL REQUIREMENTS

3.12.1 General

Disposal of hazardous or special wastes shall be in accordance with all local, State, and Federal solid and hazardous waste laws and regulations; the Resource Conservation and Recovery Act (RCRA); Section 02120: TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS; and conditions specified herein. This work shall include all necessary personnel, labor, transportation, packaging, detailed analyses (if required for disposal, manifesting or completing waste profile sheets), equipment, and reports. Product and pumpable liquids removed from the tank shall be recycled to the greatest degree practicable. The tanks removed shall be disposed of at the location designated by the contracting officer. Each tank disposed of in this manner shall be manifested as required by the installation environmental coordinator to document delivery and acceptance at the disposal facility.

3.12.2 Tank and Ancillary Equipment Disposal

After the tank, piping, and ancillary equipment have been removed from the excavation and the tank cleaned, the tank shall be cut into sections with no dimension greater than 1500 mm. (5 feet.) Tank and piping sections shall be at the location designated by the COR. Piping shall be disconnected from the tank and removed unless otherwise indicated.

3.12.3 Transportation of Wastes

Transportation shall be provided in accordance with Department of Transportation (DOT) Hazardous Material Regulations and State and local requirements, including obtaining all necessary permits, licenses, and approvals. Evidence that a State licensed hazardous waste transporter is being used shall be included in the SUBMITTALS.

3.12.4 Salvage Rights

The Contractor shall retain the rights to salvage value of recycled or reclaimed product and metal not turned in to the DRMO or otherwise identified, so long as the requirements of 40 CFR 266 and 40 CFR279, or the applicable State requirements are met. At the end of the contract, the Contractor shall provide documentation on the disposition of salvaged materials.

3.12.5 Records

Records shall be maintained of all waste determinations, including appropriate results of analyses performed, substances and sample location, the time of collection, and other pertinent data as required by 40 CFR 280, Section 74 and 40 CFR 262 Subpart D, and Section 01450: CHEMICAL DATA QUALITY CONTROL. Transportation, treatment, disposal methods and dates, the quantities of waste, the names and addresses of each transporter and the disposal or reclamation facility, shall also be recorded and available for inspection, as well as copies of the following documents:

a. Manifests.

b. Waste analyses or waste profile sheets.

c. Certifications of final treatment/disposal signed by the responsible disposal facility official.

d. Land disposal notification records required under40 CFR 268 for hazardous wastes.

Records shall be provided in accordance with Section 02120: TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS. Following contract close out, the records shall become the property of the Government.

3.12.6 Hazardous/Special Waste Manifests

Manifesting shall conform to the requirements specified in Section 02120: TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS.

3.12.7 Documentation of Treatment or Disposal

The wastes, other than recyclable or reclaimable product or metal, shall be taken to a treatment, storage, or disposal facility which has EPA or appropriate state permits and hazardous or special waste identification numbers and complies with all of the provisions of the disposal regulations. Documentation of acceptance of special waste by a facility legally permitted to treat or dispose of those materials shall be furnished to the Contracting Officer not later than 5 working days following the delivery of those materials to the facility and a copy included in the Tank Closure Report. A statement of agreement from the proposed treatment, storage or disposal facility and certified transporters to accept hazardous or special wastes shall be furnished to the Contracting Officer not less than 14 days before transporting any wastes. If the contractor select a different facility than is identified in the contract documentation shall be provided for approval to certify that the facility is authorized and meets the standards specified in 40 CFR 264.

3.13 SPILLS

Immediate containment actions shall be taken as necessary to minimize effect of any spill or leak. Cleanup shall be in accordance with applicable Federal, State, local laws and regulations, and district policy at no additional cost to the Government. Refer to Section 02120: TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS for spill response and reporting requirements.

3.14 TANK CLOSURE REPORT

Tank Closure Reports shall include the following information as a minimum:

a. A cover letter signed by a responsible company official certifying that all services involved have been performed in accordance with the terms and conditions of this specification.

b. A narrative report describing what was encountered at each site, including:

(1) condition of the UST.

(2) any visible evidence of leaks or stained soils.

(3) results of vapor monitoring readings.

(4) actions taken including quantities of materials treated or removed.

(5) reasons for selecting sample locations.

(6) sample locations.

(7) collection data such as time of collection and method of preservation.

(8) reasons for backfilling site.

(9) whether or not groundwater was encountered.

c. Copies of all analyses performed for disposal.

d. Copies of all waste analyses or waste profile sheets.

e. Copies of all certifications of final disposal signed by the responsible disposal installation official.

f. Information on who sampled, analyzed, transported, and accepted all wastes encountered, including copies of manifests, waste profile sheets, land disposal restriction, notification and certification forms, certificates of disposal, and other pertinent documentation.

g. Copies of all analyses performed for confirmation that underlying soil is not contaminated, with copies of chain-of-custody for each sample. All analyses shall give the identification number of the sample used. Sample identification numbers shall correspond to those provided on the one-line drawings.

h. Scaled one-line drawings showing tank locations, limits of excavation, limits of contamination, underground utilities within 15 m, (50 feet,) sample locations, and sample identification numbers.

i. Progress Photographs. The Contractor shall take a minimum of 4 views of the site showing such things as the location of each tank, entrance/exit road, and any other notable site condition before work begins. After work has been started at the site, the Contractor shall photographically record activities at each work location daily. Photographs shall be 76.2 x 127.0 mm (3 x 5 inches) and shall include:

(1) Soil removal, handling, and sampling.

(2) Unanticipated events such as discovery of additional contaminated areas.

(3) Soil stockpile area.

(4) Tank.

(5) Site or task-specific employee respiratory and personal protection.

(6) Fill placement and grading.

(7) Post-construction photographs. After completion of work at each site, the Contractor shall take a minimum of four (4) views of the site. Prints shall illustrate the condition and location of work and the state of progress. The photographs shall be mounted and enclosed back-to-back in a double face plastic sleeve punched to fit standard three ring binders. Each color print shall show an information box, 40 x 90 mm. (1-1/2 x 3-1/2 inches.) The information box for the 76.2 x 127.0 mm (3 x 5 inch) photographs shall be scaled down accordingly, or taped to the bottom of the photo. The box shall be typewritten and arranged as follows:

Project No.	Contract No.
Location	
Contractor/Photographer	
Photograph No.	Date/Time:
Description	
Direction of View	

SECTION 02110

CLEARING AND GRUBBING

TABLE OF CONTENTS

PART 1 GENERAL

When this specification is being used for the remediation of hazardous waste sites, the paragraph should define how both contaminated and non-contaminated materials will be disposed of.

1.1 DEFINITIONS

1.1.1 Clearing

Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including down timber, snags, brush, and rubbish occurring in the areas to be cleared.

1.1.2 Grubbing

Grubbing shall consist of the removal and disposal of stumps, roots larger than 75 millimeters (3 inches) in diameter, and matted roots from the designated grubbing areas.

1.2 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES:

PART 2 PRODUCTS AND EXECUTION

2.1 CLEARING

Trees, stumps, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees designated to be left standing within the cleared areas shall be trimmed of dead branches 40 millimeters (1-1/2 inches) or more in diameter and shall be trimmed of all branches to the heights indicated or directed. Limbs and branches to be trimmed shall be neatly cut close to the bole of the tree or main branches. Cuts more than 40 millimeters (1-1/2 inches) in diameter shall be painted with an approved tree-wound paint. Trees and vegetation to be left standing shall be protected from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require. Clearing shall also include the removal and disposal of structures that obtrude, encroach upon, or otherwise obstruct the work.

2.2 GRUBBING

Material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, shall be removed to a depth of not less than 0.5 meters (18 inches) below the original surface level of the ground. Removal shall be in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Depressions made by grubbing shall be filled with suitable material and compacted to make the surface conform to the original adjacent surface of the ground.

2.3 TREE REMOVAL

Where indicated or directed trees and stumps that are designated as trees shall be removed from areas outside those areas designated for clearing and grubbing. This work shall include the felling of such trees and the removal of their stumps and roots as specified in paragraph 2.2, GRUBBING. Trees shall be disposed of as specified in paragraph 2.4, DISPOSAL OF MATERIALS.

2.4 DISPOSAL OF MATERIALS

2.4.1 Removal of Unsatisfactory Materials

Unsatisfactory materials at the areas within 1.5 meters (5 FEET) from the building or facility lines shall be removed and replaced with satisfactory materials per SECTION 02221: EXCAVATION, FILLING AND BACKFILLING FOR BUILDINGS.

2.4.2 Disposal of Cleared and Grubbed Materials

Cleared and grubbed material and unsatisfactory materials removed shall be disposed of outside the limits of Government controlled land and at the Contractor’s responsibility.

2.5 TOPSOIL

Topsoil shall be stripped, stockpiled and reused per SECTION 02210: GRADING.

2.6 CONTRACTOR QUALITY CONTROL

The Contractor shall establish and maintain a quality control procedure to assure compliance of the installed clearing and grubbing with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to, the following”

a. Trees to be left standing or transplanted.

b. Conservation of topsoil.

c. Disposal of hazardous waste material.

2.6.1 Contractor’s Quality Control (CQC) Procedures

The CQC procedure for clearing and grubbing installation shall be submitted to the Contracting Officer for approval prior to the start of clearing and grubbing work.

SECTION 02120

TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

CODE OF FEDERAL REGULATIONS (CFR)

40 CFR 61	National Emission Standards for Hazardous Air Pollutants
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 263	Standards Applicable to Transporters of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous waste Treatment, storage, and Disposal Facilities
40 CFR 265	Interim Status Standards for owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 266	Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities

40 CFR 268	Land Disposal Restrictions
40 CFR 270	EPA Administered Permit Programs: The Hazardous Waste Permit Program
40 CFR 279	Standards for the Management of Used Oil
40 CFR 300	National Oil and Hazardous Substances Pollution Contingency Plan
40 CFR 302	Designation, Reportable Quantities, and Notification
40 CFR 761	Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions
49 CFR 107	Hazardous Materials Program Procedures
49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements
49 CFR 173	Shippers - General Requirements for Shipments and Packaging
49 CFR 178	Specifications for Packaging
USFK Pam 200-1	Environmental Quality Environmental Governing Standards

1.2 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01300 SUBMITTAL PROCEDURES:

SD-1 Data

On-site Hazardous Waste Management; GA.

Off-site Hazardous Waste Management; GA.

Prior to start of work, a plan detailing the manner in which hazardous wastes shall be managed.

SD-09 Reports

Record keeping; GA.

Information necessary to file state annual or EPA biennial reports for all hazardous waste transported, treated, stored, or disposed of under this contract. The Contractor shall not forward these data directly to the regulatory agency but to the Contracting Officer at the specified time. The submittal shall contain all the information necessary for filing of the formal reports in the form and format required by the governing Federal or state regulatory agency. A cover letter shall accompany the data to include the contract number, Contractor name, and project location.

Spill Response; FIO.

In the event of a spill or release of a hazardous substance (as designated in 40 CFR 302), or pollutant or contaminant, or oil (as governed by the Oil Pollution Act (OPA), 33 U.S.C. 2701 et seq.), the Contractor shall notify the Contracting Officer immediately. If the spill exceeds a reporting threshold, the Contractor shall follow the pre-established procedures for immediate reporting to the Contracting Officer.

Exception Reports; GA.

In the event that a manifest copy documenting receipt of hazardous waste at the treatment, storage, and disposal facility is not received within 35 days of shipment initiation, the Contractor shall prepare and submit an exception report to the Contracting Officer within 37 days of shipment initiation.

Spill and Leak Plan; GA

The contractor must provide a accidental spill or leak plan based on USFK Pam. 200-1 or installation's spill plan and submit the plan that reviewed by environment officer of the installation to the contracting Officer.

SD-13 Certificates

Qualifications; FIO.

Copies of the current certificates of registration issued to the Contractor and/or subcontractors or written statements certifying exemption from these requirements.

Off-Site Policy Compliance Certification; GA.

A letter certifying that EPA considers the facilities to be used for all off-site disposal to be acceptable in accordance with the Off-Site policy in 40 CFR 300, Section .440. This certification shall be provided for wastes from Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901 et seq., sites as well as from Comprehensive Environmental Response.

Compensation and Liability Act (CERCLA), 42 U.S.C. 9601 et seq., responses. See Attachment A sample certification at the end of this section.

Certificates of Disposal; FIO.

Certificates documenting the ultimate disposal of hazardous wastes, polychlorinated biphenyls (PCBs), and/or asbestos within 180 days of initial shipment. Receipt of these certificates will be required for final payment.

Shipping Document and Packaging Certification; GA.

All transportation related shipping documents to the Contracting Officer, through the COR, including draft hazardous waste manifests, draft land disposal restriction notifications, draft asbestos waste shipment records, draft manifests for PCBs and draft bill of lading for hazardous materials, lists of corresponding proposed labels, packages, marks, and placards to be used for shipment, waste profiles and supporting waste analysis documents, for review a minimum of 14 days prior to anticipated pickup. Packaging assurances shall be furnished prior to transporting hazardous material; "generator copies" of hazardous waste manifests, land disposal restriction notifications and asbestos waste shipment records, "generator copies" of manifests used for initiating shipments of PCBs, used oil invoices/shipment records, bill of lading, and supporting waste analysis documents shall be furnished when shipments are originated; and "receipt copies" of asbestos waste shipment records at the designated disposal facility shall be furnished not later than 35 days after acceptance of the shipment.

SD-18 Records

Notices of Non-Compliance and Notices of Violation; FIO.

Notices of non-compliance or notices of violation by a Federal, state, or local regulatory agency issued to the Contractor in relation to any work performed under this contract. The Contractor shall immediately provide copies of such notices to the Contracting Officer. The Contractor shall also furnish all relevant documents regarding the incident and any information requested by the Contracting Officer, and shall coordinate its response to the notice with the Contracting Officer or his designated representative prior to submission to the notifying authority. The Contractor shall also furnish a copy to the Contracting Officer of all documents submitted to the regulatory authority, including the final reply to the notice, and all other materials, until the matter is resolved.

1.3 QUALIFICATIONS

1.3.1 Transportation and Disposal Coordinator

The Contractor shall designate, by position and title, one person to act as the Transportation and Disposal Coordinator (TDC) for this contract. The TDC shall serve as the single point of contact for all environmental regulatory matters and shall have overall responsibility for total environmental compliance at the site including but not limited to accurate identification and classification of hazardous waste and hazardous materials; determination of proper shipping names; identification of marking, labeling, packaging and placarding requirements; completion of waste profiles, hazardous waste manifests, asbestos waste shipment records, PCB manifests, bill of lading, exception and discrepancy reports; and all other environmental documentation. The TDC shall have, at a minimum, one year of specialized experience in the management and transportation of hazardous waste.

1.3.2 Training

The Contractor's hazardous materials employees shall be trained, tested, and certified to safely and effectively carry out their assigned duties in accordance with Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE (HTRW/UST). The Contractor's employees transporting hazardous materials or preparing hazardous materials for transportation shall be trained, tested, and certified in accordance with 49 CFR 172.

1.3.3 Certification

The Contractor and/or subcontractors transporting hazardous materials shall possess a current certificate of registration issued by the Research and Special Programs Administration (RSPA), U.S. Department of Transportation, when required by 49 CFR 107, Subpart G.

1.4 LAWS AND REGULATIONS REQUIREMENTS

Work shall meet or exceed the minimum requirements established by Federal, state, and local laws and regulations which are applicable. These requirements are amended frequently and the Contractor shall be responsible for complying with amendments as they become effective. In the event that compliance exceeds the scope of work or conflicts with specific requirements of the contract, the Contractor shall notify the Contracting Officer immediately.

1.5 DEFINITIONS

a. Hazardous Material. A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated pursuant to the Hazardous Materials Transportation Act, 49 U.S.C. Appendix Section 1801 et seq. The term includes materials designated as hazardous materials under the provisions of 49 CFR 172, Sections .101 and .102 and materials which meet the defining criteria for hazard classes and divisions in 49 CFR 173. EPA designated hazardous wastes are also hazardous materials.

b. Hazardous Waste. A waste which meets criteria established in RCRA or specified by the EPA in 40 CFR 261 or which has been designated as hazardous by a RCRA authorized state program.

PART 2 PRODUCTS

2.1 MATERIALS

The Contractor shall provide all of the materials required for the packaging, labeling, marking, placarding and transportation of hazardous wastes and hazardous materials in conformance with Department of Transportation standards. Details in this specification shall not be construed as establishing the limits of the Contractor's responsibility.

2.1.1 Packaging

The Contractor shall provide bulk and non-bulk containers for packaging hazardous materials/wastes consistent with the authorizations referenced in the Hazardous Materials Table in 49 CFR 172, Section .101, Column 8. Bulk and non-bulk packaging shall meet the corresponding specifications in 49 CFR 173 referenced in the Hazardous Materials Table, 49 CFR 172, Section .101. Each packaging shall conform to the general packaging requirements of Subpart B of 49 CFR 173, to the requirements of 49 CFR 178 at the specified packing group performance level, to the requirements of special provisions of column 7 of the Hazardous Materials Table in 49 CFR 172, Section .101, and shall be compatible with the material to be packaged as required by 40 CFR 262. The Contractor shall also provide other packaging related materials such as materials used to cushion or fill voids in overpacked containers, etc. Sorbing materials shall not be capable of reacting dangerously with, being decomposed by, or being ignited by the hazardous materials being packaged. Additionally, sorbents used to treat free liquids to be disposed of in landfills shall be non-biodegradable as specified in 40 CFR 264, Section

.314.

2.1.2 Markings

The Contractor shall provide markings for each hazardous material/waste package, freight container, and transport vehicle consistent with the requirements of 49 CFR 172, Subpart D and 40 CFR 262, Section .32(for hazardous waste), 40 CFR 761, Section .45 (for PCBs) and 40 CFR 61, Section .149(d) (for asbestos). Markings must be capable of withstanding, without deterioration or substantial color change, a 180 day exposure to conditions reasonably expected to be encountered during container storage and transportation.

2.1.3 Labeling

The Contractor shall provide primary and subsidiary labels for hazardous materials/wastes consistent with the requirements in the Hazardous Materials Table in 49 CFR 172, Section .101, Column 6. Labels shall meet design specifications required by 49 CFR 172, Subpart E including size, shape, color, printing, and symbol requirements. Labels shall be durable and weather resistant and capable of withstanding, without deterioration or substantial color change, a 180 day exposure to conditions reasonably expected to be encountered during container storage and transportation.

2.1.4 Placards

For each off-site shipment of hazardous material/waste, the Contractor shall provide primary and subsidiary placards consistent with the requirements of 49 CFR 172, Subpart F. Placards shall be provided for each side and each end of bulk packaging, freight containers, transport vehicles, and rail cars requiring such placarding. Placards may be plastic, metal, or other material capable of withstanding, without deterioration, a 30 day exposure to open weather conditions and shall meet design requirements specified in 49 CFR 172, Subpart F.

2.1.5 Spill Response Materials

The Contractor shall provide spill response materials including, but not limited to, containers, adsorbent, shovels, and personal protective equipment. Spill response materials shall be available at all times in which hazardous materials/wastes are being handled or transported. Spill response materials shall be compatible with the type of material being handled.

2.2 EQUIPMENT AND TOOLS

The Contractor shall provide miscellaneous equipment and tools necessary to handle hazardous materials and hazardous wastes in a safe and environmentally sound manner.

PART 3 EXECUTION

3.1 ON-SITE HAZARDOUS WASTE MANAGEMENT

These paragraphs apply to Government owned waste only. Contractors are prohibited by 10 U.S.C. 2692 from storing contractor owned waste on site for any length of time. The Contractor shall be responsible for ensuring compliance with all Federal, state, and local hazardous waste laws and regulations and shall verify those requirements when preparing reports, waste shipment records, hazardous waste manifests, or other documents. The Contractor shall identify hazardous wastes using criteria set forth in 40 CFR 261 or all applicable state and local laws, regulations, and ordinances. When accumulating hazardous waste on-site, the Contractor shall comply with generator requirements in 40 CFR 262 and any applicable state or local law or regulations. On-site accumulation times shall be restricted to applicable time frames referenced in 40 CFR 262, Section.34 and any applicable state or local law or regulation. Accumulation start dates shall commence when waste is first generated (i.e. containerized or otherwise collected for discard). The Contractor shall only use containers in good condition and compatible with the waste to be stored. The Contractor shall be responsible for ensuring containers are closed except when adding or removing waste. The Contractor shall be responsible for immediately marking all hazardous waste containers with the words "hazardous waste" and other information required by 40 CFR 262, Section 32 and any applicable state or local law or regulation as soon as the waste is containerized. An additional marking shall be placed on containers of "unknowns" designating the date sampled, and the suspected hazard. The Contractor shall be responsible for inspecting containers for signs of deterioration and shall be responsible for responding to any spills or leaks. The Contractor shall inspect all hazardous waste areas weekly and shall provide written documentation of the inspection. Inspection logs will contain date and time of inspection, name of individual conducting the inspection, problems noted, and corrective actions taken.

3.1.1 Hazardous Waste Classification

The Contractor, in consultation with the Contracting Officer, COR, waste generator and EPA officer, shall identify all waste codes applicable to each hazardous waste stream based on requirements in 40 CFR 261 or any applicable state or local law or regulation. The Contractor shall also identify all applicable treatment standards in 40 CFR 268 and state land disposal restrictions and shall make a determination as to whether or not the waste meets or exceeds the standards. Waste profiles, analyses, classification and treatment standards information shall be submitted to Contracting Officer for review and approval.

3.1.2 Management Plan

The Contractor shall prepare a plan detailing the manner in which hazardous wastes shall be managed and describing the types and volumes of hazardous wastes anticipated to be managed as well as the management practices to be utilized. The plan shall identify the method to be used to ensure accurate piece counts and/or weights of shipments; shall identify waste minimization methods; shall propose facilities to be utilized for treatment, storage, and/or disposal; shall identify areas on-site where hazardous wastes are to be handled; shall identify whether transfer facilities are to be utilized; and if so, how the wastes will be tracked to ultimate disposal.

3.2 OFF-SITE HAZARDOUS WASTE MANAGEMENT

The Contractor shall use RCRA Subtitle C permitted facilities which meet the requirements of 40 CFR 264 or facilities operating under interim status which meet the requirements of 40 CFR 265. Off-site treatment, storage, and/or disposal facilities with significant RCRA violations or compliance problems (such as facilities known to be releasing hazardous constituents into ground water, surface water, soil, or air) shall not be used.

3.2.1 Description of TSD Facility and Transporter

The Contractor shall provide the Contracting Officer with EPA ID numbers, names, locations, and telephone numbers of TSD facilities and transporters. This information shall be contained in the Hazardous Waste Management Plan for approval prior to waste disposal.

3.2.2 Status of the Facility

Facilities receiving hazardous waste must be permitted in accordance with 40 CFR 270 or operating under interim status in accordance with 40 CFR 265 requirements or must be permitted by an authorized state program. Additionally, prior to using a TSD Facility, the Contractor shall contact the EPA Regional Off-site Coordinator specified in 40 CFR 300, Section .440, to determine the facility's status and document all information necessary to satisfy the requirements of the EPA Off-Site policy and furnish this information to the Contracting Officer.

3.2.3 Packagings Certification

Prior to shipment of any hazardous material off-site, the Contractor's TDC shall provide written certification to the Contracting Officer that hazardous materials have been properly packaged, labeled, and marked in accordance with Department of Transportation and EPA requirements.

3.2.4 Transportation

The Contractor shall use manifests for transporting hazardous wastes as required by 40 CFR 263 or any applicable state or local law or regulation. Transportation shall comply with all requirements in the Department of Transportation referenced regulations in the 49 CFR series. The Contractor shall acquire manifests in accordance with the hierarchy established in 40 CFR 262, Section .21. The Contractor shall prepare hazardous waste manifests for each shipment of hazardous waste shipped off-site. Manifests shall be completed using instructions in 40 CFR 262, Subpart B and any applicable state or local law or regulation. Manifests and waste profiles shall be submitted to Contracting Officer for review and approval. The Contractor shall prepare land disposal restriction notifications as required by 40 CFR 268 or any applicable state or local law or regulation for each shipment of hazardous waste. Notifications shall be submitted with the manifest to the Contracting Officer for review and approval. When the additional cost of sending a qualified USACE representative to a remote location for a small clean up project is unwarranted, the option of requiring the on-site Contractor to sign the manifests on behalf of the generator is permitted and should be considered. This option shall only be exercised on a project specific basis, if prior to the solicitation process, written authorization of the customer and approval of the Chief, Construction Division at the executing district has been obtained, and the technical provisions of the contract solicitation provide competing contractors notice of the requirement.

3.2.5 Treatment and Disposal of Hazardous Wastes

The hazardous waste shall be transported to an approved hazardous waste treatment, storage, or disposal facility within 90 days of the accumulation start date on each container or recorded accumulation start date whichever is earlier. The Contractor shall ship hazardous wastes only to facilities which are properly permitted to accept the hazardous waste or operating under interim status. The Contractor shall ensure wastes are treated to meet land disposal treatment standards in 40 CFR 268 prior to land disposal. The Contractor shall propose TSD facilities via submission of the Hazardous Waste Management Plan, subject to the approval of the Contracting Officer.

3.3 HAZARDOUS MATERIALS MANAGEMENT

The Contractor, in consultation with the Contracting Officer, COR and generator, shall evaluate prior to shipment of any material off-site whether the material is regulated as a hazardous waste in addition to being regulated as a hazardous material; this shall be done for the purpose of determining proper shipping descriptions, marking requirements, etceteras, as described below.

3.3.1 Identification of Proper Shipping Names

The Contractor shall use 49 CFR 172, Section .101 to identify proper shipping names for each hazardous material (including hazardous wastes) to be shipped off-site. Proper shipping names shall be submitted to the Contracting Officer in the form of draft shipping documents for review and approval.

3.3.2 Packaging, Labeling, and Marking

The Contractor shall package, label, and mark hazardous materials/wastes using the specified materials and in accordance with the referenced authorizations. The Contractor shall mark each container of hazardous waste of 440 L (110 gallons) or less with the following:

"HAZARDOUS WASTE - Federal Law Prohibits Improper Disposal.

If found, contact the nearest police or public safety authority or the U.S. Environmental Protection Agency.

Generator's name _____________________________________

Manifest Document Number ___________________________".

3.3.3 Shipping Documents

The Contractor shall ensure that each shipment of hazardous material sent off-site is accompanied by properly completed shipping documents.

3.3.3.1 PCB Waste Shipment Documents

The Contractor shall prepare hazardous waste manifests for each shipment of PCB waste shipped off-site. Manifests will be completed using instructions in 40 CFR 761, Sections .207 and .208 and all other applicable requirements. Documents shall be submitted to Contracting Officer for review and approval.

3.3.3.2 Asbestos Waste Shipment Documents

The Contractor shall prepare waste shipment records as required by 40 CFR 61 for shipments of asbestos. Waste shipment records shall be submitted to the Contracting Officer for review and approval. Waste shipment records shall be signed by the Contractor.

3.3.3.3 Other Hazardous Material Shipment Documents

The Contractor shall prepare a bill of lading for each shipment of hazardous material which is not accompanied by a hazardous waste manifest or asbestos waste shipment record which fulfills the shipping paper requirements. The bill of lading shall satisfy the requirements of 49 CFR 172, Subpart C, and 40 CFR 279 if shipping used oil and any applicable state or local law or regulation, and shall be submitted to the Contracting Officer for review and approval. For laboratory samples and treatability study samples, the Contractor shall prepare bills of lading and other documentation as necessary to satisfy conditions of the sample exclusions in 40 CFR 261, Section .4(d) and (e) and any applicable state or local law or regulation. Bill of ladings requiring shipper's certifications shall be signed by the Contractor.

3.4 OBTAINING EPA ID NUMBERS

The Contractor shall complete EPA Form 8700-12, Notification of Hazardous Waste Activity, and submit to the Contracting Officer for review and approval. The Contractor shall allow a minimum of 30 days for processing the application and assigning the EPA ID number. Shipment shall be made not earlier than one week after receipt of the EPA ID number.

3.5 SPECIAL REQUIREMENTS FOR ASBESTOS WASTES

If work involves asbestos containing wastes, the Contractor shall manage these wastes in accordance with specification Section 02051.

3.6 WASTE MINIMIZATION

The Contractor shall minimize the generation of hazardous waste to the maximum extent practicable. The Contractor shall take all necessary precautions to avoid mixing clean and contaminated wastes. The Contractor shall identify and evaluate recycling and reclamation options as alternatives to land disposal. Requirements of 40 CFR 266 shall apply

to: hazardous wastes recycled in a manner constituting disposal; hazardous

waste burned for energy recovery; lead-acid battery recycling; and hazardous wastes with economically recoverable precious metals.

3.7 RECORDKEEPING

The Contractor shall be responsible for maintaining adequate records to support information provided to the Contracting Officer regarding exception reports, annual reports, and biennial reports. The Contractor shall be responsible for maintaining asbestos waste shipment records for a minimum of 3 years from the date of shipment or any longer period required by any applicable law or regulation or any other provision of this contract.

3.8 SPILL RESPONSE

The Contractor shall respond to any spill of hazardous materials or hazardous waste which are in the custody or care of the Contractor pursuant to this contract. Any direction from the Contracting Officer concerning a spill or release shall not be considered a change under the contract. The Contractor shall comply with all applicable requirements of Federal, state, or local laws or regulations regarding any spill incident.

3.9 EMERGENCY CONTACTS

The Contractor shall be responsible for complying with the emergency contact provisions in 49 CFR 172, Section .604. Whenever the Contractor ships hazardous materials, the Contractor shall provide a 24-hr emergency response contact and phone number of a person knowledgeable about the hazardous materials being shipped and who has comprehensive emergency response and incident mitigation information for that material, or has immediate access to a person who possesses such knowledge and information. The phone must be monitored on a 24-hour basis at all times when the hazardous materials are in transportation including during storage incidental to transportation. The Contractor shall ensure that information regarding this emergency contact and phone number are placed on all hazardous materials shipping documents. The Contractor shall designate an emergency coordinator and post the following information at areas in which hazardous wastes are managed:

a. The name of the emergency coordinator.

b. Phone number through which the emergency coordinator can be contacted on a 24 hour basis.

c. The telephone number of the local fire department.

d. The location of fire extinguishers and spill control materials.

Attachment A

SAMPLE OFF-SITE POLICY CERTIFICATION MEMO

Project/Contract #:____

Waste Stream:____

Primary TSD Facility, EPA ID # and Location: ______________________________

Alter. TSD Facility, EPA ID # and Location:________________________________

EPA Region	Primary Contact	Secondary Contact
I	(617) 573-5755	(617) 573-1754
II	(212) 264-9504	(212) 264-2638
III	(215) 597-1857	(215) 597-8338
IV	(404) 347-7603	(404) 347-7603
V	(312) 353-7921	(312) 886-4445
VI	(214) 655-2282	(214) 655-2281
VII	(913) 551-7816	(913) 551-7667
VIII	(303) 293-1823	(303) 293-1506
IX	(415) 744-2129	(415) 744-2114
X	(206) 553-6646	(206) 553-1061

EPA representative contacted: ____

EPA representative phone number:____

Date contacted:____

Comment: ____
The above EPA representative was contacted on ___________. As of that date the above sites were considered acceptable in accordance with the Off-Site Policy in 40 CFR 300.440.

Signature: _________________________________ Date:_________________________

Phone number:____

SECTION 02210

GRADING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 1556 (1990; R 1998) Density and Unit Weight of Soil in-place by the Sand-Cone Method

ASTM D 1557 (1991: R 1998) Laboratory Compaction Characteristics of Soil Using the Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-/cu.m.))

ASTM D 2167 (1994) Density and Unit Weight of Soil in-Place by the Rubber Balloon Method

ASTM D 2487 (1998) Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D 2922 (1996el) Density of Soil and Soil-Aggregate in-Place by Nuclear Methods (Shallow Depth)

ASTM D 3017	(1988; R 1996el) Water Content of Soil and Rock in-place by Nuclear Methods (Shallow Depth)

KOREAN STANDARDS (KS)

KS F2302	(1996) Test Method for Particle size distribution of Soils
KS F2303	(1985) Method of Test for Liquid limit of Soils
KS F2304	(1974) Method of Test for Plastic limit of Soils
KS F2306	(1995) Method of Test for Moisture Content of Soils.
KS F2311	(1991) Test Method for Density of Soil in-place by the Sand Cone Method.
KS F2312	(1991) Test Method for Soil Compaction Using a Rammer
KS F2324	(1991) Method of Classification of Soils for Engineering Purpose.

1.2 DEFINITIONS

1.2.1 Satisfactory Materials

Materials classified in ASTM D 2487 or KS F2324 as GC, GM, SM, SC, SP, GW, GP, and SW, and free from roots and other organic matter, trash, debris, and frozen materials and stones larger than 150 mm (6 inches) in any dimension are satisfactory.

1.2.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Materials classified in ASTM D 2487 as CH, CL, ML, MH, Pt, OH, and OL are unsatisfactory. Unsatisfactory materials also include man-made fills, refuse, or backfills from previous construction. See Para 2.1, SECTION 02221: EXCAVATION FILLING AND BACKFILLING FOR BUILDINGS.

1.2.3 Cohesionless and Cohesive Materials

Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Cohesionless materials include materials classified in ASTM D 2487 or KS F2324 as GW, GP, SW, and SP. Materials classified as GM and SM will be identified as cohesionless only when the fines have a plasticity index of zero.

1.2.4 Degree of Compaction

Degree of compaction is a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557 or KS F2312 abbreviated below as a percent of laboratory maximum density. Contractor shall utilize the method A, B or C as provided ASTM D1557 or the method A, B, C, D or E as provided KS F2312, according to the soil type being tested.

1.3 SUBSURFACE DATA

Subsurface soil boring logs are shown on the drawings. The subsoil investigation report and samples of materials taken from subsurface investigations may be examined at the location designated in this contract. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

1.4 FIELD TESTING CONTROL

Testing shall be the responsibility of the Contractor and shall be performed by a Government approved commercial testing laboratory or by the Contractor subject to approval. Field density and moisture content tests shall be performed for fill, backfills, and subgrades on every 2500 square feet of each lift placed. Field in-place density shall be determined in accordance with ASTM D 1556, ASTM D 2167, ASTM D 2922, KS F2311. When ASTM D 2922 is used, the calibration curves shall be checked, and adjusted if necessary, using the sand cone method as described in paragraph Calibration of the ASTM publication. ASTM D 2922 results in a wet unit weight of soil and when using this method, ASTM D 3017, or KS F2306 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D 3017.

PART 2 PRODUCTS

2.1 ROCK FOR SLOPE PROTECTION

Coarse rock from excavations shall be conserved and used for constructing the slopes of embankments parallel or adjacent to streams, for constructing slopes or sides and bottom of channels, and for protection against erosion. Hand placing of coarse rock from excavation will be required as indicated.

2.2 BORROW MATERIAL

Borrow material shall be selected to meet requirements and conditions of the particular fill for which it is to be used. Necessary clearing, grubbing, disposal of debris, and satisfactory drainage of borrow pits shall be performed by the Contractor as incidental operations to the borrow excavation.

2.2.1 Selection

Borrow materials shall be obtained from sources outside the limits of Government-controlled land. Borrow materials shall be subject to approval. The source of borrow material shall be the Contractor's responsibility. Unless otherwise provided in the contract, the Contractor shall obtain from the owners the right to procure material, shall pay all royalties and other charges involved, and shall bear all the expense of developing the sources, including rights-of-way for hauling.

PART 3 EXECUTION

3.1 CONSERVATION OF TOPSOIL

Where indicated, topsoil shall be removed to a depth of 150 millimeters without contamination with subsoil and stockpiled convenient to areas for later application or at locations specified. Topsoil shall be removed to full depth and shall be stored separate from other excavated materials and piled free of roots, stones, and other undesirable materials. Any surplus of topsoil from excavations and grading shall be stockpiled in locations indicated.

3.2 EXCAVATION

After topsoil removal has been completed, excavation of every description, regardless of the material encountered, within the grading limits of the project shall be performed to the lines and grades indicated. Satisfactory excavation material shall be transported to and placed in fill areas within the limits of the work. All unsatisfactory material and surplus material shall be disposed of outside the limits of Government controlled property (military reservation) at the Contractor’s responsibility unless otherwise indicated on the plans or directed. In the event that it is necessary to remove unsatisfactory material to a depth greater than specified, the Contracting Officer shall be notified and an adjustment in the contract price will be considered in accordance with the contract. Excavation carried below the depths indicated, without specific directions shall, except as otherwise specified, be refilled to the proper grade with satisfactory material as directed. All additional work of this nature shall be at the Contractor’s expense. Excavation and filling shall be performed in a manner and sequence that will provide drainage at all times. Excavations shall be kept free from water while construction therein is in progress. Material required for fills in excess of that produced by excavation within the grading limits shall be obtained from borrow areas.

3.3 DITCHES, GUTTERS, AND CHANNEL CHANGES

Ditches, gutters, and channel changes shall be cut accurately to the cross sections and grades indicated. All roots, stumps, rock, and foreign matter in the sides and bottom of ditches, gutters, and channel changes shall be trimmed and dressed or removed to conform to the slope, grade, and shape of the section indicated. Care shall be taken not to excavate ditches and gutters below the grades indicated. Excessive ditch and gutter excavation shall be backfield to grade either with satisfactory, thoroughly compacted material or with suitable stone or cobble to form an adequate gutter paving as directed. All ditches and gutters excavated under this section shall be maintained until final acceptance of the work. Satisfactory material excavated from ditches and channel changes shall be placed in fill areas. Unsatisfactory and excess excavated material shall be disposed of in accordance with directions in paragraph EXCAVATION. No excavated material shall be deposited closer to the edges of the ditches than indicated and in no case less than 1.5 meter (5 feet).

3.4 BACKFILL ADJACENT TO STRUCTURES

Backfill adjacent to structures shall be placed and compacted uniformly in such manner as to prevent wedging action or eccentric loading upon or against the structures. Slopes bounding or within areas to be backfilled shall be stepped or serrated to prevent sliding of the fill. During backfilling operations and in the formation of embankments, equipment that will overload the structure in passing over and compacting these fills shall not be used. Backfill for storm drains and subdrains, including the bedding and backfill for structures other than culverts and drains, shall conform to the additional requirements in other applicable sections.

3.5 PREPARATION OF GROUND SURFACE FOR FILL

All vegetation, such as roots, brush, heavy sods, heavy growth of grass, and all decayed vegetable matter, rubbish, and other unsatisfactory material within the area upon which fill is to be placed, shall be stripped or otherwise removed before the fill is started. In no case will unsatisfactory material remain in or under the fill area. Sloped ground surfaces steeper than one vertical to four horizontal on which fill is to be placed shall be plowed, stepped, or broken up, as directed, in such manner that the fill material will bond with the existing surface. Prepared surfaces on which compacted fill is to be placed shall be wetted or dried as may be required to obtain the specified moisture content and density.

3.6 FILLS AND EMBANKMENTS

Fills and embankments shall be constructed at the locations and to lines and grades indicated. The completed fill shall conform to the shape of the typical sections indicated or shall meet the requirements of the particular case. Satisfactory material obtained during excavation may be used in forming required fill. Fill shall be satisfactory material and shall be reasonably free from roots, other organic material, and trash and from stones having a maximum diameter greater than 75 mm (3 inches). No frozen material will be permitted in the fill. Stones having a dimension greater than 50 mm (2 inches) shall not be permitted in the upper 150 mm (6 inches) of fill or embankment. The material shall be placed in successive horizontal layers of 200 mm (8 inches) in loose depth for the full width of the cross section and shall be compacted as specified. Each layer shall be compacted before the overlaying lift is placed. Moisture content of the fill or backfill material shall be adjusted by wetting or aerating, as required, to within the range that the soil compaction results in the specified density as determined from laboratory tests.

3.7 COMPACTION

Each layer of the fill or embankment shall be compacted to at least 85 percent for cohesive and 90 percent for cohesionless materials of laboratory maximum density except that compaction for structures and pavements shall be per SECTION 02221: EXCAVATION, FILLING AND BACKFILLING FOR BUILDINGS, and SECTION 02225: EARTHWORK FOR ROADWAYS, RAILROADS, AND AIRFIELDS.

3.8 FINISHED EXCAVATION, FILLS, AND EMBANKMENTS

All areas covered by the project, including excavated and filled sections and adjacent transition areas, shall be uniformly smooth-graded. The finished surface shall be reasonably smooth, compacted, and free from irregular surface changes. The degree of finish shall be that ordinarily obtainable from blade-grader operations, except as otherwise specified. Ditches and gutters shall be finished to permit adequate drainage. The surface of areas to be turfed shall be finished to a smoothness suitable for the application of turfing materials. For subgrade areas to be paved, the following shall be accomplished as required: (a) soft or otherwise unsatisfactory material shall be replaced with satisfactory excavated material or other approved materials; (b) rock encountered in the cut sections shall be excavated to a depth of 150 mm (6 inches) below finished grade for the subgrade; (c) low areas resulting from removal of unsatisfactory material or from excavation of rock shall be brought up to required grade with satisfactory materials, and the entire subgrade shall be shaped to line, grade, and cross section and shall be compacted as specified. The surface of embankments or excavated areas for road construction or other areas on which a base course or pavement is to be placed shall vary not more than 15 mm (0.05 foot) from the established grade and approved cross section. Surfaces other than those that are to be paved shall be finished not more than 45 mm (0.15 foot) above or below the established grade or approved cross section.

3.9 PROTECTION

Newly graded areas shall be protected from traffic and from erosion, and any settlement or washing away that may occur from any cause, prior to acceptance, shall be repaired and grades reestablished to the required elevations and slopes. All work shall be conducted in accordance with the environmental protection requirements of the contract.

3.10 CONTRACTOR QUALITY CONTROL

The Contractor shall establish and maintain a quality control procedure to assure compliance of the installed grading with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to, the following:

a. Clearing and grubbing.

b. Conservation of Topsoil.

c. Excavation: Lines, grades, elevations and dimensions; and removal and replacement of unsatisfactory materials.

d. Filling: Subgrade preparation; lift thickness; and borrow material.

e. Protection of structures and walls.

f. Drainage.

g. Compaction: Two moisture-density relations and two sieve analyses for each material used for each month of operation, and one sand in-place density check test for each 10,000 square feet of each lift placed and one in-place density check (nuclear) for each 2500 square feet of each lift placed.

h. Protection of graded, filled or backfilled areas from settlement or erosion.

3.10.1 Contractor's Quality Control (CQC) Procedure

The CQC procedure for grading installation shall be submitted to the Contracting Officer for approval prior to the start of grading work.

SECTION 02221

EXCAVATION, FILLING AND BACKFILLING FOR BUILDINGS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 1117 (1980) Non-woven Fabrics

ASTM D 1556 (1990; R 1996e1) Density of Soil in Place by the Sand-Cone Method

ASTM D 1557	(1991; R 1998) Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop
ASTM D 1785	(1993) Polyvinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80 and 120.
ASTM D 2167	(1994) Density and Unit Weight of Soil In-Place by the Rubber Balloon Method
ASTM D 2216	(1998) Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D 2487	(1998) Classification of Soils for Engineering; Purposes
ASTM D 2922	(1996e1) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 2937	(1994) Density of Soil in Place by the Drive-Cylinder Method
ASTM D 3017	(1988; R 1996e1) Moisture Content of Soil and Soil-Aggregate in-Place by Nuclear Methods (Shallow Depth)
ASTM D 3787	(1989) Bursting Strength of Knitted Goods: Constant-rated of Traverse (CRT), Ball Burst Test.
ASTM D 4318	(1998) Liquid Limit, Plastic Limit, and Plasticity Index of Soils

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 2126	(1994) Measuring method for Filtration Aperture of Geotextile
KS F2302	(1992) Test Method for Particle size distribution of Soils
KS F2303	(2000) Method of Test for Liquid limit of Soils
KS F2304	(1974) Method of Test for Plastic limit of Soils
KS F2306	(2000) Method of Test for Moisture Content of Soils.
KS F2311	(2001) Test Method for Density of Soil in place by the Sand Cone Method.
KS F2312	(2001) Test Method for Soil Compaction Using a Rammer
KS F2324	(2001) Method of Classification of Soils for Engineering Purpose.
KS F 2322	(2000) Permeability of Soils
KS K 0350	(2001) Testing Method for Bursting Strength of Cloth; Ball Bursting Method

KS K 0351 (2001) Testing Method of Cloth; Diaphragm Bursting Method

KS K 0520 (2001) Testing Method for breaking Strength and Elongation; Breaking of Woven Cloth; Grab Method

KS K 0537 (2001) Testing Method for Tearing Strength of Cloth, Trapezoid Method

KS M 3404 (2001) Unplasticized Polyvinyl Chloride (PVC) Pipes for General Service

1.2 DEFINITIONS

1.2.1 Satisfactory Materials

Satisfactory materials include materials classified in ASTM D 2487 as GW, GP, SW, GC, GM, SP, SM and SC and shall be free of trash, debris, roots or other organic matter, or stones larger than 76.2 mm (3 inches) in any dimension. In addition, when more than 25% of satisfactory material passes the No. 40 sieve, that portion passing the No. 40 sieve shall be either non-plastic or will have a liquid limit not greater than 25 and a plasticity index not greater than 5.

1.2.2 Unsatisfactory Materials

Unsatisfactory materials include materials classified in ASTM D 2487 as Pt, OH, OL, CH, CL, ML, and MH, expansive soils, and any other materials not defined as satisfactory. Materials with liquid limit greater than 25 and plasticity index greater than 5 shall be classified unsatisfactory.

1.2.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D 2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic.

1.2.4 Degree of Compaction

Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557, Method D, abbreviated hereinafter as percent laboratory maximum density. The contractor shall utilize the method A, B or C as provided in ASTM D1557, according to the soil type being tested

1.2.5 Expansive Soils

Expansive soils are defined as soils that have liquid limits greater than 40 and a plasticity index equal to or greater than 15 when tested in accordance with ASTM D 4318.

1.2.6 Nonfrost Susceptible (NFS) Material

Nonfrost susceptible material shall be a uniformly graded washed sand with a maximum particle size of 6.5mm and less than 3 percent passing the No. 200 size sieve, and with not more than 1.5 percent by weight finer than 0.02 mm grain size or, a uniformly graded sand-gravel with a maximum particle size of 9.5mm and less than 5 percent passing the No. 200 size sieve, and with not more than 3 percent by weight finer than 0.02 mm grain size.

1.3 SUBMITTALS.

Government approval is required for submittals with a “GA” designation; Submittals not having a GA designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Testing; FIO

Copies of all laboratory and field test reports within 24 hours of the completion of the test.

PART 2 PRODUCTS

2.1 CAPILLARY WATER BARRIER

Capillary water barrier shall consist of clean, crushed, nonporous rock, crushed gravel, or uncrushed gravel. The maximum particle size shall be 37.5mm and no more than 2 percent by weight shall pass the 4.75mm(No. 4) size sieve.

2.2 STRUCTURAL BACKFILL

Structural backfill material shall consist of sand, gravel, crushed gravel or crushed rock composed of hard, tough, durable particles reasonable well graded within the following limits:

Sieve Designation	Percent Finer by Weight
40 mm (1-1/2 inch)	100
13 mm (1/2 inch)	48-100
10 mm (3/8 inch)	42-84
4.75 mm (No. 4)	28-58
2.00 mm (No. 10)	15-40
0.425 mm (No. 40)	4-19
0.075 mm (No. 200)	0-4

2.3 GEOTEXTILE FILTER FABRIC

Geotextile filter fabric shall be a standard commercially manufactured product that has been available for a minimum of two years. Contractor shall submit fabric selection analysis, fabric samples (two each 1.0 square foot) and proposed installation procedures for approval. Also the contractor shall submit the fabric (sizes and numbers in accordance with KS F 2126, KS F 2127, KS F 2128) and Product shall conform to the following:

a. AOS (Apparent Opening Size): AOS shall be less than or equal to D85 (backfill) where 095 is fabric opening and D85 is soil grain size corresponding to percents finer than 85%. AOS obtained by the test procedure presented in KS F 2126.

b. Permeability: fabric permeability, kn (obtained by the test procedure presented in KS F 2322), shall be greater than or equal to the permeability of the soil, k (obtained by the test procedure presented in KS F 2322)

c. Porosity: 30 percent minimum (non-woven fabric)

d. Grab Strength: 130 lbs minimum (KS K 0520)

e. Puncture Strength: 40 lbs minimum (KS K 0350)

f. Burst Strength: 210 lbs minimum (KS K 0351)

g. Trapezoidal Tear Strength: 35 lbs minimum (KS K 0536)

2.4 WEEP HOLES

Weep holes unless otherwise indicated or approved shall be schedule 40 PVC pipe conforming to ASTM D 1785.

PART 3 EXECUTION

3.1 CLEARING AND GRUBBING

The areas within lines 1.5 m (5 feet) outside of each building and structure line shall be cleared and grubbed of trees, stumps, roots, brush and other vegetation, debris, existing foundations, pavements, utility lines, structures, fences, and other items that would interfere with construction operations. Stumps, logs, roots, and other organic matter shall be completely removed and the resulting depressions shall be filled with satisfactory material, placed and compacted in accordance with paragraph 3.14, FILLING AND BACKFILLING. Materials removed shall be disposed of outside the limits of Government-controlled property at the Contractor's responsibility.

3.2 TOPSOIL

Topsoil shall be stripped to a depth of 150 millimeters (6 inches) below existing grade within the designated excavations and grading lines and deposited in storage piles for later use. Excess topsoil shall be disposed as specified for excess excavated material.

3.3 EXCAVATION

Excavation shall conform to the dimensions and elevations indicated for each building, structure, and footing except as specified. Excavation shall include trenching for utility and foundation drainage systems to a point 1.5 m (5 feet) beyond the building line of each building and structure, excavation for outside grease interceptors, underground fuel tanks, and all work incidental thereto. Excavation shall extend a sufficient distance from walls and footings to allow for placing and removal of forms. Excavations below indicated depths will not be permitted except to remove unsatisfactory material. Unsatisfactory material encountered below the grades shown shall be removed as directed and replaced with satisfactory material except that structural backfill shall be used beneath footings where indicated on the drawings. Satisfactory material removed below the depths indicated without specific direction of the Contracting Officer shall be replaced at no additional cost to the Government to the indicated excavation grade with satisfactory materials, except that concrete footings or specified and approved structural backfill shall be increased in thickness to the bottom of the overdepth excavations and over-break in rock excavation. Satisfactory material and structural backfill material shall be placed and compacted as specified in paragraph FILLING AND BACKFILLING. Determination of elevations and measurements of approved overdepth excavation of unsatisfactory material below grades indicated shall be done under the direction of the Contracting Officer.

3.4 DRAINAGE AND DEWATERING

3.4.1 Drainage

Surface water shall be directed away from excavation and construction sites so as to prevent erosion and undermining of foundations. Diversion ditches, dikes and grading shall be provided and maintained as necessary during construction. Excavated slopes and backfill surfaces shall be protected to prevent erosion and sloughing. Excavation shall be performed so that the site and the area immediately surrounding the site and affecting operations at the site shall be continually and effectively drained.

3.4.2 Dewatering

Groundwater flowing toward or into excavations shall be controlled to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 900 mm (3 feet) of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously below the working level.

3.5 SHORING

Shoring, including sheet piling, shall be furnished and installed as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Shoring, bracing, and sheeting shall be removed as excavations are backfilled, in a manner to prevent caving.

3.6 CLASSIFICATION OF EXCAVATION

Rock excavation shall consist of the removal and disposal of boulders 0.375 cubic meter (1/2 cubic yard) or more in volume; solid rock; materials that cannot be removed without systematic drilling and blasting such as rock material in ledges or aggregate conglomerate deposits that are so firmly cemented as to possess the characteristics of solid rock; and concrete or masonry structures exceeding 0.375 cubic meter (1/2 cubic yard) in volume, except sidewalks and paving. Hard and compact materials such as cemented gravel, glacial till, and relatively soft or disintegrated rock that can be removed without continuous and systematic drilling and blasting will not be considered as rock excavation. Rock excavation will not be considered as such because of intermittent drilling and blasting that is performed merely to increase production. Excavation of the material claimed as rock shall not be performed until the material has been cross sectioned by the Contractor and approved by the Contracting Officer. Common excavation shall consist of all excavation not classified as rock excavation.

3.7 BLASTING

Blasting will not be permitted.

3.8 UTILITY AND DRAIN TRENCHES

Trenches for underground utilities systems and drain lines shall be excavated to the required alignments and depths. The bottoms of trenches shall be graded to secure the required slope and shall be tamped if necessary to provide a firm pipe bed. Recesses shall be excavated to accommodate bells and joints so that pipe will be uniformly supported for the entire length. Rock, where encountered, shall be excavated to a depth of at least 150 mm (6 inches) below the bottom of the pipe, and the overdepth shall be backfilled with satisfactory material placed and compacted in conformance with paragraph FILLING AND BACKFILLING.

3.9 BORROW

Where satisfactory materials are not available in sufficient quantity from required excavations, approved materials shall be obtained as specified in Section: 02210 GRADING.

3.10 EXCAVATED MATERIALS

Satisfactory excavated material required for fill or backfill shall be placed in the proper section of the permanent work required under this section or shall be separately stockpiled if it cannot be readily placed. Satisfactory material in excess of that required for the permanent work and all unsatisfactory material shall be disposed of as specified in Section 02210: GRADING.

3.11 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Excavation to final grade shall not be made until just before concrete is to be placed. For pile foundations, the excavation shall be stopped at an elevation of from 150 to 300 mm (6 to 12) inches above the bottom of the footing before driving piles. After pile driving has been completed, the remainder of the excavation shall be completed to the elevations shown. Only excavation methods that will leave the foundation rock in a solid and unshattered condition shall be used. Approximately level surfaces shall be roughened, and sloped surfaces shall be cut as indicated into rough steps or benches to provide a satisfactory bond. Shales shall be protected from slaking or other erosion resulting from ponding or flow of water.

3.12 SUBGRADE PREPARATION

Unsatisfactory material in surfaces to receive fill or in excavated areas shall be removed and replaced with satisfactory materials or structural backfill where indicated or directed. The surface shall be scarified to a depth of 150 mm (6 inches) before the fill is started. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When subgrades are less than the specified density, the ground surface shall be broken up to a minimum depth of 150 mm (6 inches), pulverized, and compacted to the specified density. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 300 mm (12 inches) and compacted as specified for the adjacent fill. Material shall not be placed on surfaces that are muddy, frozen, or contain frost. Compaction shall be accomplished by sheepfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Material shall be moistened or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Minimum subgrade density shall be as specified in paragraph FILLING AND BACKFILLING.

3.13 SOIL TREATMENT

The Contractor shall apply 1% Dursban Emulsion at a rate of four (4) gallons per ten (10) linear feet both outside and inside the foundation wall for vertical barrier against the subterranean termites, and for horizontal barrier, the same insecticide shall be applied on the capillary water barrier surface at a rate of one (1) gallon per ten (10) square feet. Both the vertical treatment agents shall be applied in accordance with the instructions on the label. Soil treatment will not be required for power plants, central heating plans, water and sewer treatment plants, incinerators, pump houses, and structures of similar nature which have no wood in their construction nor have wood or cellulose items stored within.

3.13.1 The soil treatment above shall not be undertaken if:

3.13.1.1 Duct work or vent/flue that connects to heating, ventilating, or air-conditioning (HVAC) equipment is located in the following areas:

a. In or under slabs on grade.

b. In enclosed spaces that are exposed to the ground.

c. In direct contact with the ground.

3.13.1.2 Other requirements in Appendix D to AR 420-76 are not met.

3.14 FILLING AND BACKFILLING

Satisfactory materials shall be used in bringing fills and backfills to the lines and grades indicated and for replacing unsatisfactory materials. Satisfactory materials shall be placed in horizontal layers not exceeding 200 mm (8 inches) in loose thickness, or 150 mm (6 inches) when hand-operated compactors are used. After placing, each layer shall be plowed, disked, or otherwise broken up, moistened or aerated as necessary, thoroughly mixed and compacted as specified. Backfilling shall not begin until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Backfill shall be brought to indicated finish grade and shall include backfill for outside grease interceptors and underground fuel tanks. Backfill shall not be placed in wet or frozen areas. Where pipe is coated or wrapped for protection against corrosion, the backfill material up to an elevation 600 mm (2 feet) above sewer lines and 300 mm (1 foot) above other utility lines shall be free from stones larger than 25.4 mm (1 inch) in any dimension. Heavy equipment for spreading and compacting backfill shall not be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; the area remaining shall be compacted in layers not more than 100 mm (4 inches) in compacted thickness with power-driven hand tampers suitable for the material being compacted. Backfill shall be placed carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Backfill shall not be placed against foundation walls prior to 7 days after completion of the walls. As far as practicable, backfill shall be brought up evenly on each side of the wall and sloped to drain away from the wall. Each layer of fill and backfill shall be compacted to not less than the percentage of maximum density specified below:

	Percent Laboratory maximum density Cohesive material	Percent Laboratory maximum density Cohesionless material
Fill, embankment, and backfill		
Under structures, building slabs, steps, paved areas, around footings, and in trenches	90	95
Under sidewalks and grassed areas	85	90
Expansive materials	Compacted to not less than 85 percent nor more than 95 percent	
Nonfrost susceptible materials		95
Structural backfill		100
Subgrade		
Under building slabs, steps, and paved areas, top 300 mm	90	95
Under sidewalks, top 150 mm	85	90

Approved compacted subgrades that are disturbed by the Contractor's operations or adverse weather shall be scarified and compacted as specified herein before to the required density prior to further construction thereon. Recompaction over underground utilities and heating lines shall be by hand tamping.

3.14.1 Retaining Wall Backfilling Special Requirements and Weep Holes

3.14.1.1 Sand-gravel filter material shall be installed along the back-side of walls as indicated. Material shall consist of approved sand, gravel, crushed gravel or crushed rock composed of hard, tough and durable particles graded as follows:

$$\frac{\text{D15 (Filter)}}{\text{D85 (Backfill)}} < (4 \text{ to } 5) < \frac{\text{D15 (Filter)}}{\text{D15 (Backfill)}}$$

Geotextile filter fabric material shall also be installed as indicated and per manufacturer instructions. Fabric shall completely enclose filtering material at wall tops and bottom to prevent intrusion of adjacent materials. Fabric shall conform to requirements stated herein before. The sand and gravel filter material shall be placed in lifts not to exceed 300 mm (12 inches) loose and shall be compacted to 95 percent of maximum laboratory density. Approved impervious clay material shall be installed at wall tops as indicated on the drawings to prevent surface water infiltration.

3.14.1.2 Backfill behind retaining walls other than filter material shall be with approved satisfactory material placed in lifts not to exceed 300 mm (12 inches) loose and compacted to 95 percent of maximum laboratory density. Compaction shall be with approved suitable mechanical tampers. Heavy equipment shall be per paragraph, FILLING AND BACKFILLING herein before.

3.14.1.3 Wall concrete footings to include exterior bearing faces shall be poured against undisturbed ground. Wall concrete footing thickness and width shall be increased to the bottom or bearing edge of over-excavation in satisfactory material and in overbreak in rock excavation at no additional cost to the Government.

3.14.1.4 Weep Holes shall be installed as indicated. A sand-gravel retainer screen with 6 mm (1/4 inch) maximum openings shall be provided at each weep hole extending a minimum distance of 300 mm (12 inches) beyond all sides of the weep hole. The screen shall be an approved commercial product of noncorrosive material such as brass, 304 stainless steel, fiberglass or nylon.

3.15 TESTING

Testing shall be the responsibility of the contractor and shall be performed at no additional cost to the Government. Testing shall be performed by a Government approved commercial testing laboratory or may be performed by the Contractor subject to approval.

3.15.1 Certified Laboratory Test Reports

Before delivery of materials, certified copies of the reports of all tests required herein for materials and in referenced publications shall be submitted to and approved by the Contracting Officer for record purposes.

Additional testing shall be performed and test reports submitted when the source of materials is changed. Certified test reports are required for the following:

a. Filter Material.

b. Fill, Embankment, and Backfill Material.

3.15.2 In-Place Densities

Field in-place density shall be determined in accordance with ASTM D 1556, D 2167, or D 2922. When ASTM D 2922 is used, the calibration curves shall be checked and adjusted if necessary by the procedure described in ASTM D 2922, paragraph, "ADJUSTING CALIBRATION CURVE". ASTM D 2922 method results in a wet unit weight of soil and when using this method ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gages shall also be checked along with density calibration checks as described in ASTM D 3017. The calibration checks of both the density and moisture gages shall be made at the beginning of a job on each different type of material encountered and at intervals as directed by the Contracting Officer. ASTM D 2937 shall be used only for soft, fine-grained, cohesive soils. The following number of tests, if performed at the appropriate time, shall be the minimum acceptable for each type of operation.

3.15.2.1 In-Place Density of Subgrades

One test per 278 square meter (3000 square feet) or fraction thereof.

3.15.2.2 In-Place Density of Fills and Backfills

One test per 225 square meter (2500 square feet) or fraction thereof of each lift for fill or backfill areas compacted by other than hand or hand-operated machines. The density for each lift of fill or backfill materials for trenches, pits, building perimeters or other structures or areas less than 3 meter (20 feet) in width, which are compacted with hand or hand-operated machines shall be tested as follows: One test per each area less than 81 square meter (900 square feet), or one test for each 30 meter (100 linear feet) of long narrow fills 3 meter (10 or more feet) in length. If ASTM D 2922 is used, in-place densities shall be checked by ASTM D 1556 as follows: One check test per lift for each 120 meter (400 linear feet) of long narrow fills, and a minimum of one check test per 900 square meter (10,000 square feet) of lift for other fill and backfill areas.

3.15.3 Moisture Contents

In the stockpile, excavation or borrow areas, a minimum of two tests per day per type of material or source of materials being placed during stable weather conditions. During unstable weather, tests shall be made as dictated by local conditions and approved moisture contents shall be tested in accordance with ASTM D 2216.

3.15.4 Optimum Moisture and Laboratory Maximum Density

Tests shall be made for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 382 cubic meter (500 cubic yards) of fill and backfill, or when any change in material occurs which may effect the optimum moisture content or laboratory maximum density.

3.16 CAPILLARY WATER BARRIER

Capillary water barrier under concrete floor and area-way slabs on grade shall be placed directly on the subgrade and shall be compacted with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.17 GRADING

Areas within 1.5 m (5 feet) outside of each building and structure line shall be constructed true-to-grade, shaped to drain, and shall be maintained free of trash and debris until final inspection has been completed and the work has been accepted.

3.18 SPREADING TOPSOIL

Areas outside the building lines from which topsoil has been removed shall be topsoiled. The surface shall be free of materials that would hinder planting or maintenance operations. The subgrade shall be pulverized to a depth of 50 mm (2 inches) by disking or plowing for the bonding of topsoil with the subsoil. Topsoil shall then be uniformly spread, graded, and compacted to the required thickness, elevation, and slope, and left free of surface irregularities. Topsoil shall be compacted by one pass of a cultipacker, roller, or other approved equipment weighing 1.46 kN/m to 2.34 kN/m (100 to 160 pounds per linear foot) of roller. Topsoil shall not be placed when the subgrade is frozen, excessively wet, extremely dry, or in a condition otherwise detrimental to seeding, planting, or proper grading.

3.19 PROTECTION

Settlement or washing that occurs in graded, topsoiled, or backfilled areas prior to acceptance of the work shall be repaired and grades reestablished to the required elevations and slopes.

3.20 CONTRACTOR QUALITY CONTROL

The Contractor shall establish and maintain a quality control procedure to assure compliance of the installed excavation, filling and backfilling for buildings with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to the following:

a. Clearing and grubbing.

b. Conservation of topsoil.

c. Excavation: Lines, grades, elevations, and dimensions; removal and replacement of unsatisfactory materials; maintaining distance from walls and footings; drainage; dewatering; shoring and sheet piling; width and depth of trenches; and protection or removal of existing utility lines.

d. Filling and backfilling: Subgrade preparation; lift thickness; selection of borrow material; selection of sand-gravel filter material and geotextile filter fabric; and weep holes.

e. Compaction: Two moisture-density relation and two sieve analyses for each material used for each month of operation and one sand density test for each lift.

(1) Buildings: Every 83.6 square meter (900 square feet) or fraction thereof.

(2) Utility lines: Every 120 meter (400 linear feet) or fraction thereof.

(3) Pavement subgrade: Every 278.7 square meter (3,000 square feet) or fraction thereof.

f. Furnishing, placing, and compacting capillary water barrier or non-frost susceptible material.

g. Protection of graded, filled, or backfilled areas from settlement or washing.

3.20.1 Contractor's Quality Control (CQC) Procedure

The CQC procedure for excavation, filling and backfilling for buildings shall be submitted to the Contracting Officer for approval prior to the start of excavation, filling and backfilling for building works.

SECTION 02222

EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 422	(1963; R 1990) Particle-Size Analysis of Soils
ASTM D 1556	(1990; R 1996) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(1998) Laboratory Compaction Characteristics of Soil Using the Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu. m.))
ASTM D 2167	(1994) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2487	(1998) Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2922	(1996) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017	(1988; R 1996el) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

KOREAN STANDARD (KS)

KS F 2324 (2001) Method of Classification of Soils for Engineering Purposes.

1.2 DEFINITIONS

1.2.1 Satisfactory Materials

Satisfactory materials shall consist of any material classified by KS F2324 or ASTM D 2487 as SP, GC, SC, GM, SM, GW, GP, and SW and shall be free of trash, debris, roots, or other organic matter, or stones larger than 3 inches in any dimension. Materials with liquid limit less than 25 and Plasticity Index less than 10 shall be considered satisfactory.

1.2.2 Degree of Compaction

Degree of compaction shall be expressed as a percentage of the maximum

density obtained by the test procedure presented in ASTM D 1557 or KS F2312.

1.2.3 Unstable Material

Unstable material shall consist of materials too wet to properly support the utility pipe, conduit, or appurtenant structure.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.2 Unsatisfactory Materials

Unsatisfactory materials shall be materials that do not comply with the requirements for satisfactory materials. Unsatisfactory materials include but are not limited to those materials containing roots and other organic matter, trash, debris, frozen materials and stones larger than 75 millimeters, (3 inches,) and materials classified in KS F2324 or ASTM D 2487, as CH, CL, ML, MH, PT, OH, and OL. Unsatisfactory materials also include man-made fills, refuse, or backfills from previous construction. Materials with liquid limit less than 25 and plasticity index less than 10 shall be considered satisfactory.

2.1.3 Cohesionless and Cohesive Materials

Cohesionless materials shall include materials classified in KS F2324 or ASTM D 2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic.

2.1.4 Rock

Rock shall consist of boulders measuring 1/2 cubic meter (1/2 cubic yard) or more and materials that cannot be removed without systematic drilling and blasting such as rock material in ledges, bedded deposits, unstratified masses and conglomerate deposits, and below ground concrete or masonry structures, exceeding 1/2 cubic meter (1/2 cubic yard) in volume, except that pavements will not be considered as rock.

2.1.5 Unyielding Material

Unyielding material shall consist of rock and gravelly soils with stones greater than 75 millimeters (3 inches) in any dimension or as defined by the pipe manufacturer, whichever is smaller.

2.1.6 Unstable Material

Unstable material shall consist of materials too wet to properly support the utility pipe, conduit, or appurtenant structure.

2.1.7 Select Granular Material

Select granular material shall consist of well-graded sand, gravel, crushed gravel, crushed stone or crushed slag composed of hard, tough and durable particles. Select granular shall contain not more than 10 percent by weight of material passing a 0.075 mm (No. 200) mesh sieve and no less than 95 percent by weight passing the 25 mm (l inch) sieve. The maximum allowable aggregate size shall be 50 millimeters (2 inches), or the maximum size recommended by the pipe manufacturer, whichever is smaller.

2.1.8 Initial Backfill Material

Initial backfill shall consist of select granular material or satisfactory materials free from rocks 50 millimeters (2 inches) or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, the initial backfill material shall be free of stones larger than 25 millimeters (1 inch) in any dimension or as recommended by the pipe manufacturer, whichever is smaller.

2.2 Plastic Marking Tape

Plastic marking tape shall be acid and alkali-resistant polyethylene film, 150 mm (6 inches) wide with minimum thickness of 0.102 mm (0.004 inch). Tape shall have a minimum strength of 12.1 MPa (1750 psi) lengthwise and 10.3 MPa (1500 psi) crosswise. The tape shall be manufactured with integral wires, foil backing or other means to enable detection by a metal detector when the tape is buried up to 1 meter (3 feet) deep. The tape shall be of a type specifically manufactured for marking and locating underground utilities. The metallic core of the tape shall be encased in a protective jacket or provided with other means to protect it from corrosion. Tape color shall be as specified in TABLE 1 and shall bear a continuous printed inscription describing the specific utility.

TABLE 1. Tape Color

Red:	Electric
Yellow:	Gas, Oil, Dangerous Materials
Orange:	Telephone, Telegraph, Television,

	Police, and Fire Communications
Blue:	Water Systems
Green:	Sewer Systems

PART 3 EXECUTION

3.1 EXCAVATION

Excavation shall be performed to the lines and grades indicated. Rock excavation shall include removal and disposition of material defined as rock in paragraph MATERIALS. Earth excavation shall include removal and disposal of material not classified as rock excavation. During excavation, material satisfactory for backfilling shall be stockpiled in an orderly manner at a distance from the banks of the trench equal to 1/2 the depth of the excavation, but in no instance closer than 600 mm (2 feet). Excavated material not required or not satisfactory for backfill shall be removed from the site. Grading shall be done as may be necessary to prevent surface water from flowing into the excavation, and any water accumulating therein shall be removed to maintain the stability of the bottom and sides of the excavation. Dewatering as required shall be per SECTION 02221: EXCAVATION, FILLING, AND BACKFILLING FOR BUILDINGS, STRUCTURES AND WALLS. Unauthorized overexcavation shall be backfilled in accordance with paragraph BACKFILLING AND COMPACTION at no additional cost to the Government.

3.1.1 Trench Excavation

The trench shall be excavated as recommended by the manufacturer of the pipe to be installed. Trench walls below the top of the pipe shall be sloped, or made vertical, and of such width as recommended in the manufacturer's installation manual. Where no manufacturer's installation manual is available, trench walls shall be made vertical. Trench walls more than 1.5 meters (5 feet) high shall be shored, cut back to a stable slope, or provided with equivalent means of protection for employees who may be exposed to moving ground or cave-ins. Vertical trench walls more than 1.5 meters (5 feet) high shall be shored. Trench walls which are cut back shall be excavated to at least the angle of repose of the soil. Special attention shall be given to slopes that may be adversely affected by weather or moisture content. The trench width below the top of pipe shall not exceed 600 mm (24 inches) plus pipe outside diameter (O.D.) for pipes of less than 600 mm (24 inches) inside diameter and shall not exceed 900 mm (36 inches) plus pipe outside diameter for sizes larger than 600 mm (24 inches) inside diameter. Where recommended trench widths are exceeded, re-design, stronger pipe, or special installation procedures shall be utilized by the Contractor. The cost of re-design, stronger pipe, or special installation procedures shall be borne by the Contractor without any additional cost to the Government.

3.1.1.1 Bottom Preparation

The bottoms of trenches shall be accurately graded to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Bell holes shall be excavated to the necessary size at each joint or coupling to eliminate point bearing. Stones of 50 millimeters (2 inches) or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, shall be removed to avoid point bearing.

3.1.1.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench, such material shall be removed a minimum of 100 millimeters (4 inches) below the required grade and replaced with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.

3.1.1.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, such material shall be removed to the depth directed and replaced to the proper grade with select granular material as provided in paragraph BACKFILLING AND COMPACTION. When removal of unstable material is required due to the fault or neglect of the Contractor in his performance of the work, the resulting material shall be excavated and replaced by the Contractor without additional cost to the Government.

3.1.1.4 Excavation for Appurtenances

Excavation for manholes, catch-basins, inlets, or similar structures shall be of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Rock shall be cleaned of loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Loose disintegrated rock and thin strata shall be removed. Removal of unstable material shall be as specified above. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before the concrete or masonry is to be placed.

3.1.1.5 Jacking, Boring, and Tunneling

Unless otherwise indicated, excavation shall be by open cut except that sections of a trench may be jacked, bored, or tunneled if, in the opinion of the Contracting Officer, the pipe, cable, or duct can be safely and properly installed and backfill can be properly compacted in such sections.

3.1.1.6 Stockpiles

Stockpiles of satisfactory and unsatisfactory and wasted materials shall be placed and graded as specified. Stockpiles shall be kept in a neat and well drained condition, giving due consideration to drainage at all times. The ground surface at stockpile locations shall be cleared, grubbed, and sealed by rubber-tired equipment, excavated satisfactory and unsatisfactory materials shall be separately stockpiled. Stockpiles of satisfactory materials shall be protected from contamination that may destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, such material shall be removed and replaced with satisfactory material from approved sources at no additional cost to the Government. Locations of stockpiles of satisfactory materials shall be subject to prior approval of the Contracting Officer.

3.2 BACKFILLING AND COMPACTION

Backfill material shall consist of satisfactory material, select granular material, or initial backfill material as required. Backfill shall be placed in layers not exceeding 150 mm (6 inches) loose thickness for compaction by hand operated machine compactors, and 200 mm (8 inches) loose thickness for other than hand operated machines, unless otherwise specified. Each layer shall be compacted to at least 95 percent maximum density for cohesionless soils and 90 percent maximum density for cohesive soils, unless otherwise specified.

3.2.1 Trench Backfill

Trenches shall be backfilled to the grade shown. The trench shall not be backfilled until all specified tests are performed.

3.2.1.1 Replacement of Unyielding Material

Unyielding material removed from the bottom of the trench shall be replaced with select granular material or initial backfill material.

3.2.1.2 Replacement of Unstable Material

Unstable material removed from the bottom of the trench or excavation shall be replaced with select granular material placed in layers not exceeding 150 mm (6 inches) loose thickness.

3.2.1.3 Bedding and Initial Backfill

Bedding shall be of the type and thickness shown. Initial backfill material shall be placed and compacted with approved tampers to a height of at least one foot above the utility pipe or conduit. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of the pipe.

3.2.1.4 Final Backfill

The remainder of the trench, except for special materials for roadways, railroads and airfields, shall be filled with satisfactory material. Backfill material shall be placed and compacted as follows:

a. Roadways, Railroads, and Airfields: Backfill shall be placed up to the elevation at which the requirements in Section 02225: EARTHWORK FOR ROADWAYS, RAILROADS, AND AIRFIELDS control. Water flooding or jetting methods of compaction will not be permitted.

b. Sidewalks, Turfed or Seeded Areas and Miscellaneous Areas: Backfill shall be deposited in layers of a maximum of 300 mm (12 inch) loose thickness, and compacted to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Compaction by water flooding or jetting will not be permitted. This requirement shall also apply to all other areas not specifically designated above.

Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 7 days, backfill shall be placed in such a manner that the structure will not be damaged by the shock of falling earth. The backfill material shall be deposited and compacted as specified for final backfill, and shall be brought up evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.3 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.3.1 Gas Distribution

Trenches shall be excavated to a depth that will provide not less than 450 mm (18 inches) of cover in rock excavation and not less than 600 mm (24 inches) of cover in other excavations.

3.3.2 Water Lines

Unless otherwise specifically indicated, trenches shall be of a depth to provide a minimum cover equal to established frost depth plus 150 mm (6 inches) from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe. An additional 300 mm (12 inches) of cover is required for fire protection mains or piping.

3.3.3 Heat Distribution System

Initial backfill material shall be free of stones larger than 6.3 mm (1/4 inch) in any dimension.

3.3.4 Electrical Distribution System

Direct burial cable and conduit or duct line shall have a minimum cover of 600 mm (24 inches) from the finished grade, unless otherwise indicated. Special trenching requirements for direct-burial electrical cables and conduits are specified in Section 16375: ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

3.3.5 Plastic Marking Tape

Warning tapes shall be installed directly above the pipe, at a depth of 450 millimeters (18 inches) below finished grade unless otherwise shown.

3.4 FIELD QUALITY CONTROL

Testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government.

3.4.1 Field Density Tests

Tests shall be performed in sufficient numbers to ensure that the specified density is being obtained. A minimum of one field density test per lift of backfill for every 30 meter (100 feet) of installation shall be performed. One moisture density relationship shall be determined for every 800 cubic meter (800 cubic yards) of material used. Field in-place density shall be determined in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922. When ASTM D 2922 is used, the calibration curves shall be checked and adjusted using only the sand cone method as described in paragraph "Calibration" of the ASTM publication. ASTM D 2922 method results in a wet unit weight of soil and when using either of these methods, ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gages shall be checked along with density calibration checks as described in ASTM D 3017. The calibration checks of both the density and moisture gages shall be made at the beginning of a job, on each different type of material encountered, at intervals as directed by the Contracting Officer. Six (6) copies of calibration curves, results of calibration tests, and field and laboratory density tests shall be furnished to the Contracting Officer within 24 hours of conclusion of the tests. Trenches improperly compacted shall be reopened to the depth directed, then refilled and compacted to the density specified at no additional cost to the Government.

3.4.2 Displacement of Sewers

After other required tests have been performed and the trench backfill compacted to the finished grade surface, the pipe shall be inspected to determine whether significant displacement has occurred. This inspection shall be conducted in the presence of the Contracting Officer. Pipe sizes larger than 900 mm (36 inches) shall be entered and examined, while smaller diameter pipe shall be inspected by shining a light or laser between manholes or manhole locations, or by the use of television cameras passed through the pipe. If, in the judgment of the Contracting Officer, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, the defects shall be remedied as directed at no additional cost to the Government.

3.5 CONTRACTOR QUALITY CONTROL

The Contractor shall establish and maintain a quality control procedure to assure compliance of the installed excavation, trenching, and backfilling for utilities systems with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner at no additional cost to the Government. Quality control shall include, but not be limited to, the following:

a. Conservation of topsoil.

b. Excavation: Lines, grades, elevations, and dimensions; removal and replacement of unsatisfactory materials; maintaining distance from walls and footings; drainage; dewatering; shoring and sheet piling; width and depth of trenches; and protection or removal of existing, utility lines.

c. Filling and backfilling: Trench bottom preparation; lift thickness; and selection of backfill material.

d. Compaction: Compacting fill to specified densities, with testing as hereinbefore specified.

3.5.1 Contractor's Quality Control (CQC) Procedure:

The CQC procedure for excavation, trenching, and backfilling for utilities systems installation shall be submitted to the Contracting Officer for approval prior to the start of excavation, trenching, and backfilling for utilities systems work.

SECTION 02225

EARTHWORK FOR ROADWAYS, RAILROADS, AND AIRFIELDS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS(AASHTO)

AASHTO T 180	(1997) Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and an 457mm (18-in) Drop
AASHTO T 224	(1996) Correction for Coarse Particles in the Soil Compaction Test

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates
ASTM D 422	(1963; R 1990) Particle-Size Analysis of Soils
ASTM D 1140	(1997) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve

ASTM D 1556	(1990; R 1996e1) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(1991; R 1998) Laboratory Compaction Characteristics of Soil Using the Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu. m.))
ASTM D 2167	(1994) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2487	(1998) Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2922	(1996e1) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 2937	(1994) Density of Soil in Place by the Drive- Cylinder Method
ASTM D 2992	(1996e1) Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings
ASTM D 3017	(1988; R 1996e1) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 4318	(1998) Liquid Limit, Plastic Limit, and Plasticity Index of Soils

KOREAN STANDARDS (KS)

KS F2302	(1992) Test Method for Particle size distribution of Soils
KS F2303	(2003) Method of Test for Liquid limit of Soils
KS F2304	(1974) Method of Test for Plastic limit of Soils
KS F2306	(2000) Method of Test for Moisture Content of Soils.
KS F2311	(2001) Test Method for Density of Soil in place by the Sand Cone Method.
KS F2312	(2001) Test Method for Soil Compaction Using a Rammer
KS F2324	(2001) Method of Classification of Soils for Engineering Purpose.

1.2 DEFINITIONS

1.2.1 Satisfactory Materials

Satisfactory materials shall comprise any materials classified by, MIL STD 619 and ASTM D 2487 or KS F2324 as GW, GP, SW, SP, GC, SC, SM and GM. Satisfactory materials for grading shall be comprised of stones less than 200mm, except for fill material for pavements and railroad which shall be comprised of stones less than 75mm in any dimension and free from roots and other organic matter, trash, debris, and frozen.

1.2.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Materials classified by MIL STD 619 and ASTM D 2487 or KS F2324 as CH, CL, Pt, OH, and OL are unsatisfactory. Unsatisfactory materials also include man-made fills, refuse, or backfills from previous construction.

1.2.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D 2487 or KS F2324 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Testing required for classifying materials shall be in accordance with ASTM D 4318, ASTM C 136, ASTM D 422, and ASTM D 1140 or KS F2303 and KS F2304.

1.2.4 Degree of Compaction

Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557, AASHTO T180 with AASHTO T 224 or KS F2312 abbreviated as a percent of laboratory maximum density.

1.3 CLASSIFICATION OF EXCAVATION

No consideration will be given to the nature of the materials, and all excavation will be designated as unclassified excavation. Excavation specified shall be done on a classified basis, in accordance with the following designations and classifications.

1.3.1 Rock Excavation

Rock excavation shall include blasting, excavating, grading, and disposing of material classified as rock and shall include the satisfactory removal and disposal of boulders 1/2 cubic meter or more in volume; solid rock; rock material that is in ledges, bedded deposits, and unstratified masses, which cannot be removed without systematic drilling and blasting; and firmly cemented conglomerate deposits possessing the characteristics of solid rock impossible to remove without systematic drilling and blasting. The removal of any concrete or masonry structures, except pavements, exceeding 1/2 cubic meter in volume that may be encountered in the work shall be included in this classification. If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock excavation, such material shall be uncovered and the Contracting Officer shall be notified by the Contractor. The Contractor shall not proceed with the excavation of this material until the Contracting Officer has classified the materials as common excavation or rock excavation and has taken cross sections as required. Failure on the part of the Contractor to uncover such material, notify the Contracting Officer, or allow ample time for classification and cross sectioning of the undisturbed surface of such material will cause the forfeiture of the Contractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Contracting Officer for the areas of work in which such deposits occur.

1.3.2 COMMON EXCAVATION

Common excavation shall include the satisfactory removal and disposal of all materials not classified as rock excavation.

1.4 UTILIZATION OF EXCAVATED MATERIALS

Unsatisfactory materials removed from excavations shall be disposed of in designated waste disposal or spoil areas. Satisfactory material removed from excavations shall be used, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes. No satisfactory excavated material shall be wasted without specific written authorization. Satisfactory material authorized to be wasted shall be disposed of in designated areas approved for surplus material storage or designated waste areas as directed. Newly designated waste areas on Government-controlled land shall be cleared and grubbed before disposal of waste material thereon. Coarse rock from excavations shall be stockpiled and used for constructing slopes or embankments adjacent to streams, or sides and bottoms of channels and for protecting against erosion. No excavated material shall be disposed of to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

PART 2 EXECUTION

2.1 STRIPPING OF TOPSOIL

Where indicated or directed, topsoil shall be stripped to a depth of 150 millimeters (6 inches). Topsoil shall be spread on areas already graded and prepared for topsoil, or transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later, or at locations indicated or specified. Topsoil shall be kept separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 50 mm (2 inches) in diameter, and other materials that would interfere with planting and maintenance operations. Any surplus of topsoil from excavations and grading shall be stockpiled in locations indicated.

2.2 EXCAVATION

The Contractor shall perform excavation of every type of material encountered within the limits of the project to the lines, grades, and elevations indicated and as specified. Grading shall be in conformity with the typical sections shown and the tolerances specified in paragraph FINISHING. Satisfactory excavated materials shall be transported to and placed in fill or embankment within the limits of the work. Unsatisfactory materials encountered within the limits of the work shall be excavated below grade and replaced with satisfactory materials as directed. Such excavated material and the satisfactory material ordered as replacement shall be included in excavation. Surplus satisfactory excavated material not required for fill or embankment shall be disposed of in areas approved for surplus material storage or designated waste areas. Unsatisfactory excavated material shall be disposed of in designated waste or spoil areas. During construction, excavation and fill shall be performed in a manner and sequence that will provide proper drainage at all times. Material required for fill or embankment in excess of that produced by excavation within the grading limits shall be excavated from the borrow areas indicated or from other approved areas selected by the Contractor as specified.

2.2.1 Ditches, Gutters, and Channel Changes

Excavation of ditches, gutters, and channel changes shall be accomplished by cutting accurately to the cross sections, grades, and elevations shown. Ditches and gutters shall not be excavated below grades shown. Excessive open ditch or gutter excavation shall be backfilled with satisfactory, thoroughly compacted, material or with suitable stone or cobble to grades shown. Material excavated shall be disposed of as shown or as directed, except that in no case shall material be deposited less than 1 meter (4 feet) from the edge of a ditch. The Contractor shall maintain excavations free from detrimental quantities of leaves, brush, sticks, trash, and other debris until final acceptance of the work.

2.2.2 Drainage Structures

Excavations shall be made to the lines, grades, and elevations shown, or as directed. Trenches and foundation pits shall be of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Rock or other hard foundation material shall be cleaned of loose debris and cut to a firm, level, stepped, or serrated surface. Loose disintegrated rock and thin strata shall be removed. When concrete or masonry is to be placed in an excavated area, the bottom of the excavation shall not be disturbed. Excavation to the final grade level shall not be made until just before the concrete or masonry is to be placed.

2.3 SELECTION OF BORROW MATERIAL

Borrow material shall be selected to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Borrow material shall be obtained from the borrow areas shown or from other approved sources, either private or within the limits of the project site, selected by the Contractor. Unless otherwise provided in the contract, the Contractor shall obtain from the owners the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling. Borrow material from approved sources on Government-controlled land may be obtained without payment of royalties. Unless specifically provided, no borrow shall be obtained within the limits of the project site without prior written approval. Necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon shall be considered related operations to the borrow excavation and shall be performed by and is the responsibility of Contractor at no additional cost to the Government.

2.4 OPENING AND DRAINAGE OF EXCAVATIONS AND BORROW PITS

The Contractor shall notify the Contracting Officer sufficiently in advance of the opening of any excavation or borrow pit to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, borrow pits and other excavation areas shall be excavated providing adequate drainage. Overburden and other spoil material shall be transported to designated spoil areas or otherwise disposed of as directed. Borrow pits shall be neatly trimmed and drained after the excavation is completed. The Contractor shall ensure that excavation of any area, operation of borrow pits, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

2.5 GRADING AREAS

Where indicated, work will be divided into grading areas within which satisfactory excavated material shall be placed in embankments, fills, and required backfills. The Contractor shall not haul satisfactory material excavated in one grading area to another grading area except when so directed in writing.

2.6 BACKFILL

Backfill adjacent to any and all types of structures shall be placed and compacted to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials to prevent wedging action or eccentric loading upon or against the structure. Ground surface on which backfill is to be placed shall be prepared as specified in paragraph PREPARATION OF GROUND SURFACE FOR EMBANKMENTS. Compaction requirements for backfill materials shall also conform to the applicable portions of paragraphs PREPARATION OF GROUND SURFACE FOR EMBANKMENTS, EMBANKMENTS, and SUBGRADE PREPARATION, and Section 02720: STORM-DRAINAGE SYSTEM; and Section 02222: EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

2.7 PREPARATION OF GROUND SURFACE FOR EMBANKMENTS

Ground surface on which fill is to be placed shall be stripped of live, dead, or decayed vegetation, rubbish, debris, and other unsatisfactory material; plowed, disked, or otherwise broken up; pulverized; moistened or aerated as necessary; thoroughly mixed; and compacted to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. The prepared ground surface shall be scarified and moistened or aerated as required just prior to placement of embankment materials to assure adequate bond between embankment material and the prepared ground surface.

2.8 EMBANKMENTS

2.8.1 Earth Embankments

Earth embankments shall be constructed from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 75 mm. (3 inches.) The material shall be placed in successive horizontal layers of loose material not more than 200 millimeters (8 inches) in depth. Each layer shall be spread uniformly on a soil surface that has been moistened or aerated as necessary and scarified or otherwise broken up in such a manner that the fill will bond with the surface on which it is placed. After spreading, each layer shall be plowed, disked, or otherwise broken up; moistened or aerated as necessary; thoroughly mixed; and compacted to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials. Compaction requirements for the upper portion of earth embankments forming subgrade for pavements shall be identical with those requirements specified in paragraph SUBGRADE PREPARATION. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

2.8.2 Rock Embankments

Rock embankments shall be constructed from material classified as rock excavation, as defined above, placed in successive horizontal layers of loose material not more than 300 millimeters (12 inches) in depth. Pieces of rock larger than 200 millimeters (8 inches) in greatest dimension shall not be used. Each layer of material shall be spread uniformly, completely saturated, and compacted until the intersoils are filled with well compacted materials and the layer is densely compacted mass. Each successive layer of material shall adequately bond to the material on which it is placed. Compaction shall be accomplished with vibratory compactors weighing at least 5 metric tons, or heavy rubber-tired rollers weighing at least 15 metric tons. In embankments on which pavements are to be constructed, rock shall not be used above a point within the frost penetration depth the surface of the pavement.

2.9 SUBGRADE PREPARATION

2.9.1 Construction

Subgrade shall be shaped to line, grade, and cross section, and compacted as specified. This operation shall include plowing, disking, and any moistening or aerating required to obtain specified compaction. Soft or otherwise unsatisfactory material shall be removed and replaced with satisfactory excavated material or other approved material as directed. Rock encountered in the cut section shall be excavated to a depth of 150 mm (6 inches) below finished grade for the subgrade. Low areas resulting from removal of unsatisfactory material or excavation of rock shall be brought up to required grade with satisfactory materials, and the entire subgrade shall be shaped to line, grade, and cross section and compacted as specified. After rolling, the surface of the subgrade for roadways shall not show deviations greater than 10 millimeter (3/8 inch) when tested with a 3.0 meter (10 foot) straightedge applied both parallel and at right angles to the centerline of the area. After rolling, the surface of the subgrade for airfields shall not show deviations greater than 6 millimeter (1/4 inch) when tested with a 3 meter (10 foot) straightedge applied both parallel and at right angles to the centerline of the area. The elevation of the finish subgrade shall not vary more than 15 mm (0.05 foot) from the established grade and cross section.

2.9.2 COMPACTION

Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

2.9.2.1 Subgrade for Railroads

Subgrade for railroads shall be compacted to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials.

2.9.2.2 Subgrade for Pavements

Subgrade for pavements shall be compacted to the densities specified under 2.9.2.1 above the depth below the surface of the pavement shown below.

2.9.2.3 Subgrade for Shoulders

Subgrade for shoulders shall be compacted to the densities specified under 2.9.2.1 above for the depth below the surface of shoulder shown below.

Depth Below Pavement (or Shoulder) Surfaces mm (inches)	Percent of Laboratory Maximum Density Required			
	Fill		Cut	
To	Cohesive Materials	Cohesionless Materials	Cohesive Materials	Cohesionless Materials
1070 (42)	90	95		
920 (36)			90	95

2.10 SHOULDER CONSTRUCTION

Shoulders shall be constructed of satisfactory excavated or borrow material or as otherwise shown or specified. Shoulders shall be constructed as soon as possible after adjacent paving is complete, but in the case of rigid pavements, shoulders shall not be constructed until permission of the Contracting Officer has been obtained. The entire shoulder area shall be compacted to at least the percentage of maximum density as specified in paragraph SUBGRADE PREPARATION above, for specific ranges of depth below the surface of the shoulder. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Shoulder construction shall be done in proper sequence in such a manner that adjacent ditches will be drained effectively and that no damage of any kind is done to the adjacent completed pavement. The completed shoulders shall be true to alignment and grade and shaped to drain in conformity with the cross section shown.

2.11 FINISHING

The surface of excavations, embankments, and subgrades shall be finished to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. The degree of finish for graded areas shall be within 30 mm (0.1 foot) of the grades and elevations indicated except that the degree of finish for subgrades shall be specified in paragraph SUBGRADE PREPARATION. Gutters and ditches shall be finished in a manner that will result in effective drainage. The surface of areas to be turfed shall be finished to a smoothness suitable for the application of turfing materials.

2.12 SUBGRADE AND EMBANKMENT PROTECTION

During construction, embankments and excavations shall be kept shaped and drained. Ditches and drains along subgrade shall be maintained in such a manner as to drain effectively at all times. The finished subgrade shall not be disturbed by traffic or other operation and shall be protected and maintained by the Contractor in a satisfactory condition until ballast, subbase, base, or pavement is placed. The storage or stockpiling of materials on the finished subgrade will not be permitted. No subbase, base course, ballast, or pavement shall be laid until the subgrade has been checked and approved, and in no case shall subbase, base, surfacing, pavement, or ballast be placed on a muddy, spongy, or frozen subgrade.

2.13 TESTING

Testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government. Testing shall be performed by a Government approved commercial testing laboratory or may be tested by the Contractor subject to approval. If the Contractor elects to establish testing facilities, no work requiring testing will be permitted until the Contractor's facilities have been inspected and approved by the Contracting Officer. The first inspection shall be at the expense of the Government. Cost incurred for any subsequent inspections required because of failure of the first inspection will be charged to the Contractor. Field in-place density shall be determined in accordance with ASTM D 1556, ASTM D 2922 or KS F2311. When ASTM D 2922 is used, the calibration curves shall be checked and adjusted using only the sand cone method as described in ASTM D 1556 or KS F2311. ASTM D 2922 results in a wet unit weight of soil and when using this method ASTM D 3017 or KS F2306 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gages shall also be checked along with density calibration checks as described in ASTM D 3017. The calibration checks of both the density and moisture gages shall be made at the beginning of a job on each different type of material encountered and in intervals as directed by the Contracting Officer. The Drive Cylinder Method shall be used only for soft, fine-grained, cohesive soils. Within 24 hours of conclusion of physical tests, six (6) copies of test results, including calibration curves and results of calibration tests, shall be furnished to the Contracting Officer. When test results indicate, as determined by the Contracting Officer, that compaction is not as specified, the material shall be removed, replaced and recompacted to meet specification requirements, at no additional expense to the Government. Tests on recompacted areas shall be performed to determine conformance with specification requirements. Inspections and test results shall be certified by a registered professional civil engineer. These certifications shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

2.13.1 Fill and Backfill Material Gradation Including Borrow Materials

One test per 500 cubic yards stockpiled or in-place source material. Gradation of fill and backfill material shall be determined in accordance with ASTM C 136, ASTM D 422 or ASTM D 1140.

2.13.2 In-Place Densities

2.13.2.1 One test per 200 square meter (2000 square feet), or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines.

2.13.2.2 One test per 100 square meter (1000 square feet), or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

2.13.2.3 One test per 100 meter (300 linear feet), or fraction thereof per track, of each lift of embankment or fill for railroads.

2.13.3 Check Tests on In-Place Densities: When ASTM D 2922 is used, in-place densities shall be checked by ASTM D 1556 as follows:

a. One check test per lift for each 1,000 square meter (10,000 square feet), or fraction thereof, of each lift of fill or backfill compacted by other than hand-operated machines.

b. One check test per lift for each 500 square meter (5000 square feet) of fill or backfill areas compacted by hand-operated machines.

c. One check test per lift for each 450 meter (1500 linear feet), or fraction thereof, per track of embankment or backfill for railroads.

2.13.4 Moisture Contents

In the stockpile, excavation or borrow areas, a minimum of two tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, tests shall be made as dictated by local conditions and approved by the Contracting Officer.

2.13.5 Optimum Moisture and Laboratory Maximum Density

Tests shall be made for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 400 cubic meter (500 cubic yards) of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

2.13.6 TOLERANCE TESTS FOR SUBGRADES

Continuous checks on the degree of finish specified in paragraph, SUBGRADE PREPARATION, shall be made during construction of the subgrades.

2.14 CONTRACTOR QUALITY CONTROL

The Contractor shall establish and maintain a quality control procedure to assure compliance of the installed excavation, embankment, and preparation of subgrade for roadways with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to, the following:

a. Clearing and grubbing.

b. Conservation of topsoil.

c. Excavation: Lines, grades, elevations, and dimensions; removal and replacement of unsatisfactory materials; and drainage.

d. Filling and backfilling: Subgrade preparation; lift thickness; and selection of borrow material.

e. Compaction: Proper methods and equipment; testing and reporting.

f. Protection of graded, filled, or backfilled areas from settlement, washing and erosion.

2.14.1 Contractor's Quality Control (CQC) Procedure

The CQC procedure for excavation, embankment, and preparation of subgrade for roadways installation shall be submitted to the Contracting Officer for approval prior to the start of excavation, embankment, and preparation of subgrade for roadways work.

SECTION 02232

SUBBASE COURSE

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPROTATION OFFICIALS (AASHTO)

AASHTO T 180 (1997) Moisture-Density Relations of Soils Using a 4.54 kg(10 lb) Rammer and an 457mm (18 in) Drop

American Society for Testing and Materials (ASTM)

ASTM C 29/C 29 M (1997) Bulk density and Voids in Aggregate

ASTM C 117 (1995) Materials Finer Than 75-micrometer (No. 200) Sieve in Mineral Aggregates by Washing

ASTM C 131	(1996) Resistance to Degradation of Small-size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(1996) Sieve Analysis of Fine and Coarse Aggregates
ASTM D 75	(1987; R 1997) Sampling Aggregates
ASTM D 422	(1963; R 1998) Particle Size Analysis of Soils
ASTM D 1241	(1984) Specification for materials for soil-Aggregate Subbase, Base and Surface Courses
ASTM D 1556	(1990; R 1996e1) Density of Soil in Place by the Sand-Cone Method
ASTM D 1557	(1998) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000ft-lbf/cu.ft (2700KN-m/CU.m))
ASTM D 2167	(1994) Density and Unit Weight of Soil in Place by the Rubber-Balloon Method
ASTM D 2487	(1998)Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2922	(1996e1) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017	(1988; R 1996e1) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 4318	(1998) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM E 11	(1995) Wire-Cloth Sieves for Testing Purposes
ASTM E 548	(1994) Preparation of Criteria for Use in the Evaluation of Testing Laboratories and Inspection Bodies

KOREAN STANDARDS (KS)

KS A5101	(1999) Test Sieves.
KS F2302	(1992) Test Method for Particle size distribution of Soils
KS F2303	(2000) Method of Test for Liquid limit of Soils
KS F2304	(1974) Method of Test for Plastic limit of Soils
KS F2306	(2000) Method of Test for Moisture Content of Soils.
KS F2311	(2311) Test Method for Density of Soil in place by the Sand Cone Method.
KS F2312	(2001) Test Method for Soil Compaction Using a Rammer

KS F2324	(2001) Method of Classification of Soils for Engineering Purpose.
KS F2502	(1997) Method of Test for Sieve Analysis of Aggregates.
KS F2507	(1997) Method of Test for Soundness of Aggregates by Use of Sodium Sulfate.
KS F2508	(1997) Method of Test for Abrasion of coarse Aggregates by Use of Los Angeles Machine.
KS F2528	(1997) Materials for Soil, Aggregate Subbase, Base and Surface Courses.

1.2 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment; FIO.

List of proposed equipment to be used in performance of construction work, including descriptive data.

SD-06 Test Reports

Sampling and Testing; FIO.

Copies of all laboratory and field test reports to the Contracting Officer within 24 hours of the completion of the test. See Part 1, paragraph 1.5 SAMPLING AND TESTING for a detailed list of the submittals.

SD-18 Records

Sampling and Testing; GA.

The Contractor shall furnish, the name, qualifications and description of the testing facilities of the selected commercial testing laboratory or of the Contractor proposed for use in performing the required tests.

1.3 DEGREE OF COMPACTION

Degree of compaction is a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557, Method D, AASHTO T 180, Method D or KS F2312. This will be abbreviated herein as percent of laboratory maximum density.

1.4 EQUIPMENT

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. The equipment shall be adequate and shall have the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

1.5 SAMPLING AND TESTING

Sampling and testing shall be the responsibility of the Contractor. Sampling and testing shall be performed by an approved commercial testing laboratory, or by the Contractor subject to approval. If the Contractor elects to establish testing facilities of his own, no work requiring testing will be permitted until the Contractor's facilities have been inspected and approved. The first inspection shall be at the expense of the Government and any subsequent inspections required because of failure of the first inspection will be at the expense of the Contractor. Such costs will be deducted from the total amount due the Contractor. The materials shall be tested to establish compliance with the specified requirements. Field density tests shall be performed on every 500 square meters (5,000 square feet) of completed subbase; samples for laboratory testing shall also be taken from this same area. Six (6) copies of test results shall be furnished to the Contracting Officer.

1.5.1 Sampling

Samples for laboratory testing shall be taken in conformance with ASTM D 75 or KS F2501. When deemed necessary the sampling may be observed by the Contracting Officer.

1.5.2 Tests

1.5.2.1 Sieve Analyses

Sieve analyses shall be made in conformance with ASTM C 117 and ASTM C 136 or KS F2302. Sieves shall conform to ASTM E 11 or KS A5101.

1.5.2.2 Liquid Limit and Plasticity Index

Liquid limit and plasticity index shall be determined in accordance with ASTM D 4318 or KS F2503 and KS F2504.

1.5.2.3 Density Tests

Density tests shall be measured in the field in accordance with ASTM D 1556, ASTM D 2167, KS F2311, KS F2312 and ASTM D 2922. For the method presented in ASTM D 2922 , the calibration curves shall be checked and adjusted, if necessary, using only the sand cone method described in paragraph Calibration of the ASTM publication. Test performed in accordance with ASTM D 2922 results in a wet unit weight of soil and, when using this method, ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D 3017. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

1.5.2.4 Wear Test: Wear tests shall be made on subbase course material in conformance with ASTM C 131 or KS F2508.

1.5.3 Testing Frequency

1.5.3.1 Initial Tests

One of each of the following tests shall be performed on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements prior to installation.

a. Sieve Analysis not encluding 0.02 mm size material

b. Liquid limit and plasticity index moisture-density relationship

c. Wear

d. Weight per cubic meter foot of Slag

1.5.3.2 In-Place Tests

One of each of the following tests shall be performed on samples taken from the placed and compacted subbase and select-material subbase course.

Samples shall be taken for each 1000 square meters of each layer of material placed in each area.

a. Sieve Analysis not including 0.02 mm size material

b. Field Density

c. Moisture liquid limit and plasticity index

1.5.3 Approval of Material

The source of the material shall be selected 30 days prior to the time the material will be required in the work. Tentative approval of the source will be based on an inspection by the Contracting Officer. Tentative approval of material will be based on tests of samples for the specific job. Final approval of both the source and the materials will be based on tests for gradation, liquid limit, and plasticity index, performed on samples taken from the completed and compacted subbase course.

1.6 WEATHER LIMITATION

Select-material subbase courses shall be constructed when the atmospheric temperature is above 2 degrees C. (35 degrees F.) When the temperature falls below 2 degrees C, (35 degrees F,) the Contractor shall protect all areas of completed select-material subbase course by approved methods against detrimental effects of freezing. Areas of completed select-material subbase course damaged by freezing, rainfall, or other weather conditions shall be corrected to meet specified requirements.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Subbase Course

Aggregates shall consist of crushed stone or slag, gravel, shell, sand, or other sound, durable, approved materials processed and blended or naturally combined. Aggregates shall be durable and sound, free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. Material retained on the 4.75 mm (No. 4) sieve shall have a percentage of wear not to exceed 50 percent after 500 revolutions when tested as specified in ASTM C 131. Aggregate shall be reasonably uniform in density and quality. Slag shall be an air-cooled, blast-furnace product having a dry weight of not less than 1050 kg/cubic meter.(65 pcf.) Aggregates shall have a maximum size of 50 mm and shall be within the limits specified as follows:

Maximum Allowable Percentage by Weight

	%Passing Square-Mesh Sieve			
Sieve Designation	No. 1	No. 2	No. 3	No.4
2 mm	50	80	--	85
0.075 mm	15	15	15	15

Particles having diameters less than 0.02 mm 0.0008 inches shall not be in excess of 3 percent by weight of the total sample tested as determined in accordance with ASTM D 422. The portion of any blended component and of the completed course passing the 0.425 mm (No. 40) sieve shall be either nonplastic or shall have a liquid limit not greater than 25 and a plasticity index not greater than 5.

2.1.2 Select-Material Subbase Course

Materials shall consist of selected soil or other materials from field excavation, stockpiles, or other sources. Material shall be free from lumps and balls of clay and from organic and other objectionable matter. Not more than 25 percent by weight shall pass the 0.075 mm (No. 200)sieve. The portion of material passing the 0.425 mm (No. 40) sieve shall have a liquid limit less than 35 and a plasticity index less than 12. The maximum particle size shall not exceed 75 mm.(3 inches.) Particles having diameters less than 0.02 millimeter shall not be in excess of 3 percent by weight of the total sample tested as determined in accordance with ASTM D 422.

2.1.3 Standard Gradation of the subbase course material after compaction

Gradation requirements specified herein shall apply to the completed Subbase course. The aggregates shall have a maximum size of 38 mm (1-1/2 inch) and be graded continuously well within the limits specified in Table I. Sieves shall conform to ASTM E 11 or KS A5101.

TABLE I. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	% Passing NO. 1	NO. 2	NO. 3
80 mm	-	100	-
50 mm	-	-	100
40 mm	-	70-100	80-100
28 mm (1-1/2 inch)	100	-	-
25 mm (1 inch)	65-90	-	-
19 mm	-	50-90	55-100
13 mm (1/2 inch)	40-65	-	-
4.75 mm (No. 4)	20-45	-	-
(No. 8)	-	20-55	20-55
2.00 mm (No. 10)	15-35	-	-
425 µm (No. 40)	10-25	5-25	5-25
75 µm (No. 200)	0-4	2-10	2-10

NOTE 1: Particles having diameters less than 0.02 mm shall not be in excess of 1.5 percent by weight of the total sample tested.

NOTE 2: The values are based on aggregates of uniform specific gravity, and the percentages passing the various sieves may require appropriate correction by the Contracting Officer when aggregates of varying specific gravities are used.

2.1.4 Liquid Limit, Plasticity Index and CBR value

Liquid limit and plasticity index requirements stated herein shall apply to any aggregate component that is blended to meet the required gradation and also to the aggregate in the completed base course. The portion of the aggregate passing the No. 40 sieve shall be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5. The California Bearing Ratio (CBR) values for the subbase materials are minimum 30 % for flexible pavement and minimum 80 % for concrete pavement where the concrete pavement slab directly laid over the subbase course.

PART 3 EXECUTION

3.1 OPERATION OF AGGREGATE SOURCES

All clearing, stripping and excavating work involved in the opening or operation of aggregate sources shall be performed by the Contractor. Aggregate sources shall be opened to working depth in a manner that produces excavation faces that are as nearly vertical as practicable for the materials being excavated. Materials excavated from aggregate sources shall be obtained in successive cuts extending through all exposed strata. All pockets or strata of unsuitable materials overlying or occurring in the deposit shall be wasted as directed. The methods of operating aggregate sources and the processing and blending of the material may be changed or modified by the Contracting Officer, when necessary, in order to obtain material conforming to specified requirements. Upon completion of work, aggregate sources on Government reservations shall be conditioned to drain readily, and shall be left in a satisfactory condition. Aggregate sources on private lands shall be conditioned in agreement with local laws and authorities.

3.2 STOCKPILING MATERIAL

Prior to stockpiling of material, storage sites shall be cleared and leveled by the Contractor. All materials, including approved material available from excavation and grading, shall be stockpiled in the manner and at the locations designated. Aggregates shall be stockpiled on the cleared and leveled areas designated by the Contracting Officer so as to prevent segregation. Materials obtained from different sources shall be stockpiled separately. A minimum 300 mm (12 inch) thickness of stockpiled material will be left as a buffer to prevent contamination from underlying soil.

3.3 PREPARATION OF UNDERLYING COURSE

Prior to constructing the crushed-aggregate base course, the underlying course shall be cleaned of all foreign substances. At the time of construction of the base course, the underlying course shall contain no frozen material. The underlying course shall conform to SECTION 02225: EARTHWORK FOR ROADWAYS, RAILROADS, AND AIRFIELDS or SECTION 02234: SUBBASE COURSE as applicable. Ruts or soft, yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses containing sands or gravel as defined in ASTM D 2487, the surface shall be stabilized prior to placement of the graded-crushed-aggregate base course. Stabilization shall be accomplished by mixing graded-crushed-aggregate base material into the underlying course and compacting by approved methods. The stabilized material shall be considered as part of the underlying course and shall meet all requirements of the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained by the Contractor in a satisfactory condition until the base course is placed.

3.4 GRADE CONTROL

The finished and completed subbase course shall conform to the lines, grades, and cross sections shown. The lines, grades, and cross sections shown shall be maintained by means of line and grade stakes placed by the Contractor at the work site.

3.5 MIXING OF PLACING MATERIALS

The materials shall be mixed and placed to obtain uniformity of the subbase and select-material subbase material at the water content specified. The Contractor shall make such adjustments in mixing or placing procedures or in equipment as may be directed to obtain the true grades, to minimize segregation and degradation, to reduce or accelerate loss or increase of water, and to insure a satisfactory subbase course.

3.6 LAYER THICKNESS

The compacted thickness of the completed course shall be as indicated.

When a compacted layer of 150 mm 6 inches is specified, the material may be placed in a single layer; when a compacted thickness of more than 150 mm 6 inches is required, no layer shall exceed 150 mm 6 inches nor be less than

75 mm 3 inches when compacted. mixed material shall be placed on the prepared subgrade or subbase in layers of uniform thickness with an approved spreader. When a compacted layer 150 mm (6 inches) or less in thickness is required, the material shall be placed in a single layer. Where the subbase course is placed in more than one layer, the previously constructed layers shall be cleaned of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms, as directed. Such adjustments in placing procedures or equipment shall be made as may be directed to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to insure an acceptable base course.

3.7 COMPACTION

3.7.1 Requirements

Each layer of subbase course including shoulders shall be compacted as specified to produce an average field-measured density, through the full depth, of at least 100 percent of laboratory maximum density. Water content shall be maintained during the compaction procedure and subsequent proof rolling of designated areas such that the water content is within plus or minus 2 percent of optimum water content as determined from laboratory tests as specified in density test procedures listed in paragraph 1.5 SAMPLING AND TESTING. In all places not accessible to the rollers, the base course material shall be compacted with mechanical tampers.

3.7.2 Finishing

The surface of top layer of base course shall be finished after final compaction, and proof rolled, where required, by cutting any overbuild to grade and rolling with a steel-wheeled roller. In no case will thin layers of material be added to the top layer of base course to meet grade. If the elevation of top layer of base course is 9.5 mm (3/8 inch) or more below the grade, the top layer of base shall be scarified to a depth of at least 75 mm

(3 inches), new material shall be added, and the layer shall be blended and recompacted to bring to grade. Adjustments in rolling and finishing procedures shall be made as may be directed to obtain grades, to minimize segregation and degradation of base course material, to adjust the water content, and to insure an acceptable base course. Material found unacceptable shall be removed and replaced, as directed, with acceptable material.

3.8 PROOF ROLLING

Proof rolling of the areas designated shall be in addition to compaction specified above and shall consist of application of 30 coverages with a heavy pneumatic-tired roller having four tires abreast, with each tire loaded to 15 ton (30,000 pounds) and tires inflated to 10.54 Kg/square cm (150 psi). In the areas designated, proof rolling shall be applied to the top lift of layer on which the base course is laid and to each layer of the base course. Water content of the lift of the layer on which the base course is placed, and of each layer of the base course, shall be maintained at optimum, or at the percentage directed from the start of compaction to the completion of proof rolling. Materials in the base course or underlying materials indicated unacceptable by the proof rolling shall be removed and replaced, as directed, with acceptable materials.

3.9 EDGES OF SUBBASE COURSE

Acceptable material shall be placed along the edges of the subbase course in such quantity as will compact to the thickness of the course being constructed. When the course is being constructed in two or more layers, at least a 300 mm (1-foot) width of the shoulder shall be rolled and compacted simultaneously with the rolling and compacting of each layer of the base course, as directed.

3.10 SMOOTHNESS TEST

The surface of the top layer shall not deviate more than 10 mm (3/8 inch) when tested with a 3.0 m (10-foot) straightedge applied parallel with and at right angles to the centerline of the area to be paved. Deviations exceeding 10 mm (3/8 inch) shall be corrected as directed.

3.11 THICKNESS CONTROL

The completed thickness of the subbase and selected subbase course shall be within 10 mm (3/8 inch) of the thickness indicated on the drawings. The thickness of the each course shall be measured at intervals providing at least one measurement for at least each 400 square meter (500 square yards) or part thereof of subbase course. The depth measurement shall be made by test holes at least 75 mm (3 inches) in diameter. Where the measured thickness of the subbase course is more than 10 mm (3/8 inch) deficient, such areas shall be corrected by excavating to the required depth and replacing with new material. Where the measured thickness of the subbase course is 10 mm (3/8 inch) more than indicated, it will be considered as conforming with the requirements provided the surface of the base course is within 10 mm (3/8 inch) of established grade. The average job thickness shall be the average of the job measurements as specified above but within 6 mm (1/4 inch) of the thickness indicated.

3.12 MAINTENANCE

The subbase and selected subbase course shall be maintained in a satisfactory condition until accepted.

3.13 CONTRACTOR QUALITY CONTROL

The Contractor shall establish and maintain a quality control procedure to assure compliance of the installed graded-crushed-aggregate base course with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to, the following:

a. Materials including one sieve analysis for each day's operation.

b. Use of approved equipment: Types, and number of each type.

c. Stockpiling: Location, clearing and leveling of storage areas.

d. Preparation of underlying layer surface: Compaction, surface tolerances, and correction of defective areas.

e. Grade control: Lines, grades, cross sections, and maintenance.

f. Mixing and placing: Method and equipment to be used, layer thickness, sequence of placing, spreading, uniformity of mixture, watering, leveling to the required contour and grades, removal and replacement of unsatisfactory areas.

g. Compaction: Layer thickness; one laboratory moisture-density relation test, one abrasion test, one sieve analysis, one liquid-limit test, and one plasticity-index test for material used for each week of operation; one sand-placement field density test, one sieve analysis, and liquid-limit test, one plasticity-index test, and one smoothness test for each layer per 170 square meter (1,800 square feet).

h. Maintenance.

3.13.1 Contractor's Quality Control (CQC) Procedure

The CQC procedure for graded-crushed-aggregate base course installation shall be submitted to the Contracting Officer for approval prior to the start of the graded-crushed-aggregate base course work.

SECTION 02233

GRADED-CRUSHED-AGGREGATE BASE COURSE

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180 (1997) Moisture-Density Relations of Soils Using a 10-lb. (4.54 kg) Rammer and an 18-in (457 mm) Drop

AASHTO T 224 (1996) Correction for Coarse Particles in the Soil Compaction Test

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 29/C 29M (1997) Unit Weight and Voids in Aggregate

ASTM C 88	(1999a) Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	(1995) Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	(1988; R 1993el) Specific Gravity and Absorption of Course Aggregate
ASTM C 128	(1997) Specific Gravity and Absorption of Fine Aggregate
ASTM C 131	(1996) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates
ASTM D 75	(1987; R 1997) Sampling Aggregates
ASTM D 1556	(1990; R 1996) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(1991; R 1998) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu. m.)
ASTM D 1883	(1994) CBR (California Bearing Ratio) of Laboratory-Compacted Soils
ASTM D 2217	(1985: R 1993) Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soils Constants
ASTM D 2487	(2000) Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2922	(1996e1) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017	(1996) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 4318	(2000) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM E 11	(1995) Wire-Cloth Sieves for Testing Purposes
ASTM E 548	(1994) General Criteria Used for Evaluating Laboratory Competence

KOREAN STANDARD (KS)

KS A5101	(1999) Test Sieves
KS F2507	(1997) Method of Test for Soundness of Aggregates by Use of Sodium sulfate

KS F2508 (1997) Method of Test for Abrasion of Coarse Aggregates by Use of the Los Angeles Machine

KOREAN STANDARD SPECIFICATION FOR ROAD CONSTRUCTION, 1990, PUBLISHED BY THE MINISTRY OF CONSTRUCTION, KOREA

1.2 DEFINITIONS

For the purposes of this specification, the following definitions

1.2.1 Aggregate Base Course

Aggregate base course (ABC) is well graded, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.2 Graded-crushed Aggregate Base Course

Graded-crushed aggregate (GCA) base course is well graded, crushed, durable aggregate uniformly moistened and mechanically stabilized by compaction. GCA is similar to ABC, but it has more stringent requirements and it produces a base course with higher strength and stability.

1.2.3 Degree of Compaction

Degree of compaction shall be expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557 Method D or AASHTO T 180, and corrected with AASHTO T 224.

1.2.4 Stabilized Aggregate Base

Stabilized Aggregate Base as used herein is well graded, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals having a "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools; GA

List of proposed equipment to be used in performance of construction work, including descriptive data.

SD-06 Test Reports

Sampling and testing; FIO

Field Density Tests; FIO

Calibration curves and related test results prior to using the device or equipment being calibrated. Copies of field test results within 24 hours after the tests are performed. Certified copies of test results for approval not less than 30 days before material is required for the work.

1.4 SAMPLING AND TESTING

Sampling and testing shall be the responsibility of the Contractor. Sampling and testing shall be performed by a testing laboratory approved in accordance with Section 01451 CONTRACTOR QUALITY CONTROL. Work requiring testing will not be permitted until the testing laboratory has been inspected and approved. The materials shall be tested to establish compliance with the specified requirements; testing shall be performed at the specified frequency. The Contracting Officer may specify the time and location of the tests. Copies of test results shall be furnished to the Contracting Officer within 24 hours of completion of the tests.

1.4.1 Sampling

Samples for laboratory testing shall be taken in conformance with ASTM D 75. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.4.2 Tests

The following tests shall be performed in conformance with the applicable standards listed.

1.4.2.1 Sieve Analysis

Sieve analysis shall be made in conformance with ASTM C 117 and ASTM C 136. Sieves shall conform to ASTM E 11. Particle-size analysis of the soils shall also be completed in conformance with ASTM D 422.

1.4.2.2 Liquid Limit and Plasticity Index

Liquid limit and plasticity index shall be determined in accordance with ASTM D 4318.

1.4.2.3 Moisture-Density Determinations

The maximum density and optimum moisture content shall be determined in accordance with ASTM D 1557 or AASHTO T 180, Method D and corrected with AASHTO T 224. To maintain the same percentage of coarse material, the "remove and replace" procedure as described in the NOTE 8 in Paragraph 7.2 of AASHTO T 180 shall be used.

1.4.2.4 Field Density Tests

Density shall be field measured in accordance with ASTM D 1556, ASTM D 2167] or ASTM D 2922. For the method presented in ASTM D 1556 the base plate as shown in the drawing shall be used. For the method presented in ASTM D 2922 the calibration curves shall be checked and adjusted if necessary using only the sand cone method as described in paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D 2922 result in a wet unit weight of soil and when using this method, ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D 3017 or the calibration checks of both the density and moisture gauges shall be made by the prepared containers of material method, as described in paragraph Calibration of ASTM D 2922, on each different type of material being tested at the beginning of a job and at intervals as directed.

1.4.2.5 Wear Test

Wear tests shall be made on ABC and GCA course material in conformance with ASTM C 131.

1.4.2.6 Soundness

Soundness tests shall be made on GCA in accordance with ASTM C 88.

1.4.2.7 Weight of Slag

Weight per cubic meter foot of slag shall be determined in accordance with ASTM C 29/C 29M on the [ABC] [and] [GCA] course material.

1.4.3 Testing Frequency

1.4.3.1 Initial Tests

One of each of the following tests shall be performed on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements when furnished. If materials from more than one source are going to be utilized, this testing shall be completed for each source.

a. Sieve Analysis [including 0.02 mm No. 635 size material].

b. Liquid limit and plasticity index.

c. Moisture-density relationship.

d. Wear.

e. Soundness.

f. Weight per cubic meter(foot) of Slag.

1.4.3.2 In Place Tests

Each of the following tests shall be performed on samples taken from the placed and compacted ABC and GCA. Samples shall be taken and tested at the rates indicated.

a. Density tests shall be performed on every lift of material placed and at a frequency of one set of tests for every 250 square meters, or portion thereof, of completed area.

b. Sieve Analysis shall be performed for every 500 metric tons 500 tons, or portion thereof, of material placed.

c. Liquid limit and plasticity index tests shall be performed at the same frequency as the sieve analysis.

1.4.4 Approval of Material

The source of the material shall be selected 30 days prior to the time the material will be required in the work. Tentative approval of material will be based on initial test results. Final approval of the materials will be based on sieve analysis, liquid limit, and plasticity index tests performed on samples taken from the completed and fully compacted ABC and GCA.

1.5 WEATHER LIMITATIONS

Construction shall be done when the atmospheric temperature is above 2 degrees C. 35 degrees F. When the temperature falls below 2 degrees C, 35 degrees F, the Contractor shall protect all completed areas by approved methods against detrimental effects of freezing. Completed areas damaged by freezing, rainfall, or other weather conditions shall be corrected to meet specified requirements.

1.6 PLANT, EQUIPMENT, AND TOOLS

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. The equipment shall be adequate and shall have the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

1.7 PLANT, EQUIPMENT, MACHINES, AND TOOLS

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. The equipment shall be adequate and shall have the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Aggregates

Aggregates shall consist of clean, sound, durable particles of crushed stone, crushed slag, or crushed gravel, and screenings. The Contractor shall obtain materials that meet the specification and can be used to meet the grade and smoothness requirements specified herein, after all compaction [and proof-rolling] operations have been completed. Slag shall be an air-cooled, blast-furnace product having a dry weight of not less than 1050 kg per cubic meter (65 pcf) as determined by ASTM C 29. The aggregates shall be free of silt and clay as defined by ASTM D 2487, vegetable matter, and other objectionable materials or coatings. The portion retained on the 4.75 mm No. 4 sieve shall be known as coarse aggregate; that portion passing the 4.75 mm No. 4 sieve shall be known as fine aggregate.

2.1.1.1 Coarse Aggregate

Coarse aggregates, consisting of angular fragments of uniform density and quality. Coarse aggregates shall be angular particles of uniform density. The coarse aggregate shall have a loss not greater than 20 percent weighted averaged at five cycles when tested for soundness in magnesium sulfate in accordance with ASTM C 88 or KS F2507. The coarse aggregate shall have a percentage of wear not to exceed 40 percent after 500 revolutions as determined by ASTM C 131 or KS F2508. The percentage of flat and/or elongated particles shall not exceed 20 in the fraction retained on the 13 mm (1/2 inch) sieve and in the fraction passing the 13 mm (1/2 inch sieve). A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. When the coarse aggregate is supplied from more than one source, aggregate from each source shall meet the requirements set forth herein. Crushed gravel shall be manufactured from gravel particles 90 percent of which by weight are retained on the maximum-size sieve listed in TABLE I. In the portion retained on each sieve specified, the crushed gravel shall contain at least 90 percent by weight of crushed pieces having two or more freshly fractured faces with the area of each face being at least equal to 75 percent of the smallest mid-sectional area of the place. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces.

2.1.1.2 Fine aggregates

Fine aggregate shall be angular particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. Fine aggregate shall be manufactured from gravel particles 95 percent of which by weight are retained on the 13 mm (1/2 inch) sieve.

2.1.1.3 Slag

Slag shall be an air-cooled blast-furnace product having a dry unit weight of not less than 1045 kg/cubic meter (65 pcf).

2.1.2 Binder Material

Binder material shall consist of screenings, angular sand, or other finely divided mineral matter processed or naturally combined with the coarse aggregate. Liquid-limit and plasticity-index requirements shall apply to any component that is blended to meet the required gradation and shall also apply to the completed course. The portion of any component or of the completed course passing the No. 40 sieve shall be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5.

2.1.3 Gradation

Gradation requirements specified herein shall apply to the completed base course. The aggregates shall have a maximum size of 40 millimeter(s) and be graded continuously well within the limits specified in TABLE I. Sieves shall conform to ASTM E 11, or KS A5101.

TABLE I. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	No. 1	No. 2	No. 3	No.4	No.5
50.0 mm	100	__	__	100	__
40.0mm	__	__	__	95-100	100
37.5 mm	70-100	100	__	__	__
25 mm	45-80	60-100	100	__	80-95
19 mm	__	__	__	60-90	60-90
12.5 mm	30-60	30-65	40-70	__	__
4.75 mm	20-50	20-50	20-50	30-65	30-65
2.36 mm	__	__	__	20-50	20-50
2 mm	15-40	15-40	15-40	__	__
0.425 mm	5-25	5-25	5-25	10-30	10-30
0.075 mm	0-10	0-10	0-10	2-10	2-10

TABLE I. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	No. 1	No. 2	No. 3	No. 4	No. 5
2 inch	100	--	--	100	--
1.57 inch	--	--	--	95-100	100
1-1/2 inch	70-100	100	--	--	--
1 inch	45-80	60-100	100	--	80-95
1/2 inch	30-60	30-65	40-70	--	--
¾ inch	--	--	--	60-90	60-90
No. 4	20-50	20-50	20-50	30-65	30-65
No. 8	--	--	--	20-50	20-50
No. 10	15-40	15-40	15-40	--	--
No. 40	5-25	5-25	5-25	10-30	10-30
No. 200	0-10	0-10	0-10	2-10	2-10

NOTE 1: Particles having diameters less than 0.02 mm shall not be in excess of 3 percent by weight of the total sample tested.

NOTE 2: The values are based on aggregates of uniform specific gravity, and the percentages passing the various sieves may require appropriate correction by the Contracting Officer when aggregates of varying specific gravities are used.

2.1.4 Liquid Limit, Plasticity Index and CBR.

Liquid limit and plasticity index requirements stated herein shall apply to any aggregate component that is blended to meet the required gradation and also to the aggregate in the completed base course. The portion of the aggregate passing the 0.425 mm (No. 40) sieve shall be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5. Minimum CBR value for the base course material shall be 80 %.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Prior to constructing the crushed-aggregate base course, the underlying course shall be cleaned of all foreign substances. At the time of construction of the base course, the underlying course shall contain no frozen material. The underlying course shall conform to Section 02225: EARTHWORK FOR ROADWAYS, RAILROADS, AND AIRFIELDS, Section 02234: SUBBASE COURSE, and Section 02232: SELECT-MATERIAL SUBBASE COURSE. Ruts or soft, yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses containing sand or gravel as defined in ASTM D 2487 the surface shall be stabilized prior to placement of the graded-crushed-aggregate base course. Stabilization shall be accomplished by mixing graded-crushed-aggregate base material into the underlying course and compacting by approved methods. The stabilized material shall be considered as part of the underlying course and shall meet all requirements of the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained by the Contractor in a satisfactory condition until the base course is placed.

3.2 OPERATION OF AGGREGATE SOURCES

Aggregates shall be obtained from off-site sources.

3.3 GRADE CONTROL

During construction, the lines and grades including crown and cross slope indicated for the base course shall be maintained by means of line and grade stakes placed by the Contractor.

3.4 MIXING OF MATERIALS

The coarse and fine aggregates shall be mixed in a stationary plant, or in a traveling plant or bucket loader on an approved paved working area. The Contractor shall make such adjustments in mixing procedures or in equipment as may be directed to obtain true grades, to minimize segregation or degradation, to obtain the required water content, and to ensure a satisfactory base course meeting all requirements of this specification.

3.5 PLACING

The mixed material shall be placed on the prepared subgrade or subbase in layers of uniform thickness with an approved spreader. When a compacted layer 150 mm (6 inches) or less in thickness is required, the material shall be placed in a single layer. When a compacted layer in excess of 150 mm (6 inches) is required, the material shall be placed in layers of equal thickness. No layer shall exceed 150 mm (6 inches) or be less than 75 mm (3 inches) when compacted. The layers shall be so placed that when compacted they will be true to the grades or levels required with the least possible surface disturbance. Where the base course is placed in more than one layer, the previously constructed layers shall be cleaned of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms, as directed. Such adjustments in placing procedures or equipment shall be made as may be directed to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to ensure an acceptable base course. Adequate drainage shall be provided during the entire period of construction to prevent water from collecting or standing on the area to be stabilized. Line and grade stakes shall be provided as necessary for control. Grade stakes shall be in lines parallel to the centerline of the area under construction and suitably spaced for string lining.

3.6 OPERATION OF AGGREGATE SOURCES

Aggregates shall be obtained from off-site sources.

3.7 INSTALLATION

3.7.1 Mixing and Placing

Materials shall be mixed by the stationary-plant, traveling-plant, or road-mix method and placed in such a manner as to obtain uniformity of the stabilized-aggregate base course material and at a uniform optimum water content for compaction. Contractor shall make such adjustments in mixing or placing procedures or in equipment to obtain the true grades, to minimize segregation and degradation, to reduce or accelerate loss or increase of water, and to insure a satisfactory base course.

3.7.2 Edges of Base Course

Approved material shall be placed along edges of stabilized-aggregate base course in such quantities as will compact to thickness of the course being constructed, or to the thickness of each layer in a multiple-layer course, allowing in each operation at least a 300 mm (1-foot) width of the shoulder to be rolled and compacted simultaneously with rolling and compacting of each layer of base course.

3.7.3 Compaction

Each layer of stabilized-aggregate base course including shoulders shall be compacted. Water content shall be maintained at optimum. Density of compacted mixture shall be at least 100 percent of laboratory maximum density. Rolling shall begin at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Alternate trips of the roller shall be slightly different lengths. Speed of the roller shall be such that displacement of the aggregate does not occur. Areas inaccessible to the rollers shall be compacted with mechanical tampers, and shall be shaped and finished by hand methods.

3.7.4 Layer Thickness

Compacted thickness of the stabilized course shall be as indicated. No layer shall be in excess of 150 mm (6 inches) nor less than 75 mm (3 inches) in compacted thickness.

3.7.5 Proof Rolling

Proof rolling of the areas indicated shall be in addition to the compaction specified and shall consist of the application of 30 coverages with a heavy pneumatic-tired roller having four or more tires, each loaded to a minimum of 13.6 metric ton (30,000 pounds) and inflated to a minimum of 1.035 MPa (150 psi). In areas designated, proof rolling shall be applied to the top lift layer on which the base course is laid and to each layer of base course. Water content of the top lift or layer on which base course is laid shall be maintained at optimum or at percentage directed from start of compaction to completion of proof rolling of that layer. Water content of each layer of the base course shall be maintained at plus or minus 1-1/2 percent of the optimum percentage directed from start of compaction to completion of proof rolling. Materials in base course or underlying materials that produce unsatisfactory results by the proof rolling shall be removed and replaced with acceptable materials and recompacted.

3.7.6 EDGES OF BASE COURSE

Acceptable material shall be placed along the edges of the base course in such quantity as will compact to the thickness of the course being constructed. When the course is being constructed in two or more layers, at least a 0.30 m (1 foot) width of the shoulder shall be rolled and compacted simultaneously with the rolling and compacting of each layer of the base course, as directed.

3.7.7 Finishing

The surface of the top layer shall be finished to grade and cross section shown. Finished surface shall be of uniform texture. Light blading during compaction may be necessary for the finished surface to conform to the lines, grades, and cross sections. Should the surface for any reason become rough, corrugated, uneven in texture, or traffic marked prior to completion, such unsatisfactory portion shall be scarified, reworked, recompacted, or replaced as directed.

3.8 SMOOTHNESS TEST

3.8.1 Smoothness

The surface of each layer shall show no deviations in excess of 9.5 mm (3/8 inch) when tested with the 3.0 m (10 foot) straightedge applied parallel with and at right angles to the centerline of the area to be paved. Deviations exceeding 9.5mm shall be corrected by as directed.

3.8.2 Thickness Control

The compacted thickness of the stabilized base course shall be within 13 mm (1/2 inch) of the thickness indicated. The thickness of the base course shall be measured at intervals providing at least one measurement for at least each 400 square meters (500 square yards) of base course. The depth measurement shall be made by test holes at least 75 mm (3 inches) in diameter. Where the measured thickness of the base course is more than 13 mm (1/2 inch) deficient, such areas shall be corrected by excavating to the required depth and replacing with new material. Where the measured thickness of the base course is 13 mm (1/2 inch) more than indicated, it will be considered as conforming with the requirements plus 13 mm (1/2 inch), provided the surface of the base course is within 13 mm (1/2 inch) of established grade. The average job thickness shall be the average of the job measurements as specified above but within 6 mm (1/4 inch) of the thickness indicated.

3.9 FIELD QUALITY CONTROL:

3.9.1 Field in-place density:

Field in-place density shall be determined in accordance with ASTM D 1556, ASTM D 2167 and ASTM D 2922. When ASTM D 2922 is used, the calibration curves shall be checked, and adjusted if necessary, using the sand cone method as described in paragraph, "calibration", of the ASTM publication. ASTM D 2922 results in a wet unit weight of soil and when using this method, ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D 3017 described in paragraph, "calibration", of the ASTM publication. ASTM D 2922 results in a wet unit weight of soil and when using this method, ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D 3017. If ASTM D 2922 is used, in-place densities shall be checked by ASTM D 1556 at least once per lift for each 400 square meter (500 square yards) of stabilized material. Calibration curves and calibration tests results shall be furnished within 24 hours of the conclusion of the tests. At least one field density test shall be performed for each 110 square meters(100 square yards) of each layer of base material.

3.9.2 Smoothness

Measurements for deviation from grade and cross section shown shall be taken in successive positions parallel to the road centerline with a 3.05 meter (10 foot) straightedge. Measurements shall also be taken perpendicular to the road centerline at 15 m (50 foot) intervals.

3.9.3 Thickness

Thickness of the stabilized course shall be measured at intervals in such a manner as to ensure one measurement for each 400 square meters (500 square yards) of stabilized course. Measurements shall be made in 75 mm (3-inch) diameter test holes penetrating the stabilized course.

3.10 TRAFFIC

Completed portions of the area may be opened to traffic, provided there is no marring or distorting of the surface by the traffic. Heavy equipment shall not be permitted except when necessary to construction, and then the area shall be protected against marring or damage to the completed work.

3.11 MAINTENANCE

The stabilized-aggregate base course shall be maintained in a satisfactory condition until accepted. Maintenance shall include immediate repairs to any defects and shall be repeated as often as necessary to keep the area intact.

3.12 DISPOSAL OF UNSATISFACTORY MATERIALS

Removed in-place materials that are unsuitable for stabilization; material that is removed for the required correction of defective areas; and waste material and debris shall be disposed of as directed.

3.13 CONTRACTOR QUALITY CONTROL

The Contractor shall establish and maintain a quality control procedure to assure compliance of the installed stabilized-aggregate base course with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to, the following:

a. Materials, including at least one sieve analysis for each day's operation.

b. Stockpiling material: Location and clearing and leveling of storage areas.

c. Preparation of underlying layer surface: Cleaning, compaction, surface, tolerances, and corrections of defective areas.

d. Grade control: Lines, grades and cross sections.

e. Mixing and placing: Weather limitation, method and equipment used, layer thickness, sequence of placing, spreading, uniformity of mixture watering, leveling to the required contour and grade, removal and replacement of defective areas.

f. Compaction: One laboratory moisture density relationship test per change of material or minimum of once a week; layer thickness control, one sand-displacement field density test and one sieve analysis for every 370 square meters (4,000 square feet).

g. Maintenance.

3.13.1 Contractor's Quality Control (CQC)

Quality Control for Testing of Materials shall be as specified in SECTION 01451: CONTRACTOR QUALITY CONTROL.

3.13.2 Contractor's Quality Control (CQC) Procedure

The CQC procedure for stabilized-aggregate base course installation shall be submitted to the Contracting Officer for approval prior to the start of stabilized-aggregate base course work.

SECTION 02366

PRECAST CONCRETE PILING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

THE PUBLICATIONS LISTED BELOW FORM A PART OF THIS SPECIFICATION TO THE EXTENT REFERENCED. THE PUBLICATIONS ARE REFERRED TO IN THE TEXT BY BASIC DESIGNATION ONLY.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 615/615 M (1996a) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

ASTM A 616/A 616M (1996a) Rail-Steel Deformed and Plain Bars for Concrete Reinforcement

ASTM A 617/A 617M (1996a) Axle-Steel Deformed and Plain Bars for Concrete Reinforcement

ASTM D 1143 (1981; R 1994) Piles Under Static Axial Compressive Load

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3504 (2001) Steel Bars for Concrete Reinforcement

KS F 4301 (2000) Centrifugal Reinforced Concrete Piles.

KS F 4303 (2001) Pretensioned Spun Concrete Piles

KS L 5201 (1989) Portland Cement

1.2 MEASUREMENT AND PAYMENT

1.2.1 Lump Sum

The contract price for piling shall include the cost of all necessary equipment, tools, material, labor, and supervision required to: deliver, handle, install, cut off, and withdraw the piles (including test piles), and conduct the load tests. Payment for piles will be based on the lengths of acceptable piles measured from cutoff elevations to final tip elevations. No additional payments will be made for: damaged, rejected, or misplaced piles; withdrawn piles, other than test piles withdrawn as directed; any portion of a pile remaining above the cutoff elevation; backdriving; cutting off piles; splicing; build-ups; or any cutoff length of piles.

1.2.1.1 PILE LOCATIONS AND SIZES

Locations and sizes of each pile comprising the pile driving work to include drive test piles, production (permanent) piles, and load test piles are shown on the respective Foundation Plan sheets by a numbering (Arabic) and lettering (Roman) system identifying each pile and its location by "number", and each pile's function by "letter". A legend is provided defining drive test piles as "TP", production piles as "P" or "PP", and load test piles as "LP". This letter notation is followed by the pile number when more than one (1) pile per function is driven; and shown on the respective Foundation Plans as TP-1, TP-2, ...; P-1, P-2, ...; LP-1, LP-2, ...; etc. Should the Contractor prefer an alternate system for identifying and locating the piling, he can submit his scheme to the Contracting Officer for approval prior to start of the pile driving work.

1.2.1.2 Variations in Pile Quantities

Based on the results of driving and loading the test piles, the Contracting Officer will determine and will list for the Contractor calculated pile tip elevations and the minimum driving resistance for all piles. The Contracting Officer shall have the right to increase or decrease the total length of piles to be furnished and installed by changing the pile locations or elevations, requiring the installation of additional piles, or directing the omission of piles from the requirements shown and specified. Should the length of piles installed vary from that specified because of added or omitted piles or variations in the pile lengths, the contract price for piling shall be adjusted by the applicable contract unit price per linear meter (foot) for "Additional Pile Length" or "Omitted Pile Length" multiplied by the actual length added or omitted.

1.2.1.3 Variations in the Number of Pile Load Tests

The Contracting Officer shall have the right to increase or decrease the number of pile load tests from that specified. For each load test added or deleted, the contract price shall be adjusted by the applicable contract unit price for "Each Additional Pile Load Test" or "Each Omitted Pile Load Test."

1.2.1.4 Variations in Test Pile Withdrawals

Should the number of test pile withdrawals be increased above the specified number at the direction of the Contracting Officer, the contract price for piling shall be adjusted by the contract unit price for "Each Additional Test Pile Withdrawn" multiplied by the number of additional test piles withdrawn.

1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01300: SUBMITTAL PROCEDURES.

1.3.1 Drawings

Precast Concrete Piling; GA.

Detail drawings to demonstrate compliance of driving equipment, including hammer and pile cushions, and to indicate methods of forming, reinforcing, splicing, and casting of piles. Also the drawing should indicate the handling method, support points and method of storage.

1.3.2 Reports

Field Test and Inspections; FIO.

A complete report on the pile test within seven (7) days of completion of each pile test, including, but not limited to, a description of the pile driving equipment, driving records for both test piles and reaction piles, complete test data, analysis of test data, and recommended allowable design loads based on the pile test results. The report shall be prepared by or under the direct supervision of a registered professional engineer experienced in pile load testing and load test analysis.

1.3.3 Records

Pile Driving; FIO.

A complete and accurate record of each driven pile. The record shall indicate the pile location (as driven), size, length, final elevation of tip and top, pile weight, number of splices and locations, blows required for each meter (foot) of penetration throughout the entire length of the pile and for the final 150 mm (6 inches) of penetration, and the total driving time. The record also shall include the type and size of the hammer used, the rate of operation, and the type and dimensions of driving helmet and cushion block used. Any unusual conditions encountered during pile installation shall be recorded and immediately reported to the Contracting Officer.

1.3.4 Certificate for the facility of the plant and product.

The contractor shall submit all applicable certificates showing compliance of plant facilities and products to the KS F 4301 and KS F4303.

1.4 EXPERIENCE

The work shall be performed by a Contractor specializing in the required foundation system and having experience installing the specified foundation system under similar subsurface conditions.

1.5 STORAGE AND HANDLING

The methods used in the storing and handling of the piles shall be such that the piles will not be subject to overstress or any other condition that may cause damage to the piles.

1.6 SUBSURFACE DATA

Subsurface soil data logs are shown on the drawings. The subsurface investigation report and samples of materials as taken from subsurface investigations may be examined at the location in this contract.

PART 2 PRODUCTS

2.1 PILES

2.1.1 Length

From the results of test-pile driving and test-pile loading specified in paragraph FIELD TEST AND INSPECTIONS, the Contracting Officer will specify the necessary driving resistances and pile tip elevation at various locations of the work. At least 300 mm (1 foot) of overlength shall be allowed for cutting at the required cutoff elevation. Where piles longer than the designated effective lengths, measured from tip to cutoff elevation, are required to provide specified bearings capacities, the longer piles shall be provided. Where the specified bearing capacities are obtained with piles of lengths less than the designated effective lengths, shorter piles may be used, subject to approval.

2.1.2 Ordering

Except piles for test purposes, any piles ordered or delivered to the site of the work prior to verification of the required lengths and establishment of criteria for driving permanent piles shall be at the risk of the Contractor.

2.1.3 Build-Up and Splicing

The Contractor will not be permitted to build-up piles. Sectional precast piles will not be permitted. Splices shall be of those types as indicated. Proprietary prefabricated splices may be used with prior approval. Splicing shall not be resumed until approved. Splices shall possess sufficient tensile strength to resist any tension due to uplift, pressures, heave, tensile waves in driving, or any other forces that might generate tension in the splice area.

2.1.4 Storage and Handling

The methods used in the storing and handling of the piles shall be such that the piles will not be subject to overstress or any other condition that may cause damage to the piles.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Pile Hammers

The hammer used shall have a delivered energy suitable for the total weight of the pile, the character of subsurface material to be encountered, and the pile capacity to be developed. The driving energy of the hammer shall be not less than 20,337 newton-meters (15,000 foot-pounds). Diesel-powered hammers shall be operated at the rate recommended by the manufacturer throughout the entire driving period. Sufficient pressure shall be maintained at the steam hammer so that: (a) for a double-acting hammer, the number of blows per minute during and at the completion of driving of a pile is equal approximately to that at which the hammer is rated; (b) for a single-acting hammer, there is full upward stroke of the ram; and (c) for a differential type hammer, there is a slight rise of the hammer base during each upward stroke.

3.1.2 Driving Helmets and Pile Cushions

A driving helmet or cap including a pile cushion shall be used between the top of the pile and the ram to prevent impact damage to the pile. The driving helmet or cap and pile cushion combination shall be capable of protecting the head of the pile, minimizing energy absorption and dissipation, and transmitting hammer energy uniformly over the top of the pile. The driving helmet or cap shall fit loosely around the top of the pile so that the pile is not restrained by the driving cap if the pile tends to rotate during driving. The pile cushion may be of solid wood, of laminated construction using plywood, softwood, or hardwood boards, or of other approved cushioning material. The pile cushion shall completely cover the top surface of the pile and shall be retained by the driving helmet. The minimum thickness of the pile cushion shall be 76.2 mm (3 inches), and the thickness shall be increased so as to be suitable for the size and length of pile, character of subsurface material encountered, hammer characteristics, and required driving resistance. The pile cushion shall be replaced at any time it becomes highly compressed, charred, burned, or becomes deteriorated in any manner during driving.

3.1.3 Pile Driving

Driving shall be done with fixed leads that shall hold the pile firmly in position, alignment, and in axial alignment with the hammer. Piles shall be driven continuously and without interruption to or below the "calculated" tip elevation to reach a driving resistance in accordance with the schedule that the Contracting Officer will prepare from the load test results. The pile hammer used for driving shall be the same type and operated at the same rate and in the same manner as that used for driving the test piles. If a pile fails to reach the "calculated" tip elevation or if a pile reaches the "calculated" tip elevation without reaching the required driving resistance, the Contractor shall notify the Contracting Officer and perform the corrective measures as directed. No pile shall be driven until the excavation or fill in area that piles are to occupy has been completed to within 300 mm (one foot) of the grade indicated. Final grading shall be accomplished after the pile driving has been completed. Piles shall be carefully located to the lines and spacing indicated and shall be driven either to the plumb position or the batter indicated. Care shall be taken to operate the hammer at its short stroke when the tip of the pile encounters soft material of little resistance either at the start of the driving or in passing into poor subsoil. The hammer should continue at its short stroke until sufficient resistance is built up to prevent damage due to tensile wave stresses. When driving is interrupted before final penetration is reached, the record of the penetration shall not be taken until after at least a 300 mm (12-inch) penetration has been obtained on the resumption of driving.

3.1.4 Splices

Unless otherwise directed, field splices shall be constructed as indicated. Splices shall maintain the true alignment and position of the pile sections and shall develop the full strength of the pile in both bearing and bending. Proprietary prefabricated splicer sleeves may be used upon approval.

3.1.5 Tolerances in Driving

Top of any pile at elevation of cutoff shall be within 50 millimeters (2 inches) of the planar location indicated. Manipulation of piles to force them into position will not be permitted. Piles shall be checked for heave, and those found to have heaved shall be redriven to the required tip elevation. Piles damaged or driven outside the above tolerances shall be replaced, or additional piles driven at locations specified by the Contracting Officer at no expense to the Government.

3.1.6 Cutting of Piles

Piles shall be cut off at the elevations indicated by an approved method and the surplus material shall be removed from the job site.

3.1.7 Rejected Piles

Piles damaged, mislocated, or driven out of alignment beyond the maximum tolerance shall be withdrawn and replaced by new piles or shall be cut off and abandoned. Additional piles shall be driven as directed, and excess cut off from piles; unacceptable piles shall be removed from the site of work. All work in connection with withdrawing and removing from the site rejected piles shall be done without additional cost to the Government.

3.1.8 Pile Heave

When large pile clusters or piles are driven with very close spacing, periodic elevations shall be taken on the tops of all piles to observe and determine pile heave. When such checking indicates that pile heave has occurred, and when pile driving progresses beyond effective pile heave range, all heaved piles shall be redriven to either the original resistance or the elevation, or both, as directed.

3.1.9 Long Piles

Piles having a slenderness ratio greater than 20 shall be handled and driven with special precautions to ensure against overstress or leaning from a plumb or true position. The slenderness ratio shall be the pile length divided by the least radius of gyration of the pile. When a high-resistance strata lying near the surface must be penetrated, spud piles may be used only when authorized by the Contracting Officer to minimize hard driving of long piles during the early stages of driving operations.

3.2 FIELD TEST AND INSPECTIONS

3.2.1 Test Piles

Test piles shall be of the type and shall be driven in the manner specified herein. The Contracting Officer will use test pile and load test data to determine "calculated" pile tip elevations and the necessary driving resistance. Test piles that are located within the tolerances indicated and that provide a safe design capacity as determined by the results of a satisfactory load test may be used in the finished work. Test piles shall be driven at the locations indicated. Test piles shall be driven to the tip elevation specified or indicated. The specified number of test piles shall be withdrawn as indicated after reaching the "calculated" tip elevation for visual inspection of the pile.

3.2.2 Load Tests

Load tests at locations shown or directed shall be made on test piles placed to the tip elevation indicated except as otherwise directed. Loading, testing, and recording of data shall be under the direct supervision of a registered professional engineer. The analysis of the load test data shall be under the supervision of the registered professional engineer. The installation of piles shall not proceed in a new area with substantially different subsurface conditions until a satisfactory load test has been performed in that area and the results approved. A minimum of 5 days after submission of the test data shall be allowed for approval of pile load test. A minimum of 3 days shall elapse after driving the pile before the initiation of the pile testing, unless otherwise directed. Test loading shall conform to the apparatus and methods stated in ASTM D 1143, cyclic loading method. The load shall be applied to the pile or pile group by hydraulic jacks acting against an anchored reaction frame hydraulic jacks acting against a weighted platform or box direct loading of a weighted platform using a spherical bearing to transmit the load to the pile.

3.2.3 Safe Design Capacity

The safe design capacity of a test pile as determined from the results of load tests shall be the lesser of the two values computed according to the following:

a. One-half of that load which causes a net settlement after rebound of not more than 0.23 mm per metric ton (0.01-inch per ton) of total test load.

b. One-half of the load that causes a gross settlement of not more than 25 mm, (1 inch) provided the load settlement curve shows no sign of failure.

3.2.4 Inspection

The Contracting Officer may require that certain test piles be withdrawn for test and inspection to determine the condition of the piles. When so required, such piles shall be redriven only when approved. Withdrawn piles not suitable for redriving shall be treated as rejected piles as specified in paragraph INSTALLATION.

3.2.5 Pile Capacity

For single-acting hammers: $R = 166.7WH/(S + 2.54\ P/W)$ ($R = 2WH/(S + 0.1\ P/W)$) And double-acting hammers: $R = 166.7E/(S + 2.54\ P/W)$ ($R = 2E/(S + 0.1\ P/W)$) Where: R is the allowable static pile load in newtons (pounds).

W is the weight of the striking part of the hammer in newtons(pounds).

H is the effective height of fall in meters. (feet.)

E is the actual energy delivered by the hammer per blow in newton meters. (foot-pounds.)

S is the average net penetration in millimeters (inches) per blow for the last five blows after the pile has been driven to a depth where successive blows produce approximately equal net penetration (a minimum distance of 1 meter (3 feet) for friction piles).

P is the weight of the pile in newtons(pounds.). (If P is less than W, P/W shall be taken as unity.)

3.3 CONTRACTOR QUALITY CONTROL

The Contractor shall establish and maintain a quality control procedure to assure compliance of the installed precast concrete piling with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to, the following:

3.3.1 Contractor's Quality Control (CQC) Procedure

The CQC procedure for precast concrete piling installation shall be submitted to the Contracting Officer for approval prior to the start of precast concrete piling work.

SECTION 02511

CONCRETE SIDEWALKS AND CURBS AND GUTTERS

TABLE OF CONTENTS

PART 1 GENERAL

This specification will not be used for integral or monolithic curbs of concrete pavement or for curbs and gutters for bridges.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182 (1991) Burlap Cloth Made from Jute or Kenaf Twenties Edition R(1996)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 185 (1997) Steel Welded Wire Fabric, Plain, for Concrete Reinforcement

ASTM A 615/A 615M (1996a) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

ASTM A 616/A 616M (1996a) Rail-Steel Deformed and Plain Bars for Concrete Reinforcement

ASTM A 617/A 617M (1996a) Axle-Steel Deformed and Plain Bars for Concrete Reinforcement

ASTM C 31/C 31 M (1996) Making and Curing Concrete Test Specimens in the Field

ASTM C 143 (1990a) Slump of Hydraulic Cement Concrete

ASTM C 171 (1997) Sheet Materials for Curing Concrete

ASTM C 172 (1997) Sampling Freshly Mixed Concrete

ASTM C 173 (1996) Air Content of Freshly Mixed Concrete by the Volumetric Method

ASTM C 231 (1997) Air Content of Freshly Mixed Concrete by the Pressure Method

ASTM C 309 (1997) Liquid Membrane-Forming Compounds Curing Concrete

ASTM D 1751 (1983; R 1991) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)

ASTM D 1752 (1984; R 1996) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

ASTM D 3405 (1996) Joint Sealant, Hot-Applied, for Concrete and Asphalt Pavements

KOREAN INDUSTRIAL STANDARD (KS)

KS F 3110 (2002) Plywood for Concrete form

KS F 4009 (1999) Ready-mixed Concrete

KS L 5201 (1989) Portland Cement

1.2 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES.

SD-03 Product Data

Concrete; GA

Copies of certified delivery tickets for all concrete used in the construction.

SD-06 Test Reports

Field Quality Control; FIO

Six(6) Copies of all test reports within 24 hours of completion of the test.

Certificate: GA

Six (6) copies of certificates for the plant facilities and products specified that KS approved.

1.3 WEATHER LIMITATIONS

1.3.1 Placing During Cold Weather

Concrete placement shall be discontinued when the air temperature reaches 5 degrees C (40 degrees F) and is falling. Placement may begin when the air temperature reaches 2 degrees C (35 degrees F) and is rising. Provisions shall be made to protect the concrete from freezing during the specified curing period. If necessary to place concrete when the temperature of the air, aggregates, or water is below 2 degrees C, (35 degrees F,) placement shall be approved in writing. Approval shall be contingent upon full conformance with the following provisions. The underlying material shall be prepared and protected so that it is entirely free of frost when the concrete is deposited. Mixing water and aggregates shall be heated as necessary to result in the temperature of the in-place concrete being between 10 and 30 degrees C. (50 and 85 degrees F.) Methods and equipment for heating shall be approved. The aggregates shall be free of ice, snow, and frozen lumps before entering the mixer. Covering and other means shall be provided for maintaining the concrete at a temperature of at least 10 degrees C (50 degrees F) for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period.

1.3.2 Placing During Warm Weather

The temperature of the concrete as placed shall not exceed 30 degrees C (85 degrees F) except where an approved Retarder is used. The mixing water and/or aggregates shall be cooled, if necessary, to maintain a satisfactory placing temperature. In no case shall the placing temperature exceed 35 degrees C. (95 degrees F.)

1.4 PLANT, EQUIPMENT, MACHINES, AND TOOLS

1.4.1 General Requirements

Plant, equipment, machines, and tools used in the work shall be subject to approval and shall be maintained in a satisfactory working condition at all times. The equipment shall have the capability of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Use of the equipment shall be discontinued if it produces unsatisfactory results. The Contracting Officer shall have access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.4.2 Slip Form Equipment

Slip form paver or curb forming machine, will be approved based on trial use on the job and shall be self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in one pass.

PART 2 PRODUCTS

2.1 CONCRETE

Concrete shall conform to the applicable requirements of section 02515: CONCRETE PAVEMENT FOR ROADS AND AIRFIELDS except as otherwise specified. Concrete shall have a minimum compressive strength of 240 Kg per square centimeter (23.5 Mpa, 3400 psi) at 28 days. Maximum size of aggregate shall be 37.5 mm. (1-1/2 inches.)

2.1.1 Air Content

Mixtures shall] may have air content by volume of concrete of 5 to 7 percent, based on measurements made immediately after discharge from the mixer.

2.1.2 Slump

The concrete slump shall be 50 millimeters (inches) plus or minus 25mm (1 inch) for hand placed concrete or 25 mm (1 inch) plus or minus 10 mm (1/2 inch) for slipformed concrete where determined in accordance with ASTM C 143.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Impervious sheet materials shall conform to ASTM C 171, type optional, except that polyethylene film, if used, shall be white opaque.

2.2.2 Burlap

Burlap shall conform to AASHTO M 182.

2.2.3 White Pigmented Membrane-Forming Curing Compound

White pigmented membrane-forming curing compound shall conform to ASTM C 309, Type 2.

2 2.4 CONCRETE PROTECTION MATERIALS

Concrete protection materials shall be a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.3 JOINT FILLER STRIPS

2.3.1 Contraction Joint Filler for Curb and Gutter

Contraction joint filler for curb and gutter shall consist of hard-pressed fiberboard.

2.3.2 Expansion Joint Filler, Premolded

Expansion joint filler, premolded, shall conform to ASTM D 1751 or ASTM D 1752, 9.5 mm (3/8 inch) thick, unless otherwise indicated.

2.4 JOINT SEALANTS

2.4.1 Joint Sealant, Cold-Applied

Joint sealant, cold-applied shall conform to. ASTM C 920

2.4.2 Joint Sealant, Hot-Poured

Joint sealant, hot-poured shall conform to ASTM D 3405.

2.5 FORM WORK

Form work shall be designed and constructed to insure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Forms shall be of wood or steel, straight, of sufficient strength to resist springing during depositing and consolidating concrete. Wood forms shall be surfaced plank, 50 mm (2-inch) nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Wood forms shall have a nominal length of 3 m (10 feet). Radius bends may be formed with 19 mm (3/4-inch) boards, laminated to the required thickness. Steel forms shall be channel-formed sections with a flat top surface and with welded braces at each end and at not less than two intermediate points. Ends of steel forms shall be interlocking and self-aligning. Steel forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers. Steel forms shall have a nominal length of 3 m (10 feet) with a minimum of two welded stake pockets per form. Stake pins shall be solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.5.1 Sidewalk Forms

Sidewalk forms shall be of a height equal to the full depth of the finished sidewalk.

2.5.2 Curb and Gutter Forms

Curb and gutter outside forms shall have a height equal to the full depth of the curb or gutter. The inside form of curb shall have batter as indicated and shall be securely fastened to and supported by the outside form. Rigid forms shall be provided for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 3 m (10 feet) or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 38 mm (1-1/2 inch) benders, for the full height of the curb, created together.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

The subgrade shall be constructed to the specified grade and cross section prior to concrete placement. Subgrade shall be placed and compacted to conform to applicable requirements of Section. The subgrade will be indicated as extending at least 600 mm (2 feet) in width back of curb, gutter, entrance, and combination curb

3.1.1 Sidewalk Subgrade

The subgrade shall be tested for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

3.1.2 Curb and Gutter Subgrade

The subgrade shall be tested for grade and cross section by means of a template extending the full width of the curb and gutter. The subgrade shall be of materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade

The subgrade shall be maintained in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade shall be in a moist condition when concrete is placed. The subgrade shall be prepared and protected so as to produce a subgrade free from frost when the concrete is deposited.

3.2 FORM SETTING

Forms shall be carefully set to the indicated alignment, grade and dimensions. Forms shall be held rigidly in place by a minimum of three stakes per form placed at intervals not to exceed 1.2 meters(4 feet.). Corners, deep sections, and radius bends shall have additional stakes and braces, as required. Clamps, spreaders, and braces shall be used where required to insure rigidity in the forms. Forms shall be removed without injuring the concrete. Bars or heavy tools shall not be used against the concrete in removing the forms. Any concrete found defective after form removal shall be promptly and satisfactorily repaired. Forms shall be cleaned and coated with form oil each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.

3.2.1 Sidewalks

Forms for sidewalks shall be set with the upper edge true to line and grade with an allowable tolerance of 3 mm (1/8 inch) in any 3 m (10-foot) long section. After forms are set, grade and alignment shall be checked with a 3.05 m (10-foot) straightedge. Forms shall have a transverse slope as indicated with the low side adjacent to the roadway. Side forms shall not be removed for 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters

The forms of the front of the curb shall be removed not less than 2 hours nor more than 6 hours after the concrete has been placed. Forms back of curb shall remain in place until the face and top of the curb have been finished as specified for concrete finishing. Gutter forms shall not be removed while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks

Concrete shall be placed in the forms in one layer of such thickness that when consolidated and finished the sidewalks will be of the thickness indicated. After concrete has been placed in the forms, a strike-off guided by side forms shall be used to bring the surface to proper section to be compacted. The concrete shall be consolidated with an approved vibrator, and the surface shall be finished to grade with a wood float, bull float, or darby, edged and broom finished.

3.3.2 Concrete Finishing

After straight edging, when most of the water sheen has disappeared, and just before the concrete hardens, the surface shall be finished to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. A scored surface shall be produced by brooming with a fiber-bristle brush in a direction transverse to that of the traffic followed by edging.

3.3 3 Edge and Joint Finishing

All slab edges, including those at formed joints, shall be finished carefully with an edger having a radius of 3 mm. (1/8 inch.) Transverse joint shall be edged before brooming, and the brooming shall eliminate the flat surface left by the surface face of the edger. Corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing shall be cleaned and filled solidly with a properly proportioned mortar mixture and then finished.

3.3.4 Surface and Thickness Tolerances

Finished surfaces shall not vary more than 7.9 mm (5/16 inch) from the testing edge of a 3 m (10-foot) straightedge. Permissible deficiency in section thickness will be up to 6.4 mm (1/4 inch).

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter

Concrete shall be placed to the section required in a single lift. Consolidation shall be achieved by using approved mechanical vibrators.

3.4.2 Concrete Finishing

Exposed surfaces shall be floated and finished with a smooth wood float until true to grade and section and uniform in texture. Floated surfaces shall then be brushed with a fine-hair brush with longitudinal strokes. The edges of the gutter and top of the curb shall be rounded with an edging tool to a radius of 13 mm. (1/2 inch.) Immediately after removing the front curb form, the face of the curb shall be rubbed with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. The front curb surface, while still wet, shall be brushed in the same manner as the gutter and curb top. The top surface of gutter and entrance shall be finished to grade with a wood float.

3.4.3 Joint Finishing

Curb edges at formed joints shall be finished as indicated.

3.4.4 Surface and Thickness Tolerances

Finished surfaces shall not vary more than 6.4 mm (1/4 inch) from the testing edge of a 3 m (10-foot) straightedge. Permissible deficiency in section thickness will be up to 6.4 mm (1/4 inch).

3.5 SIDEWALK JOINTS

Sidewalk joints shall be constructed to divide the surface into rectangular areas. Transverse contraction joints shall be spaced at a distance equal to the sidewalk width or 1.5 m (5 feet) on centers, whichever is less, and shall be continuous across the slab. Longitudinal contraction joints shall be constructed along the centerline of all sidewalks 3 m (10 feet) or more in width. Transverse expansion joints shall be installed at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, transverse expansion joints shall be installed as indicated. Expansion joints shall be formed about structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated.

3.5.1 Contraction Joints

The contraction joints shall be formed in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness, using a jointer to cut the groove, or by sawing a groove in the hardened concrete with a power-driven saw, unless otherwise approved. Sawed joints shall be constructed by sawing a groove in the concrete with a 3 mm (1/8-inch) blade to the depth indicated. An ample supply of saw blades shall be available on the job before concrete placement is started, and at least one standby sawing unit in good working order shall be available at the job-site at all times during the sawing operations.

3.5.2 Expansion Joints

Expansion-joint filler will not be required between curbs that abut the sidewalk longitudinally. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of performed filler material conforming to ASTM D 1752 or building paper. Expansion joints shall be formed with 9.5 mm(3/8 inch) joint filler strips. Joint filler shall be placed with top edge 6 mm (1/4 inch) below the surface and shall be held in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, joint edges shall be rounded with an edging tool having a radius of 3 mm, (1/8 inch,) and concrete over the joint filler shall be removed. At the end of the curing period, expansion joints shall be carefully cleaned and filled with joint sealer. Joints shall be sealed as specified in Section

02580: JOINT SEALING IN CONCRETE PAVEMENTS FOR ROADS AND AIRFIELDS. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing shall be done so that the material will not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 10 degrees C (50 degrees F) at the time of application of joint sealing material. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

3.6 CURB AND GUTTER JOINTS

Curb and gutter joints shall be constructed at right angles to the line of curb and gutter.

3.6.1 Contraction Joints

Contraction joints shall be constructed directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 1.5 m (5 feet) nor greater than 4.5 m (15 feet) in length. Contraction joints shall be constructed by means of 3 mm (1/8-inch) thick separators and of a section conforming to the cross section of the curb and gutter. Separators shall be removed as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.

3.6.2 Expansion Joints

Expansion joints shall be formed by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Expansion joints shall be provided in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement, and shall be of the same type and thickness as joints in the pavement. Where curb and gutter do not abut portland cement concrete pavement, expansion joints at least 9.5 mm (3/8 inch) in width shall be provided at intervals not exceeding 35 meters. Expansion joints shall be provided in nonreinforced concrete gutter at locations indicated. Expansion joints and the top 1-inch depth of curb and gutter contraction-joints shall be sealed with joint sealer. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing shall be done so that the material will not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 10 degrees C (50 degrees F) at the time of application of joint sealing material. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

3.7 CURING AND PROTECTION

3.7.1 General Requirements

Concrete shall be protected against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Unhardened concrete shall be protected from rain and flowing water. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. Protection shall be provided as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method

The entire exposed surface shall be covered with two or more layers of burlap. Mats shall overlap each other at least 150 mm. (6 inches.) The mat shall be thoroughly wetted with water prior to placing on concrete surface and shall be kept continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method

The entire exposed surface shall be wetted with a fine spray of water and then covered with impervious sheeting material. Sheets shall be laid directly on the concrete surface with the light-colored side up and overlapped 300 mm (12 inches) when a continuous sheet is not used. The curing medium shall not be less than 450 mm (18-inches) wider than the concrete surface to be cured, and shall be securely weighted down by heavy wood planks, or a bank of moist earth placed along edges and laps in the sheets. Sheets shall be satisfactorily repaired or replaced if torn or otherwise damaged during curing. The curing medium shall remain on the concrete surface to be cured for not less than 7 days.

3.7.1.3 Membrane Curing Method

A uniform coating of white-pigmented membrane-curing compound shall be applied to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Formed surfaces shall be coated immediately after the forms are removed and in no case longer than 1 hour after the removal of forms. Concrete shall not be allowed to dry before the application of the membrane. If any drying has occurred, the surface of the concrete shall be moistened with a fine spray of water and the curing compound applied as soon as the free water disappears. Curing compound shall be applied in two coats by hand-operated pressure sprayers at a coverage of approximately 5 square meters per liter (200 square feet per gallon) for both coats. The second coat shall be applied in a direction approximately at right angles to the direction of application of the first coat. The compound shall form a uniform, continuous, coherent film that will not check, crack, or peel and shall be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, an additional coat shall be applied to the affected areas within 30 minutes. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified above. Areas where the curing compound is damaged by subsequent construction operations within the curing period shall be resprayed. Necessary precautions shall be taken to insure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed before the concrete in the region of the joint is resprayed with curing compound. The method used for sealing the joint groove shall prevent loss of moisture from the joint during the entire specified curing period. Approved standby facilities for curing concrete pavement shall be provided at a location accessible to the job site for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Concrete surfaces to which membrane-curing compounds have been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.7.2 Backfilling

After curing, debris shall be removed and the area adjoining the concrete shall be backfilled, graded, and compacted to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Completed concrete shall be protected from damage until accepted. The Contractor shall repair damaged concrete and clean concrete discolored during construction. Concrete that is damaged shall be removed and reconstructed for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Removed damaged portions shall be disposed of as directed.

3.7.4 Protective Coating

Protective coating of linseed oil mixture shall be applied to the exposed-to-view concrete surface.

3.7.4.1 Application

Curing and backfilling operation shall be completed prior to applying protective coating. Concrete shall be surface dry and thoroughly clean before each application. Coverage shall be not more than 11 square meters per liter (50 square yards per gallon) for first application and not more than 15.5 square meters per liter (70 square yards per gallon) for second application, except that the number of applications and coverage for each application for commercially prepared mixture shall be in accordance with the manufacturer's instructions. Coated surfaces shall be protected from vehicular and pedestrian traffic until dry.

3.7.4.2 Precautions

Protective coating shall not be heated by direct application of flame or electrical heaters and shall be protected from exposure to open flame, sparks, and fire adjacent to open containers or applicators. Material shall not be applied at temperatures lower than 10 degrees C. (50 degrees F.)

3.8 FIELD QUALITY CONTROL

3.8.1 General Requirements

The Contractor shall perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, the Contractor shall take the action and submit reports as required below, and any additional tests to insure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing

The Contractor shall provide molded concrete specimens for strength tests. Samples of concrete placed each day shall be taken neither less than once a day nor less than once for every 190 cubic meters (250 cubic yards) of concrete. The samples for strength tests shall be taken in accordance with ASTM C 172. Cylinders for acceptance shall be molded in conformance with ASTM C 31 by an approved testing laboratory. Each strength test result shall be the average of two test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 4 MPa.(500 psi.)

3.8.2.2 Air Content

Air content shall be determined in accordance with ASTM C 173 or ASTM C 231. ASTM C 231 shall be used with concrete and mortar made with relatively dense natural aggregates. Two tests for air content shall be made on randomly selected batches of each class of concrete placed during each shift. Additional tests shall be made when excessive variation in concrete workability is reported by the placing foreman or the Government inspector. If results are out of tolerance, the placing foreman shall be notified and he shall take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

3.8.2.3 Slump Test

Two slump tests shall be made on randomly selected batches of each class of concrete for every 190 cubic meters, (250 cubic yards,) or fraction thereof, of concrete placed during each shift. Additional tests will be performed when excessive variation in the workability of the concrete is noted or when excessive crumbling or slumping is noticed along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation

The anticipated thickness of the concrete shall be determined prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, the subgrade shall be true to grade prior to concrete placement and the thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation

The finished surface of each category of the completed work shall be uniform in color and free of blemishes and form or tool marks.

3.9 SURFACE DEFICIENCIES AND CORRECTIONS

3.9.1 Thickness Deficiency

When measurements indicate that the completed concrete section is deficient in thickness by more than 6 mm (1/4 inch) the deficient section will be removed, between regularly scheduled joints, and replaced.

3.9.2 High Areas

In areas not meeting surface smoothness and plan grade requirements, high areas shall be reduced either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete shall not exceed 5 percent of the area of any integral slab, and the depth of grinding shall not exceed 6 mm. (1/4 inch.) All pavement areas requiring grade or surface smoothness corrections in excess of the limits specified above shall be removed and replaced.

3.9.3 Appearance

The Government will inspect exposed surfaces of the finished work and any deficiencies in appearance will be identified. Areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work shall be removed and replaced.

SECTION 02515

CONCRETE PAVEMENT FOR ROADS AND AIRFIELDS

TABLE OF CONTENTS

PART 1 GENERAL

This guide specification covers the requirements for construction of concrete pavement for airfields and heavy-duty roads and hardstands, and vehicular pavement with volumes less than or equal to 2000 cubic meters (2500 cu. yd.) of concrete

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 301 (1999) Standard Specifications for Structural Concrete

ACI 305R (1999) Hot Weather Concreting

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 184/A 184M (1996) Fabricated Deformed Steel Bar Mats for Concrete Reinforcement

ASTM A 615/A 615M (2000) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

ASTM C 31/C 31M (2000) Making and Curing Concrete Test Specimens in the Field

ASTM C 33 (1999ael) Concrete Aggregates

ASTM C 39/C 39M (1999) Compressive Strength of Cylindrical Concrete Specimens

ASTM C 94/C 94M (2000) Ready-Mixed Concrete

ASTM C 123 (1998) Lightweight Particles in Aggregate

ASTM C 143/C 143M (2000) Slump of Hydraulic Cement Concrete

ASTM C 150 (1999a) Portland Cement

ASTM C 192/C 192M (2000) Making and Curing Concrete Test Specimens in the Laboratory

ASTM C 231 (1997el) Air Content of Freshly Mixed Concrete by the Pressure Method

ASTM C 260 (2000) Air-Entraining Admixtures for Concrete

ASTM C 494/C 494M (1999a) Chemical Admixtures for Concrete

ASTM C 595 (2000a) Blended Hydraulic Cements

ASTM C 595M (1997) Blended Hydraulic Cements (Metric)

ASTM C 618 (2000) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete

ASTM C 666 (1997) Resistance of Concrete to Rapid Freezing and Thawing

ASTM C 881 (1999) Epoxy-Resin-Base Bonding Systems for Concrete

ASTM C 989 (1999) Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

ASTM C 1077	(1998) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM D 1751	(1999) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R 1996el) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 130	(1989) Scratch Hardness of Coarse Aggregate Particles
COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete
COE CRD-C 540	(1971; R 1981) Standard Specification for Nonbituminous Inserts for Contraction Joints in Portland Cement Concrete Airfield Pavements, Sawable Type
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstop

NATIONAL READY-MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(1996) Concrete Plant Standards

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3504	(2001) Steel Bars for Concrete Reinforcement
KS D 7017	(1999) Welded Steel Wire Fabrics
KS F 2538	(1990) Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction.
KS F 2560	(1997) Chemical Admixture for Concrete
KS F 4009	(1999) Ready-mixed Concrete
KS L 5201	(1989) Portland Cement

1.2 ACCEPTABILITY OF WORK

The pavement will be accepted on the basis of tests made by the Government and by the Contractor or its suppliers, as specified herein. The Government may, at its discretion, make check tests to validate the results of the Contractor's testing. Concrete samples shall be taken by the Contractor at the placement to determine the slump, air content, and strength of the concrete. Test cylinders shall be made for determining conformance with the strength requirements of these specifications and, when required, for determining the time at which pavements may be placed into service. All air content measurements shall be determined in accordance with ASTM C 231. All slump tests shall be made in accordance with ASTM C 143/C 143M. All test cylinders shall be 150 by 300 mm (6 by 12 inch) cylinders and shall be fabricated in accordance with ASTM C 192/C 192M, using only steel molds, cured in accordance with ASTM C 31/C 31M, and tested in accordance with ASTM C 39/C 39M. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days. The Contractor shall furnish all materials, labor, and facilities required for molding, curing, testing, and protecting test specimens at the site and in the laboratory.

1.2.1 Evaluation Sampling

Sampling, testing, and mixture proportioning shall be performed by a commercial Testing Laboratory, conforming with ASTM C 1077.

1.2.1 Surface Testing

Surface testing for surface smoothness, edge slump and plan grade shall be performed as indicated below by the Testing Laboratory. The measurements shall be properly referenced in accordance with paving lane identification and stationing, and a report given to the Government within 24 hours after measurement is made. A final report of surface testing, signed by a Registered Engineer, containing all surface measurements and a description of all actions taken to correct deficiencies, shall be provided to the Government upon conclusion of surface testing.

1.2.2.1 Surface Smoothness Requirements

The finished surfaces of the pavements shall have no abrupt change of 3 mm (1/8 inch) or more, and all pavements shall be within the tolerances specified in Table 1 when checked with the straightedge.

TABLE 1 STRAIGHTEDGE SURFACE SMOOTHNESS--PAVEMENTS

Item No.	Pavement Category	Direction of Testing	Tolerances, mm
1	Runways and Taxiways	Longitudinal Transverse	3 6
2	Calibration hardstands and compass swinging bases	Longitudinal Transverse	3 3
3	All other airfield and helicopter paved areas	Longitudinal Transverse	6 6
4	Roads and Streets	Longitudinal Transverse	5 6.5

5	Tank Hardstands, Parking Areas, Open Storage Areas	Longitudinal Transverse	6.5 6.5

1.2.2.2 Surface Smoothness Testing Method

The surface of the pavement shall be tested with the straightedge to identify all surface irregularities exceeding the tolerances specified above. The entire area of the pavement shall be tested in both a longitudinal and a transverse direction on parallel lines approximately 4.5 m (15 feet apart). The straightedge shall be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined by placing the straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length and measuring the maximum gap between the straightedge and the pavement surface, in the area between these two high points.

1.2.3 Edge Slump Testing and Conformance

When slip-form paving is used, not more than 15 percent of the total free edge [of any 255 mm 10 inch or thicker slab] of the slipformed portion of the pavement, shall have an edge slump exceeding 6 mm 1/4 inch and no slab shall have an edge slump exceeding 9 mm. 3/8 inch. Edge slump shall be determined as above for surface smoothness, at each free edge of each slipformed paving lane constructed. Measurements shall be made at 1.5 to 4.5 m 5 to 15 foot spacings, and as directed. When edge slump exceeding the limits specified above is encountered on either side of the paving lane, additional straightedge measurements shall be made, if required, to define the linear limits of the excessive slump. The concrete for the entire width of the paving lane within these limits of excessive edge slump shall be removed and replaced. Adding concrete or paste to the edge or otherwise manipulating the plastic concrete after the sliding form has passed, or patching the hardened concrete, shall not be used as a method for correcting excessive edge slump.

1.2.4 Plan Grade Testing and Conformance

The finished surface of the pavements shall conform, within the tolerances shown in Table 1, to the lines, grades, and cross sections shown. The finished surface of new abutting pavements shall coincide at their juncture. The finished surface of airfield runway, taxiway, and apron pavements shall vary not more than 12 mm 0.04 foot above or below the plan grade line or elevation indicated. The surfaces of other pavements shall vary not more than 18 mm 0.06 foot above or below the plan grade line or elevation indicated. Each pavement category shall be checked by the Contractor for conformance with plan grade requirements by running lines of levels at intervals to determine the elevation at each joint intersection.

1.3 PRECONSTRUCTION TESTING OF MATERIALS

The Contractor shall not be entitled to any additional payment or extension of time because of delays caused by sampling and testing additional sources, or samples, necessitated by failure of any samples. Aggregates shall be sampled and tested by the Test Laboratory and shall be representative of the materials to be used for the project. Test results, signed by a Registered Engineer, shall be submitted 30 days before commencing paving. No aggregate shall be used unless test results show that it meets all requirements of these specifications, including compliance with ASTM C 33 and deleterious materials limitations.

1.4 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment; GA

Manufacturer's literature on the concrete plant; mixing equipment; hauling equipment; placing and finishing, and curing equipment; at least 7 days prior to start of paving.

Paving; GA

Paving Schedules at least 7 days prior to start of paving.

Mixture Proportions; GA

The report of the Contractor's mixture proportioning studies showing the proportions of all ingredients and supporting information on aggregate and other materials that will be used in the manufacture of concrete, at least 14 days prior to commencing concrete placing operations.

1.5 EQUIPMENT

1.5.1 Batching and Mixing

The batching plant shall conform to NRMCA CPMB 100, or KS F 4009 the equipment requirements in ASTM C 94/C 94M, and as specified. Water shall not be weighed or measured cumulatively with another ingredient. All concrete materials batching shall meet ASTM C 94/C 94M requirements. Mixers shall be stationary mixers. Batching, mixers, mixing time, permitted reduction of mixing time, and concrete uniformity shall meet the requirements of ASTM C 94/C 94M, and shall be documented in the initial weekly QC Report.

1.5.2 Transporting Equipment

Transporting equipment shall be in conformance with ASTM C 94/C 94M and as specified herein. Concrete shall be transported to the paving site in rear-dump trucks, in truck mixers designed with extra large blading and rear opening specifically for low slump concrete, or in agitators. Bottom-dump trucks shall not be used for delivery of concrete.

1.5.3 Delivery Equipment

When concrete transport equipment cannot operate on the paving lane, side-delivery transport equipment consisting of self-propelled moving conveyors shall be used to deliver concrete from the transport equipment and discharge it in front of the paver. Front-end loaders, dozers, or similar equipment shall not be used to distribute the concrete.

1.5.4 Paver-Finisher

The paver-finisher shall be a heavy-duty, self-propelled machine designed specifically for paving and finishing high quality pavement. The paver-finisher shall weigh at least 3280 kg per m 2200 lb./foot of lane width, and shall be powered by an engine having at least 15000 W per meter 6.0 horsepower per foot of lane width. The paver-finisher shall spread, consolidate, and shape the plastic concrete to the desired cross section in one pass. The paver-finisher shall be equipped with a full width "knock-down" auger, capable of operating in both directions, which will evenly spread the fresh concrete in front of the screed or extrusion plate.Immersion vibrators shall be gang mounted at the front of the paver on a frame equipped with suitable controls so that all vibrators can be operated at any desired depth within the slab or completely withdrawn from the concrete. The vibrators shall be automatically controlled so that they will be immediately stopped as forward motion of the paver ceases. The spacing of the immersion vibrators across the paving lane shall be as necessary to properly consolidate the concrete, but the clear distance between vibrators shall not exceed 750 mm, 30 inches, and the outside vibrators shall not exceed 300 mm 12 inches from the edge of the lane. The paver-finisher shall be equipped with a transversely oscillating screed or an extrusion plate to shape, compact, and smooth the surface.

1.5.4.1 Paver-Finisher with Fixed Forms

The paver-finisher shall be equipped with wheels designed to ride the forms, keep it aligned with the forms, and to spread the preventing deformation of the forms.

1.5.4.2 Slipform Paver-Finisher

The slipform paver-finisher shall be automatically controlled and crawler mounted with padded tracks. Horizontal alignment shall be electronically referenced to a taut wire guideline. Vertical alignment shall be electronically referenced on both sides of the paver to a taut wire guideline, to an approved laser control system, or to a ski operating on a completed lane. Control from a slope-adjustment control or control operating from the underlying material shall not be used.

1.5.4.3 Other Types of Finishing Equipment

Bridge deck finishers shall be used for pavements 250 mm 10 inchesor less in thickness, where longitudinal and transverse surface smoothness tolerances are 6.5 mm (1/4 inch) or greater. Clary screeds or other rotating tube floats will not be allowed on the project.

1.5.5 Curing Equipment

Equipment for curing is specified in paragraph CURING.

1.5.6 Texturing Equipment

Texturing equipment shall be as specified below.

1.5.6.1 Fabric Drag

A fabric drag shall consist of a piece of fabric material as wide as the lane width securely attached to a separate wheel mounted frame spanning the paving lane or to one of the other similar pieces of equipment. The material shall be wide enough to provide 300 to 450 mm (12 to 18 inches) dragging flat on the pavement surface. The fabric material shall be clean, reasonably new burlap, kept clean and saturated during use or The fabric material shall be an artificial turf fabricated of a plastic material.

1.5.6.2 Deep Texturing Equipment

Texturing equipment shall consist of a stiff bristled broom, a comb with spring wire tines or spring strips which will produce true, even grooves forming a drag at least 1.2 m 4 feet long. This drag shall be mounted in a wheeled frame spanning the paving lane and constructed to mechanically pull the drag in a straight line across the paving lane perpendicular to the centerline.

1.5.7 Sawing Equipment

Equipment for sawing joints and for other similar sawing of concrete shall be standard diamond-tip-bladed concrete saws mounted on a wheeled chassis.

1.5.8 Straightedge

The Contractor shall furnish and maintain at the job site one 4 m (12 foot) straightedge for testing concrete surface smoothness. The straightedge shall be constructed of aluminum or magnesium alloy and shall have blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Straightedges shall have handles for operation on the pavement.

PART 2 - PRODUCTS

2.1 MATERIALS

2.1.1 Cement

2.1.1.1 General

Cement may be furnished in bulk or packages. When cement is furnished in packages, mixing batch proportions sha11 be adjusted to require complete packages of cement.

2.1.1.2 Portland Cement

Portland cement shall conform to ASTM C 150 or KS L 5201 Type I

2.1.1.3 High Early-Strength Portland Cement

High early-strength portland cement shall conform to KS L 5301, Type III.

2.1.2 Pozzolan (Fly Ash)

Fly ash shall conform to ASTM C 618 Class F, including all the supplementary optional physical requirements. Fly ash shall conform to EPA requirements

2.1.5 Ground Granulated Blast-Furnace Slag (GGBF Slag) Ground granulated blast-furnace slag shall conform to ASTM C 989 Grade 120

2.2 AGGREGATES

Aggregates shall consist of clean, hard, uncoated particles meeting the requirements of ASTM C 33, including deleterious materials, abrasion loss and soundness requirements of ASTM C 33, and other requirements specified herein. [Aggregate not having a satisfactory demonstrable service record shall have a durability factor of 50 or more when subjected to freezing and thawing in concrete in accordance with ASTM C 666. In addition to the grading requirements specified for coarse aggregate and for fine aggregate, the combined aggregate grading shall meet the following requirements.a. If necessary, a blending aggregate shall be used to meet the required combined grading. This blending aggregate shall be batched separately. The combined grading of all aggregates used, in the proportions selected, shall be computed on the basis of cumulative percent retained on each sieve specified for fine and coarse aggregate.b. The materials selected and the proportions used shall be such that when the Coarseness Factor (CF) and the Workability Factor (W) are plotted on a diagram as described in d. below, the point thus determined shall fall within the parallelogram described therein.c. The Coarseness Factor (CF) shall be determined from the following equation:

CF = (cumulative percent retained on the 9.5 mm sieve)(100)/(cumulative percent retained on the 2.36 mm sieve)

The Workability Factor (W) is defined as the cumulative percent passing the 2.36 mm No. 8 sieve. However, W shall be adjusted, upwards only, by 2.5 percentage points for each 42 kg 94 pounds of cementitious material per cubic meter yard greater than 335 kg per cubic meter. (564 pounds per cubic yard).

2.2.1 Coarse Aggregate

Coarse aggregate shall consist of crushed or uncrushed gravel, crushed stone, or a combination thereof. Aggregate used for paving compass calibration hardstands shall be free of materials having magnetic properties. Coarse aggregate used for paving power check pads shall be limestone, dolomite, or basalt, or another aggregate if that aggregate has a proven service record demonstrating that it will not cause thermal distress from jet blast. The nominal maximum size of the coarse aggregate shall be 38.1mm (1-1/2 inches). When the nominal maximum size is greater than 25.0 mm, 1 inch, the aggregates shall be furnished in two ASTM C 33 size groups, No. 67 and No. 4. The amount of deleterious material in each size of coarse aggregate shall not exceed the limits shown in ASTM C 33 Class 1N, 4M or 4S, depending on the weathering region, and the following limits:

a. Lightweight particles 1.0 max. percent by mass (ASTM C 123).

b. Other soft particles 2.0 max. percent by mass (COE CRD-C 130).

c. Total of all deleterious 5.0 max. percent by mass (substances listed in ASTM C 33 and above, exclusive of material finer than 0.075 mm No. 200 sieve).

d. The separation medium for lightweight particles shall have a density of 2.0 Mg/cubic meters. Sp. Gr. of 2.0.

2.2.2 Fine Aggregate

Fine aggregate shall consist of natural sand, manufactured sand, or a combination of the two, and shall be composed of clean, hard, durable particles. Aggregate used for paving compass calibration hardstands shall be free of materials having magnetic properties. All fine aggregate shall be composed of clean, hard, durable particles meeting the requirements of ASTM C 33 and the requirements herein. The amount of deleterious material in the fine aggregate shall not exceed the limits in ASTM C 33and shall not exceed the following limits:

a. Lightweight particles (ASTM C 123) 1.0 percent max. by mass using

a medium with a density of 2.0 Mg/cubic meter. Sp. Gr. of 2.0.

b. The total of all deleterious material types, listed in ASTM C 33

and above, shall not exceed 3.0 percent of the mass of the fine

aggregate.

2.3 CHEMICAL ADMIXTURES

2.3.1 Air-Entraining Admixtures

The air-entraining admixture shall conform to ASTM C 260 or KS F2560 and shall consistently entrain the air content in the specified ranges under field conditions. The air-entraining admixture shall be in a solution of suitable viscosity for field use.

2.3.2 Accelerator

Calcium chloride shall conform to ASTM C 494/C 494M Type C. Calcium chloride and admixtures containing calcium chloride shall not be used. When approved or directed, the Contractor shall use not more than 1 percent of calcium chloride, by weight, of the cement. It shall be measured accurately and shall be added to the batch in solution in a portion of the mixing water. The use of calcium chloride in concrete shall in no way relieve the Contractor of responsibility for compliance with the requirements of these specifications governing protection and curing of concrete.

2.3.3 Retarder

A water reducing or retarding admixture shall conform to ASTM C 494/C 494M or KS F2520. Type G or H admixtures are not allowed

2.4 Curing Materials

Membrane-forming curing compounds shall be white pigmented compounds conforming to CRD-C 300. Burlap shall be new or shall be clean

material never used for anything other than curing concrete.

2.5 WATER

Water for mixing and curing shall be clean, potable, and free of injurious amounts of oil, acid, salt, or alkali.

2.6 JOINT MATERIALS

2.6.1 Expansion Joint Material

Expansion joint filler shall be a preformed material conforming to ASTM D 1751, ASTM D 1752 Type I II III or KS F 2538. Expansion joint filler shall be 20 mm 3/4 inch thick.

2.6.2 Slip Joint Material

Slip joint material shall be 6 mm 1/4 inch thick expansion joint filler conforming to ASTM D 1751, ASTM D 1752 or KS F 2538.

2.6.3 Contraction Joint Inserts

Sawable contraction joint inserts shall conform to COE CRD-C 540. Nonsawable contraction joint inserts shall have sufficient stiffness to permit placement in plastic concrete without deviation from a straight line and shall conform to the physical requirements of COE CRD-C 540, with the exception of resistance to sawing. Material for polyvinyl chloride inserts shall conform to COE CRD-C 572. No metal inserts of any kind shall be used.

2.7 REINFORCING

2.7.1 General

Reinforcing bars shall conform to ASTM A 615/A 615M Grade 40 or higher; or KS D 3504. Bar mats shall conform to ASTM A 184/A 184M. Reinforcement shall be free from loose, flaky rust, loose scale, oil, grease, mud, or other coatings that might reduce the bond with concrete.

2.7.2 Steel Fiber Reinforcing

Minimum ultimate tensile strength of the fibers shall be 345 MPa.50000 psi. The maximum aspect ratio (length divided by diameter) shall not exceed 100. Fibers longer than 60 mm 2-1/2 inches shall not be used. The fibers shall be deformed and shall be furnished in small bundles adhered with water soluble glue.

2.7.3 Bar Mats

Bar mats shall conform to ASTM A 184. The bar members shall be billet, rail or axle steel.

2.8 Dowels

2.8.1 Dowels

Dowels shall be single piece, plain (non-deformed) steel bars conforming to ASTM A 615/A 615M Grade 60 or higher. Dowels shall be free of loose, flaky rust and loose scale and shall be clean and straight.

2.8.2 Tie Bars

Tie bars shall be deformed steel bars conforming to ASTM A 615/A 615M Grade 40 or higher; or KS D 3504. Grade 60 or higher bars shall not be used for bars that are bent and straightened during construction.

2.9 EPOXY RESIN

All epoxy-resin materials shall be two-component materials conforming to ASTM C 881, Class as appropriate for each application temperature to be encountered; except, that in addition, the materials shall meet the following requirements:

a. Material for use for embedding dowels and anchor bolts shall be

Type IV, Grade 3.

b. Material for use as patching for complete filling of spalls, wide cracks, and other voids and for use in preparing epoxy resin mortar shall be Type III, Grade as approved.

c. Material for injecting cracks shall be Type IV, Grade 1.

d. Material for bonding freshly mixed portland cement concrete, mortar, or freshly mixed epoxy resin concrete to hardened concrete shall be Type V, Grade as approved.

2.10 SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES

Specified flexural strength for concrete is 4.14 Mpa (600 psi) at 28 days. Maximum allowable water-cementitious material ratio is 0.45. The water-cementitious material ratio is based on absolute volume equivalency, where the ratio is determined using the weight of cement for a cement only mix, or using the total volume of cement plus pozzolan converted to an equivalent weight of cement by the absolute volume equivalency method described in ACI 211.1. The concrete shall be air-entrained with a total air content of 6 plus or minus 1 percent. The maximum allowable slump of the concrete shall be 75 mm 3 inches for pavement constructed with fixed forms. For slipformed pavement, the maximum allowable slump shall be 30 mm 1-1/4 inches. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result falls below the specified strength f'c by more than 3.5 MPa. 500 psi. Additional analysis or testing, including taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

2.11 MIXTURE PROPORTIONS

2.11.1 Composition Concrete

Composition concrete shall be composed of cementitious material, water, fine and coarse aggregates, and admixtures. Fly ash, if used, shall be used only at a rate between 15 and 35 percent by mass of the total cementitious material] and conform to EPA requirements. Admixtures shall consist of air entraining admixture and may also include accelerator, retarder or water-reducing admixture. High range water-reducing admixtures and admixtures to produce flowable concrete shall not be used. No substitutions shall be made in the materials used in the mixture proportions without additional tests to show that the quality of the concrete is satisfactory.

2.11.2 Concrete Mixture Proportioning Studies

Trial design batches, mixture proportioning studies, and testing shall be the responsibility of the Contractor, and shall be performed by the Test Laboratory and signed by a Registered Engineer. No concrete pavement shall be placed until the Contracting Officer has approved the Contractor's mixture proportions. All materials used in mixture proportioning studies shall be representative of those proposed for use on the project. If there is a change in materials, additional mixture design studies shall be made using the new materials. Trial mixtures having proportions, slumps, and air content suitable for the work shall be based on methodology described in ACI 211.1. At least three different water-cementitious ratios, which will produce a range of strength encompassing that required on the project, shall be used. Laboratory trial mixtures shall be proportioned for maximum permitted slump and air content. Maximum sand content shall be 40 percent of the total aggregate SSD weight. Aggregate quantities shall be based on the mass in a saturated surface dry condition.

2.11.3 Mixture Proportioning Procedure

The Contractor shall perform the following:

a. Fabricate, cure and test 6 test cylinders per age for each mixture at 7 and 28 days.

b. Using the average strength for each w/(c+p), plot the results from each of the three mixtures on separate graphs for w/(c+p) versus 28-day strength.

c. From the graphs select a w/(c+p) which will produce a mixture giving a 28-day strength equal to the required strength determined in accordance with the following paragraph.

2.11.4 Average Strength Required for Mixtures

In order to ensure meeting, during production, the strength requirements specified, the mixture proportions selected shall produce a required average strength, exceeding the specified strength, in accordance with procedures in Chapter 3 of ACI 301, "Proportioning". The aggregate shall consist of crushed or uncrushed gravel, crushed stone, crushed adequately seasoned blast-furnace slag, or a combination thereof.

PART 3 EXECUTION

3.1 CONDITIONING OF UNDERLYING MATERIAL

Underlying material, subgrade, base course or subbase course, upon which concrete is to be placed shall be clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. After the underlying material has been prepared for concrete placement, no equipment shall be permitted thereon.

3.2 WEATHER LIMITATIONS

3.2.1 Hot Weather Paving

The temperature of concrete shall not exceed 32 degrees C. 90 degrees F. Steel forms, dowels and reinforcing shall be cooled prior to concrete placement when steel temperatures are greater than 49 degrees C. 120 degrees F.

3.2.2 Cold Weather Paving

The ambient temperature of the air at the placing site and the temperature of surfaces to receive concrete shall be not less 5 degrees C. 40 degrees F. The temperature of the concrete when placed shall be not less than 10 degrees C. 50 degrees F. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals or other materials shall not be incorporated in the concrete to prevent freezing. Upon written approval, chemical admixture conforming to ASTM C 494/C 494M Type C or E may be used provided it contains no calcium chloride. Calcium chloride shall not be used at any time. Covering and other means shall be provided for maintaining the concrete at a temperature of at least 10 degrees C 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period. Pavement damaged by freezing shall be completely removed and replaced at the Contractor's expense as specified in paragraph, REPAIR, REMOVAL, AND REPLACEMENT OF SLABS.

3.3 CONCRETE PRODUCTION

3.3.1 General Requirements

Concrete shall be deposited in front of the paver within 45 minutes from the time cement has been charged into the mixing drum, except that if the ambient temperature is above 32 degrees C, 90 degrees F, the time shall be reduced to 30 minutes. Every load of concrete delivered to the paving site shall be accompanied by a batch ticket from the operator of the batching plant. Tickets shall show at least the mass, or volume, of all ingredients in each batch delivered, [the water meter and revolution meter reading on truck mixers] and the time of day. Tickets shall be delivered to the placing foreman who shall keep them on file and deliver them to the Government daily.

3.3.2 Transporting and Transfer-Spreading Operations

Non-agitating equipment shall be used only on smooth roads and for haul time less than 15 minutes. [No equipment shall be allowed to operate on the prepared and compacted underlying material in front of the paver-finisher.] [Equipment shall be allowed to operate on the underlying material only if no damage is done to the underlying material and its degree of compaction. Any disturbance to the underlying material that does occur shall be corrected before the paver-finisher reaches the location of the disturbance and the equipment shall be replaced or procedures changed to prevent any future damage.

3.4 PAVING

Pavement shall be constructed with paving and finishing equipment utilizing

fixed forms or slipforms.

3.4.1 Consolidation

The paver vibrators shall be inserted into the concrete not closer to the underlying material than 50 mm. 2 inches. The vibrators or any tamping units in front of the paver shall be automatically controlled so that they shall be stopped immediately as forward motion ceases. Excessive vibration shall not be permitted. Concrete in small, odd-shaped slabs or in locations inaccessible to the paver mounted vibration equipment shall be vibrated with a hand-operated immersion vibrator. Vibrators shall not be used to transport or spread the concrete.

3.4.2 Operation

When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provisions shall be made to prevent damage to the previously constructed pavement, including keeping the existing pavement surface free of any debris, and placing rubber mats beneath the paver tracks. Transversely oscillating screeds and extrusion plates shall overlap the existing pavement the minimum possible, but in no case more than 200 mm. 8 inches.

3.4.3 Required Results

The paver-finisher shall be operated to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. The paver-finishing operation shall produce a surface finish free of irregularities, tears, voids of any kind, and any other discontinuities. It shall produce only a very minimum of paste at the surface. Multiple passes of the paver-finisher shall not be permitted. The equipment and its operation shall produce a finished surface requiring no hand finishing, other than the use of cutting straightedges, except in very infrequent instances. No water, other than true fog sprays (mist), shall be applied to the concrete surface during paving and finishing.

3.4.4 Fixed Form Paving

Forms shall be steel, except that wood forms may be used for curves having a radius of 45 m 150 feet or less, and for fillets. Forms may be built up with metal or wood, added only to the base, to provide an increase in depth of not more than 25 percent. The base width of the form shall be not less than eight-tenths of the vertical height of the form, except that forms 200 mm 8 inches or less in vertical height shall have a base width not less than the vertical height of the form. Wood forms for curves and fillets shall be adequate in strength and rigidly braced. Forms shall be set on firm material cut true to grade so that each form section when placed will be firmly in contact with the underlying layer for its entire base. Forms shall not be set on blocks or on built-up spots of underlying material. Forms for overlay pavements and for other locations where forms must be set on existing pavements shall be held securely in place with stakes or by other approved methods. Holes in existing pavements for form stakes shall be carefully drilled without cracking or spalling the existing pavement. Prior to setting forms for paving operations, the Contractor shall demonstrate the proposed form setting procedures at an approved location and shall not proceed further until the proposed method is approved. Forms shall remain in place at least 12 hours after the concrete has been placed. Forms shall be removed without injuring the concrete.

3.4.5 Slipform Paving

The slipform paver shall shape the concrete to the specified and indicated cross section in one pass, and shall finish the surface and edges so that only a very minimum amount of hand finishing is required. Dowels shall not be installed by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete. If a keyway is required, a 0.45 to 0.55 mm 26 gauge thick metal keyway liner shall be installed as the keyway is extruded. The keyway liner shall be protected and shall remain in place and become part of the joint.

3.4.6 Placing Reinforcing Steel

Reinforcement shall be positioned on suitable chairs securely fastened to the subgrade prior to concrete placement, or may be placed on an initial layer of consolidated concrete, with the subsequent layer placed within 30 minutes of the first layer placement. If reinforcing for Continuously Reinforced Concrete Pavement (CRCP) is required, the entire operating procedure and equipment proposed shall be submitted for approval at least 30 days prior to proposed start of paving.

3.4.7 Placing Dowels and Tie Bars

Dowels shall be installed with alignment not greater than 1 mm per 100 mm. 1/8 inch per ft. Except as otherwise specified below, location of dowels shall be within a horizontal tolerance of plus or minus 15 mm5/8 inch and a vertical tolerance of plus or minus 5 mm. 3/16 inch. The portion of each dowel intended to move within the concrete or expansion cap shall be painted with one coat of rust inhibiting primer paint, and then oiled just prior to placement. Dowels [and tie bars] in joints shall be omitted when the center of the [dowel] [tie bar] is located within a horizontal distance from an intersecting joint equal to or less than one-fourth of the slab thickness.

3.4.7.1 Contraction Joints

Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane shall be held securely in place by means of rigid metal basket assemblies. The [dowels] [and tie bars] shall be welded to the assembly or held firmly by mechanical locking arrangements that will prevent them from becoming distorted during paving operations. The basket assemblies shall be held securely in the proper location by means of suitable anchors.

3.4.7.2 Construction Joints-Fixed Form Paving

Installation of dowels and tie bars shall be by the bonded-in-place method, supported by means of devices fastened to the forms. Installation by removing and replacing in preformed holes will not be permitted.

3.4.7.3 Dowels Installed in Hardened Concrete

Installation shall be by bonding the dowels into holes drilled into the hardened concrete. Holes approximately 3 mm 1/8 inch greater in diameter than the dowels shall be drilled into the hardened concrete. Dowels shall be bonded in the drilled holes using epoxy resin injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel shall not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic collar fitted around the dowel. The vertical alignment of the dowels shall be checked by placing the straightedge on the surface of the pavement over the top of the dowel and measuring the vertical distance between the straightedge and the beginning and ending point of the exposed part of the dowel. [Where tie bars are required in longitudinal construction joints of slipform pavement, bent tie bars shall be installed at the paver, in front of the transverse screed or extrusion plate. If tie bars are required, a standard keyway shall be constructed, and the bent tie bars shall be inserted into the plastic concrete through a 0.45 to 0.55 mm 26 gauge thick metal keyway liner. Tie bars shall not be installed in preformed holes. The keyway liner shall be protected and shall remain in place and become part of the joint. Before placement of the adjoining paving lane, the tie bars shall be straightened, without spalling the concrete around the bar.

3.4.7.4 Expansion Joints

Dowels in expansion joints shall be installed by the bonded-in-place method or by bonding into holes drilled in hardened concrete, using procedures specified above.

3.5 FINISHING

Clary screeds, "bridge deck" finishers, or other rotating pipe or tube type equipment shall not be permitted. The sequence of machine operations shall be transverse finishing, longitudinal machine floating if used, straightedge finishing, texturing, and then edging of joints. Hand finishing shall be used only infrequently and only on isolated areas of odd slab shapes and in the event of a breakdown of the mechanical finishing equipment. Supplemental hand finishing for machine finished pavement shall be kept to an absolute minimum. Equipment to be used for supplemental hand finishing shall primarily be 3 to 4 m 10 to 12 feet cutting straightedges; only very sparing use of bull floats shall be allowed. At no time shall water be added to the surface of the slab in any way, except for fog (mist) sprays to prevent plastic shrinkage cracking.

3.5.1 Machine Finishing With Fixed Forms

The machine shall be designed to ride the forms. Machines that cause displacement of the forms shall be replaced. The machine shall make only one pass over each area of pavement. If the equipment and procedures do not produce a surface of uniform texture, true to grade, in one pass, the operation shall be immediately stopped and the equipment, mixture, and procedures adjusted as necessary.

3.5.2 Machine Finishing With Slipform Pavers

If there is sufficient concrete slurry or fluid paste on the surface that it runs over the edge of the pavement, the paving operation shall be immediately stopped and the equipment, mixture, or operation modified to prevent formation of such slurry. Any slurry which does run down the vertical edges shall be immediately removed. No slurry, concrete or concrete mortar shall be used to build up along the edges of the pavement to compensate for excessive edge slump, either while the concrete is plastic or after it hardens.

3.5.3 Surface Correction

While the concrete is still plastic, irregularities and marks in the pavement surface shall be eliminated by means of cutting straightedges, 3 to 4 m 10 to 12 feet in length. Depressions shall be filled with freshly mixed concrete, struck off, consolidated, and refinished. Projections above the required elevation shall also be struck off and refinished. Long-handled, flat "bull floats" shall be used sparingly and only as necessary to correct minor, scattered surface defects. Finishing with hand floats and trowels shall be held to the absolute minimum necessary. Joints and edges shall not be overfinished.

3.5.4 Hand Finishing

Hand finishing operations shall be used only for those unusual slabs as specified previously. Grate tampers (jitterbugs) shall not be used. As soon as placed and vibrated, the concrete shall be struck off and screeded. The surface shall be tamped with a strike-off and tamping screed, or vibratory screed. Immediately following the final tamping of the surface, the pavement shall be floated longitudinally. Long-handled, flat bull floats shall be used sparingly and only as necessary to correct surface defects. Finishing with hand floats and trowels shall be held to the absolute minimum necessary. Joints and edges shall not be overfinished. No water shall be added to the pavement during finishing operations.

3.5.5 Texturing

Before the surface sheen has disappeared and before the concrete hardens, the surface of the pavement shall be given a texture as described herein. Following initial texturing on the first day of placement, the Placing Foreman, Contracting Officer representative, and a representative of the Using

Agency shall inspect the texturing for compliance with design requirements. After curing is complete, all textured surfaces shall be thoroughly power broomed to remove all debris. [Any type of transverse texturing shall produce grooves in straight lines across each lane within a tolerance of plus or minus 13 mm 1/2 inch of a true line.] The concrete in areas of recesses for tie-down anchors, lighting fixtures, and other outlets in the pavement shall be finished to provide a surface of the same texture as the surrounding area.

3.5.5.1 Fabric-Drag Surface Finish

Surface texture shall be applied by dragging the surface of the pavement, in the direction of the concrete placement, with a moist fabric drag. The dragging shall produce a uniform finished surface having a fine sandy texture without disfiguring marks.

3.5.5.2 Broom Texturing

Surface texture shall be applied using a mechanical stiff bristle broom drag of a type that will uniformly score the surface transverse to the pavement center line. The broom shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Successive passes of the broom shall be overlapped the minimum necessary to obtain a uniformly textured surface. The scores should be uniform in appearance and approximately 1.5 mm 1/16 inchin depth but not more than 3 mm 1/8 inch in depth. Hand brooming will be permitted only on isolated odd shaped slabs or slabs where hand finishing is permitted.

3.5.5.3 Wire-Comb Texturing

Surface texture transverse to the pavement center line shall be applied using a mechanical wire comb drag. The comb shall be capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Successive passes of the comb shall be overlapped the minimum necessary to obtain a continuous and uniformly textured surface. The scores shall be 2 to 5 mm 1/16 to 3/16 inch deep, 1.5 to 3 mm 1/16 to 1/8 inch wide, and spaced 10 mm 3/8 inch apart.

3.5.5.4 Surface Grooving

The areas indicated on the drawings shall be grooved with a spring tine drag producing individual grooves 6 mm 1/4 inch deep and 6 mm1/4 inch wide at a spacing between groove centerlines of 50 mm. 2 inches. These grooves shall be cut perpendicular to the centerline. Before grooving begins, the concrete shall be allowed to stiffen sufficiently to prevent dislodging of aggregate. Grooves shall not be cut within 150 mm 6 inches of a transverse joint or crack.

3.5.6 Edging

The edges of slipformed lanes shall not be edged. After texturing has been completed, the edge of the slabs along the forms shall be carefully finished with an edging tool to form a smooth rounded surface of 3 mm (1/8 inch) radius. No water shall be added to the surface during edging.

3.6 CURING

Concrete shall be continuously protected against loss of moisture and rapid temperature changes for at least 7 days from the completion of finishing operations. Unhardened concrete shall be protected from rain and flowing water. During hot weather with low humidity and/or wind, the Contractor shall institute measures to prevent plastic shrinkage cracks from developing. ACI 305R contains means of predicting plastic shrinkage cracking and preventative measures. Plastic shrinkage cracks that occur shall be filled by injection of epoxy resin after the concrete hardens. Plastic shrinkage cracks shall never be troweled over or filled with slurry. Curing shall be accomplished by one of the following methods.

3.6.1 Membrane Curing

A uniform coating of white-pigmented membrane-forming curing compound shall be applied to the entire exposed surface of the concrete including pavement edges as soon as the free water has disappeared from the surface after finishing. If evaporation is high and no moisture is present on the surface even though bleeding has not stopped, fog sprays shall be used to keep the surface moist until setting of the cement occurs. Curing compound shall then be immediately applied. Curing compound shall be applied to the finished surfaces by means of a self-propelled automatic spraying machine, equipped with multiple spraying nozzles with wind shields, spaning the newly paved lane. The curing compound shall be applied at a maximum application rate of 5 square meters per L. 200 square feet per gallon. The application of curing compound by hand-operated, mechanical powered pressure sprayers will be permitted only on odd widths or shapes of slabs where indicated and on concrete surfaces exposed by the removal of forms. The compound shall form a uniform, continuous, cohesive film that will not check, crack, or peel and that will be free from pinholes and other discontinuities. Areas where the curing compound develops the above defects or is damaged by heavy rainfall, sawing or other construction operations within the curing period, shall be immediately resprayed.

3.6.2 Moist Curing

Concrete to be moist-cured shall be maintained continuously wet for the entire curing period, commencing immediately after finishing. Surfaces shall be cured by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap. Impervious sheet curing shall not be used.

3.7 JOINTS

No deviation from the jointing pattern shown on the drawings shall be made without written approval of the Design District Pavement or Geotechnical Engineer. All joints shall be straight, perpendicular to the finished grade of the pavement, and continuous from edge to edge or end to end of the pavement with no abrupt offset and no gradual deviation greater than 13 mm. 1/2 inch.

3.7.1 Longitudinal Construction Joints

Dowels, Keys and Tie bars shall be installed in the longitudinal construction joints, or the edges shall be thickened as indicated. The dimensions of the keyway shall not vary more than plus or minus 3 mm1/8 inch from the dimensions indicated and shall not deviate more than plus or minus 6 mm 1/4 inch from the mid-depth of the pavement. If any length of completed keyway of 1.5 m 5 feet or more fails to meet the above tolerances, dowels shall be installed.]

3.7.2 Transverse Construction Joints

Transverse construction joints shall be installed at a planned transverse joint, at the end of each day's placing operations and when concrete placement is interrupted. Transverse construction joints shall be constructed either by utilizing headers and hand placement and finishing techniques, or by placing concrete beyond the transverse construction joint location and then saw cutting full depth and removing concrete back to the transverse construction joint location. For the latter case, dowels shall be installed using methods for dowels installed in hardened concrete described above. All transverse construction joints shall be dowelled.

3.7.3 Expansion Joints

Expansion joints shall be formed where indicated, and about any structures and features that project through or into the pavement, using preformed joint filler of the type, thickness, and width indicated, and shall extend the full slab depth. Edges of the concrete at the joint face shall be edged. The joint filler strips shall be installed to form a recess at the pavement surface to be filled with joint sealant. Expansion joints shall be constructed with [dowels] [thickened edges] for load transfer.

3.7.4 Slip Joints

Slip joints shall be installed the full depth of the slab using expansion joint preformed joint filler material attached to the face of the original concrete placement. A reservoir for joint sealant shall be constructed at the top of the joint. Edges of the joint face shall be edged.

3.7.5 Contraction Joints

Transverse and longitudinal contraction joints shall be of the weakened-plane or dummy type. Longitudinal contraction joints shall be constructed by sawing a groove in the hardened concrete with a power-driven saw. Transverse contraction joints shall be constructed in conformance with requirements for sawed joints or insert-type contraction joints.

3.7.5.1 Sawed Joints

Sawed contraction joints shall be constructed by sawing a groove in the concrete with a 3 mm 1/8 inch blade to the indicated depth. The time of initial sawing shall vary depending on existing and anticipated weather conditions and shall be such as to prevent uncontrolled cracking of the pavement. Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. The joints shall be sawed at the required spacing consecutively in the sequence of the concrete placement. Sawing at a given joint location shall be discontinued when a crack develops ahead of the saw cut. Immediately after the joint is sawed, the saw cut and adjacent concrete surface shall be thoroughly flushed with water until all waste from sawing is removed from the joint. The surface shall be resprayed with curing compound as soon as free water disappears. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed with cord or backer rod before the concrete in the region of the joint is resprayed with curing compound.

3.7.5.2 Insert-Type Joints

Insert-type joints shall not be used for slipformed pavements. Insert-type non-metallic contraction joints shall be constructed by installing a preformed insert in the plastic concrete to form a weakened plane to induce cracking. Inserts shall be installed using a machine equipped with a vibrating bar for cutting a groove in the plastic concrete for placement of the insert or for vibrating the insert into place at the prescribed joint location. The installed insert shall be perpendicular to the finished grade of the pavement, with the top of the insert not more than 3 mm1/8 inch below the pavement surface.

3.7.6 Thickened Edge Joints

Underlying material in the transition area shall meet the requirements for smoothness and compaction specified for all other areas of the underlying material.

3.7.7 Special Joints

Special joints (undercut joints) shall be constructed adjacent to existing pavement as indicated. The concrete shall be worked under the edge of the existing pavement to completely fill the void and shall be thoroughly consolidated by the use of hand-held vibrators.

3.8 REPAIR, REMOVAL, AND REPLACEMENT OF SLABS

New pavement slabs that contain full-depth cracks shall be removed and replaced, as specified herein at no cost to the Government. Removal and replacement shall be full depth, shall be full width of the paving lane, and the limit of removal shall be from each original transverse joint. The Contracting Officer will determine whether cracks extend full depth of the pavement and may require minimum 150 mm 6 inch diameter cores to be drilled on the crack to determine depth of cracking. Cores shall be drilled and the hole later filled by the Contractor with a well consolidated concrete mixture bonded to the walls of the hole with epoxy resin. Drilling of cores and refilling holes shall be at no expense to the Government. Cracks that do not extend full depth of slab shall be cleaned and then pressure injected with epoxy resin, Type IV, Grade 1. The Contractor shall ensure that the crack is not widened during epoxy resin injection. Where a full depth crack intersects the original transverse joint, the slab(s) containing the crack shall be removed and replaced, with dowels installed, as required below. Spalls along joints shall be repaired as specified.

3.8.1 Removal and Replacement of Full Slabs

Unless there are keys or dowels present, all edges of the slab shall be sawcut full depth. If keys, dowels, or tie bars are present along any edges, these edges shall be sawed full depth 150 mm 6 inches from the edge if only keys are present, or just beyond the end of dowels or tie bars if they are present. These joints shall then be carefully sawed on the joint line to within 25 mm 1 inch of the depth of the dowel or key. The main slab shall be further divided by sawing full depth, at appropriate locations, and each piece lifted out and removed. The narrow strips along keyed or doweled edges shall be carefully broken up and removed. Care shall be taken to prevent damage to the dowels, tie bars, or keys or to concrete to remain in place. Protruding portions of dowels shall be painted and lightly oiled. The joint face below keys or dowels shall be suitably trimmed so that there is no abrupt offset. If underbreak occurs at any point along any edge, the area shall be hand-filled with concrete, producing an even joint face from top to bottom, before replacing the removed slab. If underbreak over 100 mm 4 inches deep occurs, the entire slab containing the underbreak shall be removed and replaced. Where there are no dowels, tie bars, or keys on an edge, or where they have been damaged, dowels of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete. Original damaged dowels or tie bars shall be cut off flush with the joint face. All four edges of the new slab shall thus contain dowels or original keys or original tie bars. Prior to placement of new concrete, the underlying material shall be graded and recompacted, and the surfaces of all four joint faces shall be cleaned of all loose material and contaminants, and coated with a double application of membrane forming curing compound as bond breaker. Placement of concrete shall be as specified for original construction. The resulting joints around the new slab shall be prepared and sealed as specified.

3.8.2 Repairing Spalls Along Joints

Spalls along joints and cracks shall be repaired by first making a vertical saw cut at least 25 mm 1 inch outside the spalled area and to a depth of at least 50 mm. 2 inches. Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete. The cavity shall be thoroughly cleaned with high pressure water jets supplemented with compressed air to remove all loose material. Immediately before filling the cavity, a prime coat shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Prime coat for portland cement repairs shall be a neat cement grout and for epoxy resin repairs shall be epoxy resin, Type III, Grade 1. The cavity shall be filled with low slump portland cement concrete or mortar, or with epoxy resin concrete or mortar. Portland cement concrete shall be used for larger spalls, those more than 0.009 cubic meter 1/3 cu. ft. in size after removal operations; portland cement mortar shall be used for spalls between 0.00085 and 0.009 cubic meter; 0.03 and 1/3 cu. ft; and epoxy resin mortar or Type III, Grade 3 epoxy resin for those spalls less than 0.00085 cubic meter0.03 cu. ft. in size after removal operations. Portland cement concretes and mortars shall be very low slump mixtures, proportioned, mixed, placed, tamped, and cured. If the materials and procedures are approved in writing, latex modified concrete mixtures may be used for repairing spalls less than 0.009 cubic meter 1/3 cu.ft. in size.] Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions, mixing, placing, tamping and curing procedures as recommended by the manufacturer. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints. [In lieu of sawing, spalls not adjacent to joints, and popouts, both less than 150 mm 6 inches in maximum dimension, may be prepared by drilling a core 50 mm 2 inches in diameter greater than the size of the defect, centered over the defect, and 50 mm 2 inches deep or 13 mm 1/2 inch into sound concrete, whichever is greater. The core hole shall be repaired as specified above for other spalls.]

3.8.3 Areas Defective in Plan Grade or Smoothness

In areas not meeting the specified limits for surface smoothness and plan grade, high areas shall be reduced to attain the required smoothness and grade, except as depth is limited below. High areas shall be reduced by grinding the hardened concrete with a surface grinding machine after the concrete is 14 days or more old. The depth of grinding shall not exceed 6 mm. 1/4 inch. All pavement areas requiring plan grade or surface smoothness corrections in excess of the specified limits, shall be removed and replaced. In pavement areas given a wire comb or tined texture, areas exceeding 2 square meters 25 square feet that have been corrected by rubbing or grinding shall be retextured by grooving machine sawn grooves meeting the requirements for the wire comb or tined texture. All areas in which grinding has been performed will be subject to the thickness tolerances specified in paragraph Thickness. Any grinding performed on individual slabs with excessive deficiencies shall be performed at the Contractor's own decision without entitlement to additional compensation if eventual removal of the slab is required.

3.9 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR

Existing concrete pavement shall be removed as indicated and as specified in Section 02220 DEMOLITION modified, and expanded as specified herein. Removal, repair and replacement shall be made as indicated and as specified in paragraph REPAIR, REMOVAL, AND REPLACEMENT OR SLABS.

3.10 PAVEMENT PROTECTION

The Contractor shall protect the pavement against all damage prior to final acceptance of the work. Traffic shall be excluded from the new pavement. As a construction expedient in paving intermediate lanes between newly paved pilot lanes, operation of the hauling equipment will be permitted on the new pavement after the pavement has been cured for 7 days and the joints have been sealed or otherwise protected. All new and existing pavement carrying construction traffic or equipment shall be continuously kept completely clean. Special cleaning and care shall be used where Contractor's traffic uses or crosses active airfield pavement.

3.11 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL (CQC)

Paragraph ACCEPTABILITY OF WORK contains additional CQC requirements. The Contractor shall perform the inspection and tests described below and, based upon the results of these inspections and tests, shall take the action required and submit reports as specified. When, in the opinion of the

Contracting Officer, the paving operation is out of control, concrete placement shall cease.

3.11.1 Batch Plant Control

A daily report shall be prepared indicating checks made for scale accuracy with test weights, checks of batching accuracy, and corrective action taken prior to and during placement for weighing or batching, type and source of cement used, type and source of pozzolan or slag used, amount and source of admixtures used, aggregate source, the required aggregate and water masses per cubic meter, yd, amount of water as free moisture in each size of aggregate, and the batch aggregate and water masses per cubic meteryd. For each class of concrete batched during each day's plant operation.

3.11.2 Concrete Mixture

a. Air Content Testing. Air content tests shall be made when test specimens are fabricated. In addition, at least two other tests for air content shall be made on randomly selected batches of each separate concrete mixture produced during each 8-hour period of paving. Whenever air content reaches specified limits, an immediate confirmatory test shall be made. If the second test also shows air content at or exceeding specified limits, an adjustment shall immediately be made in the amount of air-entraining admixture batched to bring air content within specified limits. If the next adjusted batch of concrete is not within specified limits, concrete placement shall be halted until concrete air content is within specified limits.

b. Slump Testing. Slump tests shall be made when test specimens are fabricated. Additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government inspector. Whenever slump approaches the maximum limit, an adjustment shall immediately be made in the batch masses of water and fine aggregate, without exceeding the maximum w/(c+p). When a slump result exceeds the specification limit, no further concrete shall be delivered to the paving site until adjustments have been made and slump is again within the limit.

c. Temperature. The temperature of the concrete shall be measured when strength specimens are fabricated.

d. Concrete Strength Testing. Four (4) cylinders from the same batch shall be fabricated, cured and tested for compressive strength, testing two cylinders at 7-day and two cylinders at 28-day age. A minimum of one set of four (4) cylinders shall be fabricated, cured and tested for each shift of concrete placement. Control charts for strength, showing the 7-day and 28-day CQC compressive strengths, and the 28-day required compressive strength, shall be maintained and submitted with weekly CQC Reports.

3.11.3 Inspection Before Placing

Underlying materials, joint locations and types, construction joint faces, forms, reinforcing, dowels, and embedded items shall be inspected by a Registered Engineer in sufficient time prior to each paving operation in order to certify to the Contracting Officer that they are ready to receive concrete.

The results of each inspection shall be reported in writing, and the certification signed by the Registered Engineer, prior to each days' paving.

3.11.4 Paving Operations

The placing foreman shall supervise all placing and paving operations, shall determine that the correct quality of concrete is placed in each location as shown, shall insure that the concrete is consolidated full depth and that finishing is performed as specified. The placing foreman shall be responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, volume of concrete placed, and method of paving and any problems encountered.

3.11.5 Curing Inspection

a. Moist Curing Inspections. Each day on both work and non-work days, an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded. When any inspection finds an area of inadequate curing, immediate corrective action shall be taken, and the required curing period for the area shall be extended by 1 day.

b. Membrane Curing Inspection. At the end of each day's placement, the CQC Representative shall determine the quantity of compound used by measurement of the container; shall determine the area of concrete surface covered; shall then compute the rate of coverage in square meters per Lsquare feet per gallon and shall also note whether or not coverage is uniform. When the coverage rate of the curing compound is less than that specified or when the coverage is not uniform, the entire surface shall be sprayed again.

3.11.6 Cold-Weather Protection

At least once per day, an inspection shall be made of all areas subject to cold-weather protection. Any deficiencies shall be noted, corrected, and reported.

3.11.7 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. A weekly report, signed by a registered engineer, shall be prepared for the updating of control charts and test data, and all CQC inspections and actions covering the entire period from the start of the construction through the current week. Reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all CQC records. A copy of weekly reports shall be faxed to the Design District Pavement or Geotechnical Engineer. At the completion of concrete placement, a certification report shall be prepared containing mix designs, all updated control charts and concrete test data, quality control reports, smoothness reports, and other pertinent data on the concrete, with a certification by a registered engineer that the concrete placed meets all specification requirements. A copy of the certification report shall be mailed to the Design District pavement or Geotechnical Engineer

SECTION 02551

BITUMINOUS PAVING FOR ROADS, STREETS AND OPEN STORAGE AREAS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO MP 1 (1998)Provisional Specification for Performance Graded Asphalt Binder

AASHTO MP 2 (1998; Interim 1999) Superpave Volumetric Mix Design

AASHTO TP53 (1998; Interim 1999) Determining Asphalt Content of Hot Mix Asphalt by the Ignition Method

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 29/C 29M	(1997) Unit Weight and Voids in Aggregate
ASTM C 88	(1999a) Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	(1995) Materials Finer than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	(1996) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 566	(1997) Evaporable Total Moisture Content of Aggregate by Drying
ASTM C 1252	(1998) Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)
ASTM D 140	(1998) Sampling Bituminous Materials
ASTM D 242	(1995) Mineral Filler for Bituminous Paving Mixtures
ASTM D 946	(1999) Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 995	(1995b) Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
ASTM D 1461	(1985)) Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D 1559	(1989) Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM D 2041	(1995) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2172	(1995) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2419	(1995) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D 2489	(1984; R 1994el) Degree of Particle Coating of Bituminous-Aggregate Mixtures ASTM D 2726 (1996el) Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixture ASTM D 2950 (1997) Density of Bituminous Concrete in Place by Nuclear Method
ASTM D 3381	(1999) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 3665	(1999) Random Sampling of Construction Materials
ASTM D 3666	(1998) Minimum Requirements for Agencies Testing and Inspecting Bituminous Paving Materials

ASTM D 4125 (1994el)Asphalt Content of Bituminous Mixtures by the ` Nuclear Method

ASTM D 4791 (1995) Flat or Elongated Particles in Coarse Aggregate

ASTM D 4867/D 4867M --(1996) Effect of Moisture on Asphalt Concrete Paving Mixtures

ASTM D 5444 (1998) Mechanical Size Analysis of Extracted Aggregate

ASTM D 6307 (1998) Asphalt Content of Hot Mix Asphalt by Ignition Method

ASPHALT INSTITUTE (AI)

AI MS-2 (1997) Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types AI MS-22 (1998; 2nd Edition) Construction of Hot-Mix Asphalt Pavements

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION (CDT)

CDT Test 526 (1978) Operation of California Profilograph and Evaluation of Profiles

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 171 (1995) Test Method for Determining Percentage of Crushed Particles in Aggregate

KOREAN INDUSTRIAL STANDARD (KS)

KS F 2349 (1999) Hot-mixed, Hot-laid Bituminous Paving Mixtures.

KS F 2357 (1997) Aggregates for Bituminous Paving Mixtures.

KS F 2507 (1997) Method of Test for Soundness of Aggregates by Use of Sodium Sulfate.

KS F 2508 (1997) Method of Test for Abrasion of Coarse Aggregates by Use of Los Angeles Machine.

1.2 DESCRIPTION OF WORK

The work shall consist of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. HMA designed and constructed in accordance with this section shall conform to the lines, grades, thicknesses, and typical cross sections shown on the drawings. Each course shall be constructed to the depth, section, or elevation required by the drawings and shall be rolled, finished, and approved before the placement of the next course.

1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES:

SD-03 Product Data

Mix Design; GA

Proposed JMF.

Contractor Quality Control; GA.

Quality control plan.

Material Acceptance and Percent Payment; GA.

Acceptance test results and pay calculations.

SD-04 Samples

Asphalt Cement Binder; GA.

(20 L)(5 gallon) sample for mix design verification when requested by the COR.

Aggregates; GA

Sufficient materials to produce [90 kg] [200 lb] of blended mixture for mix design verification if requested by the COR.

SD-06 Test Reports

Aggregates; GA

QC Monitoring; FIO.

Aggregate and QC test results.

SD-07 Certificates

Asphalt Cement Binder; GA.

Copies of certified test data.

Testing Laboratory; GA.

Certification of compliance.

Plant Scale Calibration Certification

1.4 ASPHALT MIXING PLANT

Plants used for the preparation of hot-mix asphalt shall conform to the requirements of ASTM D 995 with the following changes:

a. Truck Scales. The asphalt mixture shall be weighed on approved certified scales at the Contractor's expense. Scales shall be inspected and sealed at least annually by an approved calibration laboratory.

b. Testing Facilities. The Contractor shall provide laboratory facilities at the plant for the use of the Government's acceptance testing and the Contractor's quality control testing.

c. Inspection of Plant. The Contracting Officer shall have access at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. The Contractor shall provide assistance as requested, for the Government to procure any desired samples.

d. Storage Bins. Use of storage bins for temporary storage of hot-mix asphalt will be permitted as follows:

(1) The asphalt mixture may be stored in non-insulated storage bins for a period of time not exceeding 3 hours.

(2) The asphalt mixture may be stored in insulated storage bins for a period of time not exceeding 8 hours. The mix drawn from bins shall meet the same requirements as mix loaded directly into trucks.

1.5 HAULING EQUIPMENT

Trucks used for hauling hot-mix asphalt shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Petroleum based products shall not be used as a release agent. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers (tarps) shall be securely fastened.

1.6 ASPHALT PAVERS

Asphalt pavers shall be self-propelled, with an activated screed, heated as necessary, and shall be capable of spreading and finishing courses of hot-mix asphalt which will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

1.6.1 Receiving Hopper

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

1.6.2 Automatic Grade Controls

If an automatic grade control device is used, the paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. A transverse slope controller shall not be used to control grade. The controls shall be capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 9.14 m 30 feet in length.

b. Taut stringline set to grade.

c. Short ski or shoe for joint matching.

d. Laser control.

1.7 ROLLERS

Rollers shall be in good condition and shall be operated at slow speeds to avoid displacement of the asphalt mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Equipment which causes excessive crushing of the aggregate shall not be used.

1.8 WEATHER LIMITATIONS

The hot-mix asphalt shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 1. The temperature requirements may be waived by the Contracting Officer, if requested; however, all other requirements, including compaction, shall be met.

Table 1. Surface Temperature Limitations of Underlying Course

Mat Thickness, mm	Degrees C
75 or greater	4
Less than 75	7

PART 2 PRODUCTS

2.1 BITUMINOUS HOT MIX

Shall consist of coarse aggregate, fine aggregate, mineral filler, bituminous material, and approved additives, if required, of the qualities and in the proportions specified and shall conform to the requirements contained in paragraphs PROPORTIONING OF MIXTURE and ACCEPTABILITY OF WORK.

2.1.1 Aggregates

Aggregates shall consist of crushed stone, crushed gravel, crushed slag, screening, sand, and mineral filler, as required. The portion of materials retained on the 4.75 mm (No. 4) sieve shall be known as coarse aggregate, the portion passing the 4.75 mm (No. 4) sieve and retained on the 0.075 millimeter (No. 200) sieve as fine aggregate, and the portion passing the 0.075 millimeter (No. 200) sieve as mineral filler. Aggregate gradation shall conform to gradation(s) specified in KS F 2349 or in Table 6.4 of Standard Specification for Road and High way, published by the Korean Ministry of Construction The characteristics of the aggregates shall conform to the KS F 2357 and KS F 2358, the percentage passing various sieves may be changed by the Contracting Officer when aggregates of varying specific gravities are used. Adjustments of percentage passing various sieves may be changed by the Contracting Officer when aggregates vary by more than 0.25 in modulus of aggregate from the specified.

2.1.1.1 Coarse Aggregate

Coarse aggregate shall consist of clean, sound, durable particles meeting the following requirements.

a. Percentage of loss shall not exceed 35 as determined in accordance with KS F 2508.

b. Percentage of loss shall not exceed 12 after five cycles performed in accordance with KS F 2507, using Sodium Sulfate (Na_2SO_4).

c. The specific gravity of the crushed slag shall not be less than 2.6 and water content should be not more than 1.0 % or the dry weight of crushed slag shall not be less than 1200 kg/cubic meter (75 pcf), as determined in accordance with ASTM C 29.

d. Crushed gravel retained on the 4.75 mm (No. 4) sieve and each coarser sieve shall contain at least 75 percent by weight of crushed pieces having one or more fractured faces with the area of each face equal to at least 75 percent of the smallest midsectional area of piece. When two fractures are contiguous, the angle between planes of fractures shall be at least 30 degrees to count as two fractured faces.

e. Particle shape of crushed aggregates shall be essentially cubical. The quantity of flat and elongated particles in any sieve size shall not exceed 20 percent by weight, when determined in accordance with ASTM D 4791.

f. Percentage of water absorption by the course aggregate shall not exceed 3.0 by the dry weight of the aggregate.

2.1.1.2 Fine Aggregate

Fine aggregate shall consist of clean, sound, durable particles including natural sand or crushed stone, slag, or gravel that meets requirements for wear and soundness specified for coarse aggregate. Fine aggregate produced by crushing gravel shall have at least 90 percent by weight of crushed particles having two or more fractured faces in the portion retained on the 0.600 millimeter (No. 30) sieve. This requirement shall apply to the material before blending with natural sand when blending is necessary. Quantity of natural sand to be added to the wearing- and intermediate-course mixtures shall not exceed 25 percent by weight of coarse and fine aggregate and material passing the 0.075 millimeter (No. 200 sieve). Natural sand shall be clean and free from clay and organic matter. Percentage of loss shall not exceed 15 after five cycles of the soundness test performed in accordance with ASTM C 88, using magnesium sulfate or the percentage of the loss shall not exceed 12 by weight, determined in accordance with KS F 2507, using Sodium Sulfate (Na_2SO_4).

2.1.1.3 Mineral Filler

Mineral filler shall conform to ASTM D 242.

Grain size in mm	Percent Finer
0.05	70-100
0.02	35-65
0.005	10-22

Grain size shall be determined in accordance with ASTM D 422.

2.1.2 Bituminous Material

Asphalt cement shall conform to KS M 2208, Class 1, Grade AC 10 or AC 20, or KS M 2201, penetration grade AC 60~70 or AC 85~100 or ASTM D 3381, Grade AC10 or 20.

2.1.3 Additives

The use of additives such as antistripping and antifoaming agents is subject to approval.

2.2 PROPORTIONING OF MIXTURE

2.2.1 Job Mix Formula

The contractor shall furnish the contracting officer the JMF for the bituminous mixture to get an approval from the contracting officer. The JMF shall be delivered from the sample test result which showed the best result for the pavement. Blending of the aggregates will be accomplished by the contractor. No payment will be made for mixtures JMF. The formula will indicate the percentage of each stockpile and mineral filler, the percentage of each size aggregate, the percentage of bitumen, and the temperature of the completed mixture when discharged from the mixer. Tolerances are given in TABLE II for asphalt content, temperature, and aggregate grading for tests conducted on the mix as discharged from the mixing plant; however, the final evaluation of aggregate gradation and asphalt content will be based on paragraph ACCEPTABILITY OF WORK. Bituminous mix that deviates more than 14 degrees C (25 degrees F) from the JMF shall be rejected. The JMF may be adjusted during construction to improve paving mixtures, as directed, without adjustments in the contract unit prices.

TABLE II. JOB-MIX TOLERANCES

Material	Tolerance, Plus or Minus
Aggregate passing 4.75 mm sieve or larger	3 percent

Aggregate passing 2.36, 1.18, 0.6, and 0.3 mm sieves	3 percent
Aggregate passing 150 and 75 micrometer sieves	1 percent
Binder content	0.4 percent
Temperature of mixing	14 degrees C

2.2.2 Test Properties of Bituminous Mixtures

Finished mixture shall meet requirements described below when tested in accordance with ASTM D 3515 or KS F 2349, 50 blow mix. All samples will be compacted with 50 blows of specified hammer on each side of sample. When bituminous mixture fails to meet the requirements specified below, the paving operation shall be stopped until the cause of noncompliance is determined and corrected.

2.2.2.1 Stability, Flow, and Voids

Requirements for stability, flow, and voids are shown in TABLES III and IV for non-absorptive and absorptive aggregates, respectively.

TABLE III. Marshall Design Criteria

	Wearing Course	Intermediate Course
Stability minimum, newtons	2200	2200
Flow, 25/100-millimeter units	8-18	20
Voids total mix, percent (1)	3-5	4-6
Voids filled with bitumen, percent (2)	75-85	65-75

(1) The Contracting Officer may permit deviations from limits specified when gyratory method of design is used to develop the JMF.

(2) The Contracting Officer may permit deviation from limits specified for voids filled with bitumen in the intermediate course in order to stay within limits for percent voids total mix.

PART 3 EXECUTION

3.1 BASE COURSE CONDITIONING

The surface of the base course will be inspected for adequate compaction and surface tolerances specified in Section 02722: Aggregate Base Course. Unsatisfactory areas shall be corrected.

3.2 EXISTING PAVEMENT CONDITIONING

3.3 PREPARATION OF BITUMINOUS MIXTURES

Rates of feed of aggregates shall be regulated so that the moisture content and temperature of aggregates will be within specified tolerances. Aggregates, mineral filler, and bitumen shall be conveyed into the mixer in proportionate quantities required to meet the JMF. Mixing time shall be as required to obtain a uniform coating of the aggregate with the bituminous material. Temperature of bitumen at time of mixing shall not exceed 150 degrees C. (300 degrees F). Temperature of aggregate and mineral filler in the mixer shall not exceed 160 degrees C (325 degrees F) when bitumen is added. Overheated and carbonized mixtures or mixtures that foam shall not be used.

3.4 WATER CONTENT OF AGGREGATES

Drying operations shall reduce the water content of mixture to less than 0.75 percent. The water content test will be conducted in accordance with ASTM D 2216; the weight of the sample shall be at least 500 grams. If the water content is determined on hot bin samples, the water content will be a weighted average based on composition of blend.

3.5 STORAGE OF BITUMINOUS PAVING MIXTURE

Storage shall conform to the applicable requirements of ASTM D 3515; however, in no case shall the mixture be stored for more than 3 hours.

3.6 TRANSPORTATION OF BITUMINOUS MIXTURE

Trucks used for hauling hot-mix asphalt shall have tight, clean, smooth metal beds lightly coated with minimum amount of paraffin oil, lime solution or other approved material. Petroleum based products shall not be used as a release agent. Excessive releasing agent shall be drained prior to loading. Each load shall be covered with canvas or other approved material of ample size to protect mixture from weather and to prevent loss of heat. Loads that have crusts of cold, unworkable material or that have become wet will be rejected. Hauling over freshly placed material will not be permitted.

3.7 SURFACE PREPARATION OF UNDERLYING COURSE

Immediately before placing the hot mix asphalt, the underlying course shall be cleaned of all foreign or objectionable matter with power brooms and hand brooms.

3.8 PRIME COATING

Surfaces of previously constructed base course shall be sprayed with a coat of bituminous material conforming to Section 02558: BITUMINOUS TACK COAT/PRIME COAT.

3.9 TACK COATING

Contact surfaces of previously constructed pavement, curbs, manholes, and other structures shall be sprayed with a thin coat of bituminous material conforming to Section 02558: BITUMINOUS TACK COAT.

3.10 PLACING

Bituminous courses shall be constructed only when the base course or existing pavement has no free water on the surface. Bituminous mixtures shall not be placed without ample time to complete spreading and rolling during daylight hours, unless approved satisfactory artificial lighting is provided.

3.10.1 Offsetting Joints

The wearing course shall be placed so that longitudinal joint of the wearing course will be offset from joints in the intermediate course by at least 300 mm (1 foot). Transverse joints in the wearing course shall be offset by at least 600 mm (2 feet) from transverse joints in the intermediate course.

3.10.2 General Requirements for Use of Mechanical Spreader

Range of temperatures of mixtures, when dumped into the mechanical spreader, shall be as determined by the Contracting Officer. Mixtures having temperatures less than 110 degrees C (225 degrees F) when dumped into the mechanical spreader shall not be used. The mechanical spreader shall be adjusted and the speed regulated so that the surface of the course being laid will be smooth and continuous without tears and pulls, and of such depth that, when compacted, the surface will conform to the cross section indicated. Placing with respect to center line areas with crowned sections or high side of areas with one-way slope shall be as directed. Each lot of material placed shall conform to requirements specified in paragraph ACCEPTABILITY OF WORK. Placing of the mixture shall be as nearly continuous as possible and speed of placing shall be adjusted, as directed, to permit proper rolling. When segregation occurs in the mixture during placing, the spreading operation shall be suspended until the cause is determined and corrected.

3.10.3 Placing Strips Succeeding Initial Strips

In placing each succeeding strip after initial strip has been spread and compacted as specified below, the screed of the mechanical spreader shall overlap the previously placed strip 50 to 75 mm (2 to 3 inches) and be sufficiently high so that compaction produces a smooth dense joint. Mixture placed on the edge of a previously placed strip by the mechanical spreader shall be pushed back to the edge of the strip by use of a lute. Excess mixture shall be removed and wasted.

3.10.4 Hand spreading in Lieu of Machine Spreading

In areas where the use of machine spreading is impractical, the mixture shall be spread by hand. Spreading shall be in a manner to prevent segregation. The mixture shall be spread uniformly with hot rakes in a loose layer of thickness that, when compacted, will conform to required grade, density, and thickness.

3.11 COMPACTION OF MIXTURE

Rolling shall begin as soon after placing, as the mixture will bear a roller without undue displacement. Delays in rolling freshly spread mixture will not be permitted. After initial rolling, preliminary tests of crown, grade, and smoothness shall be made by the Contractor. Deficiencies shall be corrected so that the finished course will conform to requirements for grade and smoothness specified herein. Crown, grade, and smoothness will be checked in each lot of completed pavement by the Contracting Officer for compliance and will be evaluated as specified in paragraph ACCEPTABILITY OF WORK. After the Contractor is assured of meeting crown, grade, and smoothness requirements, rolling shall be continued until a mat density of 97.0 to 100.0 percent and a joint density of 95.0 to 100.0 percent of density of laboratory-compacted specimens of the same mixture is obtained. The density will be determined and evaluated as specified in paragraph ACCEPTABILITY OF WORK. Places inaccessible to rollers shall be thoroughly compacted with hot hand tampers.

3.11.1 Testing of Mixture

At the start of the plant operation, a quantity of mixture shall be prepared that is sufficient to construct a test section at least 15 m (50 feet) long, two spreader widths wide and of thickness to be used in the project. Mixture shall be placed, spread, and rolled with equipment to be used in the project and in accordance with the requirements specified above. This test section shall be tested and evaluated as a lot and shall conform to all specified requirements. If test results are satisfactory, the test section shall remain in place as part of the completed pavement. If tests indicate that the pavement does not conform to specification requirements, necessary adjustments to plant operations and rolling procedures shall be made immediately, and test section will be evaluated as specified in paragraph ACCEPTABILITY OF WORK. Additional test sections, as directed, shall be constructed and sampled for conformance to specification requirements. In no case shall the Contractor start full production of an intermediate or wearing course mixture without approval.

3.11.2 Correcting Deficient Areas

Mixtures that become contaminated or are defective shall be removed to the full thickness of the course. Edges of the area to be removed shall be cut so that sides are perpendicular and parallel to the direction of traffic and so that the edges are vertical. Edges shall be sprayed with bituminous materials conforming to Section 02558: BITUMINOUS TACK COAT. Fresh paving mixture shall be placed in the excavated areas in sufficient quantity so that the finished surface will conform to grade and smoothness requirements. Paving mixture shall be compacted to the density specified herein. Skin patching of an area that has been rolled shall not be permitted.

3.12 JOINTS

3.12.1 General

Joints between old and new pavements, between successive work days, or joints that have become cold less than 80 degrees C (175 degrees F) shall be made to insure continuous bond between the old and new sections of the course. All joints shall have the same texture and smoothness as other sections of the course. Contact surfaces of previously constructed pavements coated by dust, sand, or other objectionable material shall be cleaned by brushing or shall be cut back as directed. When directed by the Contracting Officer, the surface against which new material is placed shall be sprayed with a thin, uniform coat of bituminous material conforming to Section 02558: BITUMINOUS TACK COAT. Material shall be applied far enough in advance of placement of a fresh mixture to insure adequate curing. Care shall be taken to prevent damage or contamination of the sprayed surface.

3.12.2 Transverse Joints

The roller shall pass over the unprotected end of a strip of freshly placed material only when placing is discontinued or delivery of the mixture is interrupted to the extent that the material in place may become cold. In all cases, prior to continuing placement, the edge of previously placed pavement shall be cut back to expose an even vertical surface for full thickness of the course. In continuing placement of a strip, the mechanical spreader shall be positioned on the transverse joint so that sufficient hot mixture will be spread to obtain a joint after rolling that conforms to the required density and smoothness specified herein.

3.12.3 Longitudinal Joints

Edges of a previously placed strip shall be prepared such that the pavement in and immediately adjacent to the joint between this strip and the succeeding strip meets the requirements for grade, smoothness, and density specified in paragraph ACCEPTABILITY OF WORK.

3.13 ACCEPTABILITY OF WORK

3.13.1 General

A lot shall be that quantity of construction that will be evaluated for compliance with specification requirements. A lot shall be equal to 12 hours of production. The Government will conduct all initial acceptance tests. Additional tests required to determine acceptability of nonconforming material will be preformed by the Government at the expense of the Contractor.

3.13.1.1 Lot Evaluation

In order to evaluate aggregate gradation, asphalt content, and density, each lot shall be divided into four equal sublots. For density determination, one random sample shall be taken from the mat, and one random sample shall be taken from the joint of each sublot. A coring machine will be used for taking mat and joint samples from the completed pavement. Core samples will be taken with the coring machine centered over the joint. After air drying to a constant weight, random samples obtained from the mat shall be used for density determination in accordance with ASTM D 2041. Samples for determining asphalt content and aggregate gradation shall be taken from loaded trucks within each sublot. Asphalt content shall be determined in accordance with ASTM D 2172, Method A or B. Aggregate gradation shall be determined for the mix by testing the recovered aggregate in accordance with ASTM C 136 and ASTM C 117.

3.13.1.2 Lot Failure

When a lot of material fails to meet the specification requirements, that lot shall be removed and replaced or accepted at a reduced price. The lowest percent payment for any pavement characteristic (i.e., gradation, asphalt content, density, grade, and smoothness) defined below shall be the percent payment for that lot. The percent payment is based on the pavement characteristics and the contract unit price.

3.13.1.3 Optional Sampling and Testing

The Contracting Officer reserves the right to sample and test any area which appears to deviate from the specification requirements. Testing in these areas will be in addition to the lot testing, and the requirements for these areas will be the same as those for a lot.

3.13.2 Aggregate Gradation

The mean absolute deviation of the four sublot aggregate gradations from the JMF for each sieve size will be evaluated and compared with TABLE V. The percent payment based on aggregate gradation shall be the lowest value determined for any sieve size in TABLE V. All tests for aggregate gradation will be completed and reported within 24 hours after completion of construction of each lot. The computation of mean absolute deviation for one sieve size is illustrated below:

Example: Assume the following JMF and sublot test results for aggregate gradation

		Percent by Weight Passing Sieves			
Sieve Size	JMF	Test No. 1	Test No. 2	Test No. 3	Test No. 4
19 mm	100	100	100	100	100
12.5 mm	88	87	88	90	88
9.5 mm	75	72	77	78	74
4.75 mm	64	60	65	67	62
2.36 mm	53	50	56	57	52
1.18 mm	42	39	44	45	41
0.600 mm	32	30	34	35	32
0.300 mm	20	17	20	22	21
0.150 mm	10	8	10	10	11
0.075 mm	6	4	7	8	6

Mean Absolute Deviation (for 75 micrometer No. 200 sieve) = ((Absolute value of 4-6) + (Absolute value of 7-6) + (Absolute value of 8-6) + (Absolute value of 6-6))/4 = (2 + 1 + 2 + 0)/4 = 1.25

The mean absolute deviation for other sieve sizes can be determined in a similar way for this example to be:

Sieve Size	19 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	0.600 mm	0.300 mm	0.075 mm
Mean Absolute Deviation	0	0.75	2.25	2.50	2.75	2.25	1.75	1.50	0.75

The least percent payment based on any sieve size listed in TABLE V would be 98 percent for the 75 micrometer (No. 200 sieve). Therefore for this example the percent payment based on aggregate gradation is 98 percent.

TABLE V. PERCENT PAYMENT BASED ON MEAN ABSOLUTE DEVIATION OF AGGREGATE GRADATIONS FROM JMF

Sieve Percent Payment Based On Mean Absolute Deviation from JMF

Size	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	Above 6.0
19 mm	100	100	100	100	98	95	90
12.5 mm	100	100	100	100	98	95	90
9.5 mm	100	100	100	100	98	95	90
4.75 mm	100	100	100	100	98	95	90
2.36 mm	100	100	100	98	95	90	reject
1.18 mm	100	100	100	98	95	90	reject
0.600 mm	100	100	100	98	95	90	reject
0.300 mm	100	100	100	98	95	90	reject
0.150 mm	100	98	95	90	90	reject	reject
0.075 mm	100	98	90	reject	reject	reject	reject

3.13.3 Asphalt Content

The mean absolute deviation of the four asphalt contents from the JMF will be evaluated and compared with TABLE VI. The percent payment based on asphalt content shall be the value determined in TABLE VI. Asphalt content tests shall be completed and reported within 24 hours after construction of the lot.

TABLE VI. PERCENT PAYMENT BASED ON ASPHALT CONTENT

Mean Absolute Deviation of Extracted Asphalt Content from JMF	Percent Payment
less than 0.25	100
0.25-0.30	98
0.31-0.35	95
0.36-0.40	90
above 0.40	reject

3.13.4 Density

The average mat and joint densities will be expressed as a percentage of the laboratory density. The laboratory density for each lot will be determined in accordance with CEMP ET method from four sets of laboratory samples. One sample will be obtained from each of the four sublots and will be divided into three specimens to produce one set of laboratory samples. Laboratory samples will be prepared from asphalt mixture which has not been reheated. Samples will be compacted at 121.1 degrees C (250 degrees F) within 2 hours of the time the mixture was prepared at the asphalt plant. Laboratory samples will be prepared in accordance with CEMP ET method.

3.13.4.1 Field Density

The field density will be determined and compared with TABLE VII. The percent payment based on density shall be the lowest value determined from TABLE VII. The percent payment based on mat density will be for all of the material placed in the lot. The percent payment based on joint density will be for the amount of material represented by an area equal to the lot joint length by 3 m (10 feet) wide not to exceed the lot size.

TABLE VII. PERCENT PAYMENT BASED ON DENSITY

Average Mat Density	Percent	Average Joint Density

(4 Cores)	Payment	(4 Cores)
97.0-100.0	100.0	95.0-100.0
96.9	100.0	94.9
96.8-100.1	99.9	94.8
96.7	99.8	94.7
96.6-100.2	99.6	94.6
96.5	99.4	94.5
96.4-100.3	99.1	94.4
96.3	98.7	94.3

TABLE VII. PERCENT PAYMENT BASED ON DENSITY

Average Mat Density (4 Cores)	Percent Payment	Average Joint Density (4 Cores)
96.2-100.4	98.3	94.2
96.1	97.8	94.1
96.0-100.5	97.3	94.0
95.9	96.3	93.9
95.8-100.6	94.1	93.8
95.7	92.2	93.7
95.6-100.7	90.3	93.6
95.5	87.9	93.5
95.4-100.8	85.7	93.4
95.3	83.3	93.3
95.2-100.9	80.6	93.2
95.1	78.0	93.1
95.0-101.0	75.0	93.0
below 95.0, above 101.0	reject	below 93.0

3.13.4.2 Lot Density

All density results on a lot will be completed and reported within 24 hours after construction of that lot. When the Contracting Officer considers it necessary to take additional samples for density measurements, samples will be taken in groups of four (one for each sublot). The percent payment will be determined for each additional group of four samples and averaged with the percent payment for the original group to determine the final percent payment. The Contractor shall fill all sample holes with hot mix and compact.

3.13.5 Grade

Grade-conformance tests will be conducted by the Government. The finished surface of the pavement will be tested for conformance with plan-grade requirements. Within 5 working days after completion of placement of a particular lot, the Contracting Officer will inform the Contractor in writing of results of grade-conformance tests. The finished grade of each pavement area shall be determined by running lines of levels at intervals of 8 m (25 feet) or less longitudinally and transversely to determine the elevation of the completed pavement. When more than 5 percent of all measurements made within a lot are outside the tolerances specified in paragraph GRADE AND SURFACE-SMOOTHNESS REQUIREMENTS, the payment for that lot will not exceed 95 percent of the bid price. In areas where the grade exceeds the plan-grade tolerances given in paragraph GRADE AND SURFACE-SMOOTHNESS REQUIREMENTS by more than 50 percent, the Contractor shall remove the deficient area and replace with fresh paving mixture at no additional cost to the Government. Sufficient material shall be removed to allow at least 1 inch of asphalt concrete to be placed. Skin patching for correcting low areas or planing for correcting high areas shall not be permitted.

3.13.6 Surface Smoothness

After completion of final rolling of a lot, the compacted surface will be tested by the Contracting Officer with a 3.66 m (12-foot) straightedge. Measurements will be made perpendicular to and across all mats at distances along the mat not to exceed 8 m.(25 feet.) Location and deviation from straightedge of all measurements will be recorded. When more than 5 percent of all measurements along the mat within a lot exceed the specified tolerance, the unit price for that lot shall not exceed 95 percent of the bid price. Any joint or mat area surface deviation which exceeds the tolerance given in paragraph GRADE AND SURFACE-SMOOTHNESS REQUIREMENTS by more than 50 percent shall be corrected to meet the specification requirements. The Contractor shall remove the deficient area and replace with fresh paving mixture at no additional cost to the Government. Sufficient material shall be removed to allow at least 25 mm (1 inch) of asphalt concrete to be placed. Skin patching for correcting low areas or planing for correcting high areas shall not be permitted.

SECTION 02558

BITUMINOUS TACK AND PRIME COATS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 20 (1970; R 1996) Penetration Graded Asphalt Cement

AASHTO M 81 (1992; R 1996) Cut-Back Asphalt (Rapid-Curing Type)

AASHTO M 82 (1975; R 1996) Cut-Back Asphalt (Medium-Curing Type)

AASHTO M 226 (1980; R 1996) Viscosity Graded Asphalt Cement

AASHTO T 40 (1978; R 1996) Sampling Bituminous Materials

AMERICAN SOCIETY OF TESTING AND MATERIALS (ASTM)

ASTM D 140 (2000) Sampling Bituminous Materials

ASTM D 946 (1982; R 1999) Penetration-Graded Asphalt Cement for Use in Pavement Construction

ASTM D 977 (1998) Emulsified Asphalt

ASTM D 1250	(1980; R 1997e1) Petroleum Measurement Tables
ASTM D 2026	(1972; R 1997) Cutback Asphalt (Slow-Curing Type)
ASTM D 2027	(1976; R 1997) Cutback Asphalt (Medium-Curing Type)
ASTM D 2028	(1976; R 1997) Cutback Asphalt (Rapid-Curing Type)
ASTM D 2397	(1998) Cationic Emulsified Asphalt
ASTM D 2995	(1999) Determining Application Rate of Bituminous Distributors
ASTM D 3381	(1992; R 1999) Viscosity-Graded Asphalt Cement for Use in Pavement Construction

KOREAN INDUSTRIAL STANDARD (KS):

KS M 2202	(1999) Cut Back Asphalt
KS M 2203	(1998) Emulsified Asphalt

1.2 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES.

SD-09 Reports

Tests; FIO.

Copies of all test results for bituminous materials, within 24 hours of completion of tests. Certified copies of the manufacturer's test reports indicating compliance with applicable specified requirements, not less than 30 days before the material is required in the work.

SD-18 Records

Waybills and Delivery Tickets; FIO.

Waybills and delivery tickets, during progress of the work.

1.3 PLANT, EQUIPMENT, MACHINES AND TOOLS

1.3.1 General Requirements

Plant, equipment, machines and tools used in the work shall be subject to approval and shall be maintained in a satisfactory working condition at all times.

1.3.2 Bituminous Distributor

The distributor shall have pneumatic tires of such size and number to prevent rutting, shoving or otherwise damaging the base surface or other layers in the pavement structure. The distributor shall be designed and equipped to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled rates with an allowable variation from the specified rate of not more than plus or minus 5 percent, and at variable widths. Distributor equipment shall include a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. The distributor shall be equipped to circulate and agitate the bituminous material during the heating process.

1.3.3 Power Brooms and Power Blowers

Power brooms and power blowers shall be suitable for cleaning the surfaces to which the bituminous coat is to be applied.

1.4 WEATHER LIMITATIONS

Bituminous coat shall be applied only when the surface to receive the bituminous coat is dry. Bituminous coat shall be applied only when the atmospheric temperature in the shade is 10 degrees C (50 degrees F). For above and when the temperature has not been below 2 degrees C (35 degrees F) for the 12 hours prior to application.

PART 2 PRODUCTS

2.1 TACK COAT

Cutback asphalt, Asphalt, or Emulsified asphalt shall conform to ASTM D 2028, ASTM D 946, ASTM D 3381, ASTM D 977, ASTM D 2397 or AASHTO M 81 AASHTO M 20, or KS M 2202 RC-0, RC-1 or KS M 2203 RS (c)-4

2.2 PRIME COAT

Cutback asphalt, or Emulsified asphalt shall conform to ASTM D 977, ASTM D 2026, ASTM D 2027, ASTM D 2028, ASTM D 2397 or AASHTO M 81 or KS M 2202 MC-0, MC-1, MC-2, or KS M 2203 RS (c)-3

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Immediately before applying the bituminous coat, all loose material, dirt, clay, or other objectionable material shall be removed from the surface to be treated. The surface shall be dry and clean at the time of treatment.

3.2 APPLICATION RATE

The exact quantities within the range specified, which may be varied to suit field conditions, will be determined by the Contracting Officer.

3.2.1 Tack Coat

Bituminous material for the tack coat shall be applied in quantities of not less than 0.20 liter (0.05 gallon) nor more than 0.70 liter per square meter (0.15 gallon per square yard) of pavement surface.

3.2.2 Prime Coat

Bituminous material for the prime coat shall be applied in quantities of not less than 0.70 liter 0.15 gallon nor more than 1.80 liters per square meter 0.40 gallon per square yard of pavement surface.

3.3 APPLICATION TEMPERATURE

3.3.1 Viscosity Relationship

Asphalt application temperature shall provide an application viscosity between 10 and 60 seconds, Saybolt Furol, or between 20 and 120 square mm/sec, 20 and 120 centistokes, kinematic. The temperature viscosity relation shall be furnished to the Contracting Officer.

3.3.2 Temperature Ranges

The viscosity requirements shall determine the application temperature to be used. The following is a normal range of application temperatures:

Liquid Asphalts

SC-250	75-132 degrees C
MC-1	40-80 degrees C
MC-2	40-90 degrees C
MC-30	29-87 degrees C
MC-70	50-107 degrees C
MC-250	75-132 degrees C
RC-0	25-60 degrees C
RC-1	30-70 degrees C
RC-70	50-90 degrees C*
RC-250	75-12 degrees C*

Paving Grade Asphalts

Penetration Grades

200-300	plus 130 degrees C
120-150	plus 132 degrees C
85-100	plus 137 degrees C

Viscosity Grades

AC 2.5	plus 132 degrees C
AC 5	plus 137 degrees C
AC 10	plus 137 degrees C
AR 1000	plus 135 degrees C
AR 2000	plus 140 degrees C
AR 4000	plus 143 degrees C

Emulsions

RS-1	20-60 degrees C
RS(C)-3	directed by the COR if needed
RS(C)-4	directed by the COR if needed
MS-1	20-70 degrees C
HFMS-1	20-70 degrees C
SS-1	20-70 degrees C
SS-1h	20-70 degrees C
CRS-1	52-85 degrees C
CSS-1	20-70 degrees C
CSS-1h	20-70 degrees C

*These temperature ranges exceed the flash point of the material and care should be taken in their heating.

3.4 APPLICATION

Following preparation and subsequent inspection of the surface, the bituminous coat shall be applied at the specified rate with uniform distribution over the surface to be treated. All areas and spots missed by the distributor shall be properly treated with the hand spray. Until the succeeding layer of pavement is placed, the surface shall be maintained by protecting the surface against damage and by repairing deficient areas at no additional cost to the Government. If required, clean dry sand shall be spread to effectively blot up any excess bituminous material. No smoking, fires, or flames other than those from the heaters that are a part of the equipment shall be permitted within 8 meters 25 feet of heating, distributing, and transferring operations of bituminous material other than bituminous emulsions. All traffic, except for paving equipment used in constructing the surfacing, shall be prevented from using the underlying material, whether primed or not, until the surfacing is completed. The bituminous coat shall conform to all requirements as described herein. To obtain uniform application of the prime coat on the surface treated at the junction of previous and subsequent applications, building paper shall be spread on the surface for a sufficient distance back from the ends of each application to start and stop the prime coat on the paper. Immediately after application, the building paper shall be removed and destroyed.

3.5 CURING PERIOD

Following application of the bituminous material and prior to application of the succeeding layer of pavement, the bituminous coat shall be allowed to cure and to obtain evaporation of any volatile or moisture. Prime coat shall be allowed to cure without being disturbed for a period of at least 48 hours or longer, as may be necessary to attain penetration into the treated course.

3.6 FIELD QUALITY CONTROL

Minimum one core samples of the bituminous pavement shall be taken and tested thickness and density of the pavement for compliance with the applicable specified requirements. A sample shall be obtained and tested by the Contractor for every 500 meters of each lanes or 1500 square meters of the pavement. The holes drilled by the core should be filled properly with the same materials. The sample may be retained and tested by the Government at no cost to the Contractor.

3.7 SAMPLING AND TESTING

Sampling and testing shall be performed by an approved commercial testing laboratory or by facilities furnished by the Contractor. No work requiring testing will be permitted until the facilities have been inspected and approved.

3.7.1 Sampling

The samples of bituminous material, unless otherwise specified, shall be in accordance with ASTM D 140 or AASHTO T 40. Sources from which bituminous materials are to be obtained shall be selected and notification thereof furnished the Contracting Officer within 15 days after the award of the contract.

3.7.2 Calibration Test

The Contractor shall furnish all equipment, materials, and labor necessary to calibrate the bituminous distributor. Calibration shall be made with the approved job material and prior to applying the bituminous coat material to the prepared surface. Calibration of the bituminous distributor shall be in accordance with ASTM D 2995.

3.7.3 Trial Applications

Before providing the complete bituminous coat, three lengths of at least 30 meters (100 feet) for the full width of the distributor bar shall be applied to evaluate the amount of bituminous material that can be satisfactorily applied.

3.7.3.1 Tack Coat Trial Application Rate

Unless otherwise authorized, the trial application rate of bituminous tack coat materials shall be applied in the amount of 0.20 liters per square meter (0.05 gallons per square yard). Other trial applications shall be made using various amounts of material as may be deemed necessary.

3.7.3.2 Prime Coat Trial Application Rate

Unless otherwise authorized, the trial application rate of bituminous materials shall be applied in the amount of 1.10 liters per square meter (0.25 gallon per square yard). Other trial applications shall be made using various amounts of material as may be deemed necessary.

3.7.4 Sampling and Testing During Construction

Quality control sampling and testing shall be performed as required in paragraph FIELD QUALITY CONTROL.

SECTION 02580

PAVEMENT MARKINGS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 247 (1981; R1996) Glass Beads Used in Traffic Paint

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 792 (1998) Density and Specific Gravity Relative Density of Plastics by Displacement

ASTM D 4280 (1996) Extended Life Type, Non-plowable, Prismatic, Raised, Retro-reflective Pavement Markers

ASTM D 4505 (1996) Preformed Plastic Pavement Marking Tape for Extended Service Life

ASTM E 28 (1999) Softening Point by Ring-and-Ball Apparatus

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-B-1325	(Rev C; Notice 1; Canc. Notice 2) Beads (Glass Spheres) Retro-Reflective (Metric)
FS TT-P-1952	(Rev D; Canc. Notice 1) Paint, Traffic and Airfield Marking, Waterborne (Metric)

KOREAN INDUSTRIAL STANDARD (KS)

KS M 5333	(1995) HOT MELT TYPE TRAFFIC PAINTS

1.2 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section: 01330 SUBMITTALPROCEDURES.

SD-01 Data

Equipment; GA.

Lists of proposed equipment to be used in performance of construction work, including descriptive data, and notifications of proposed Contractor actions as specified in this section. List of removal equipment shall include descriptive data indicating area of coverage per pass, pressure adjustment range, tank and flow capacities, and safety precautions required for the equipment operation.

SD-06 Instructions

Composition Requirements; GA.

Manufacturer's current printed product description and Material Safety Data Sheets (MSDS) for each type paint/color proposed for use.

Qualifications; FIO

Document certifying that personnel are qualified for equipment operation and handling of chemicals.

SD-09 Reports

Sampling and Testing; FIO.

Certified copies of the test reports, prior to the use of the materials at the job site. Testing shall be performed in an approved independent laboratory.

SD-13 Certificates

Volatile Organic Compound (VOC) Content; FIO.

Certificate stating that the proposed pavement marking paint meets the VOC regulations of the local Air Pollution Control District having jurisdiction over the geographical area in which the project is located.

1.3 DELIVERY AND STORAGE

All materials shall be delivered and stored in sealed containers that plainly show the designated name, formula or specification number, batch number, color, date of manufacture, manufacturer's name, and directions, all of which shall be plainly legible at time of use.

1.4 EQUIPMENT

All machines, tools and equipment used in the performance of the work shall be approved and maintained in satisfactory operating condition. Equipment operating on roads and runways will display low speed traffic markings and traffic warning lights.

1.4.1 Paint Application Equipment

The equipment to apply paint to pavements shall be a self-propelled or mobile-drawn pneumatic spraying machine with suitable arrangements of atomizing nozzles and controls to obtain the specified results. The machine shall have a speed during application not less than 8 kilometers per hour (5 mph), and shall be capable of applying the stripe widths indicated, at the paint coverage rate specified in paragraph APPLICATION, and of even uniform thickness with clear-cut edges. Equipment used for marking streets and highways shall be capable of placing the prescribed number of lines at a single pass as solid lines, intermittent lines or a combination of solid and intermittent lines using a maximum of two different colors of paint as specified. The equipment used to apply the paint binder to airfield pavements shall be a self-propelled or mobile-drawn pneumatic spraying machine with an arrangement of atomizing nozzles capable of applying a line width at any one time in multiples of 150 mm (6 inches), from 150 mm (6 inches) to 900 mm (36 inches). The paint applicator shall have paint reservoirs or tanks of sufficient capacity and suitable gauges to apply paint in accordance with requirements specified. Tanks shall be equipped with suitable air-driven mechanical agitators. The spray mechanism shall be equipped with quick-action valves conveniently located, and shall include necessary pressure regulators and gauges in full view and reach of the operator. Paint strainers shall be installed in paint supply lines to insure freedom from residue and foreign matter that may cause malfunction of the spray guns. The paint applicator shall be readily adaptable for attachment of an air-actuated dispenser for the reflective media approved for use. Pneumatic spray guns shall be provided for hand application of paint in areas where the mobile paint applicator cannot be used.

1.4.2 Thermoplastic Application Equipment

1.4.2.1 Thermoplastic Material

Thermoplastic material shall be applied to the primed pavement surface by spray techniques or by the extrusion method, wherein one side of the shaping die is the pavement and the other three sides are contained by, or are part of, suitable equipment for heating and controlling the flow of material. By either method, the markings shall be applied with equipment that is capable of providing continuous uniformity in the dimensions of the stripe.

1.4.2.2 Application Equipment

Application equipment shall provide continuous mixing and agitation of the material. Conveying parts of the equipment between the main material reservoir and the extrusion shoe or spray gun shall prevent accumulation and clogging. All parts of the equipment which come into contact with the material shall be easily accessible and exposable for cleaning and maintenance. All mixing and conveying parts up to and including the extrusion shoes and spray guns shall maintain the material at the required temperature with heat-transfer oil or electrical-element-controlled heat. The application equipment shall be so constructed as to ensure continuous uniformity in the dimensions of the stripe. The applicator shall provide a means for cleanly cutting off stripe ends squarely and shall provide a method of applying "skiplines." The equipment shall be capable of applying varying widths of traffic markings. The applicator shall be equipped with a drop-on type bead dispenser capable of uniformly dispensing reflective glass spheres at controlled rates of flow. The bead dispenser shall be automatically operated and shall begin flow prior to the flow of composition to assure that the strip is fully reflectorized.

1.4.2.3 Mobile and Maneuverable

Application equipment shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc. The equipment used for the placement of thermoplastic pavement markings shall be of two general types: mobile applicator and portable applicator.

a. Mobile Application Equipment: The mobile applicator shall be defined as a truck-mounted, self-contained pavement marking machine that is capable of hot applying thermoplastic by either the extrusion or spray method. The unit shall be equipped to apply the thermoplastic marking material at temperatures exceeding 190 degrees C (375 degrees F), at widths varying from 75 to 300 mm (3 to 12 inches) and in thickness varying from 1.0 to 5.0 mm (0.020 to 0.190 inch) shall have an automatic drop-on bead system. The mobile unit shall be capable of operating continuously and of installing a minimum of 6 kilometers (20,000 lineal feet) of longitudinal markings in a 8-hour day.

(1) The mobile unit shall be equipped with a melting kettle of such capacity as to hold a minimum of 2.7 metric tons (6000 pounds) of molten thermoplastic material. The kettle shall be capable of heating the thermoplastic composition to temperatures of 195 to 220 degrees C (375 to 425 degrees F). The heating mechanism shall be by means of a thermostatically controlled heat transfer liquid. Heating of the composition by direct flame shall not be allowed. Oil and material temperature gauges shall be visible at both ends of the kettle. The mobile unit shall be equipped with a minimum of two extrusion shoes located one on each side of the truck, and shall be capable of marking simultaneous edge line and centerline stripes. Each extrusion shoe shall be a closed, oil-jacketed unit; shall hold the molten thermoplastic at a temperature of 195 to 220 degrees C (375 to 425 degrees F); and shall be capable of extruding a line of 75 to 200 mm (3 to 8 inches) in width; and at a thickness of not less than 3 mm (0.125 inch) nor more than 5.0 mm (0.190 inch), and of generally uniform cross section. The mobile unit

shall be equipped with a spray gun system. The spray system shall consist of a minimum of four spray guns, located two on each side of the truck, and shall be capable of marking simultaneous edge line and centerline stripes. The spray system shall be surrounded (jacketed) with heating oil so as to maintain the molten thermoplastic at a temperature of 195 to 220 degrees C (375 to 425 degrees F); and shall be capable of spraying a stripe of 75 to 300 mm (3 to 12 inches) in width, and in thickness varying from 1.5 mm (0.055 inch) to 2.5 mm (0.095 inch), and of generally uniform cross section.

(2) The mobile unit shall be equipped with an electronic programmable line pattern control system. The control system shall be capable of applying skip or solid lines in any sequence, through any and all of the extrusion shoes, or the spray guns, and in programmable cycle lengths. In addition, the mobile unit shall be equipped with an automatic counting mechanism capable of recording the number of lineal meters (feet) of thermoplastic markings applied to the pavement surface with an accuracy of 0.5 percent.

b. Portable Application Equipment: The portable applicator shall be defined as hand-operated equipment, specifically designed for placing special markings such as crosswalks, stop bars, legends, arrows, and short lengths of lane, edge and centerlines. The portable applicator shall be capable of applying thermoplastic pavement markings by the extrusion method. It is intended that the portable applicator will be loaded with hot thermoplastic composition from the melting kettles on the mobile applicator. The portable applicator shall be equipped with all the necessary components, including a materials storage reservoir, bead dispenser, extrusion shoe, and heating accessories, so as to be capable of holding the molten thermoplastic at a temperature of 195 to 220 degrees C (375 to 425 degrees F), of extruding a line of 75 to 300 mm (3 to 12 inches) in width, and in thickness of not less than 3.0 mm (0.125 inch) nor more than 5.0 mm (0.190 inch) inch and of generally uniform cross section.

1.4.3 Reflective Media Dispenser

The dispenser for applying the reflective media shall be attached to the paint dispenser and operate automatically and simultaneously with the applicator through the same control mechanism. The dispenser shall be capable of adjustment and designed to provide uniform flow of reflective media over the full length and width of the stripe at the rate of coverage specified in paragraph APPLICATION at all operating speeds of the applicator to which it is attached.

1.4.4 Preformed Tape Application Equipment

Mechanical application equipment shall be used for the placement of preformed marking tape. Mechanical application equipment shall be defined as a mobile pavement marking machine specifically designed for use in applying precoated, pressure-sensitive pavement marking tape of varying widths, up to 300 mm (12 inches). The applicator shall be equipped with rollers, or other suitable compactive device, to provide initial adhesion of the preformed, pressure-sensitive marking tape with the pavement surface. Additional hand-operated rollers shall be used as required to properly seat the thermoplastic tape.

1.4.5 Surface Preparation Equipment

1.4.5.1 Sandblasting Equipment

Sandblasting equipment shall include an air compressor, hoses, and nozzles of proper size and capacity as required for cleaning surfaces to be painted. The compressor shall be capable of furnishing not less than 70.8 liters per sec (150 cfm) of air at a pressure of not less than 620 kPa (90 psi) at each nozzle used, and shall be equipped with traps that will maintain the compressed air free of oil and water.

1.4.5.2 Waterblast Equipment

The water pressure shall be specified at 17.9 MPa (2600 psi) at 60 degrees C (140 degrees F) in order to adequately clean the surfaces to be marked.

1.4.6 Traffic Controls

Suitable warning signs shall be placed near the beginning of the work site and well ahead of the work site for alerting approaching traffic from both directions. Small markers shall be placed along newly painted lines or freshly placed raised markers to control traffic and prevent damage to newly painted surfaces or displacement of raised pavement markers. Painting equipment shall be marked with large warning signs indicating slow-moving painting equipment in operation.

1.5 HAND-OPERATED, PUSH-TYPE MACHINES

All machines, tools, and equipment used in performance of the work shall be approved and maintained in satisfactory operating condition. Hand-operated push-type machines of a type commonly used for application of paint to pavement surfaces shall be acceptable for marking small streets and parking areas. Applicator machine shall be equipped with the necessary paint tanks and spraying nozzles, and shall be capable of applying paint uniformly at coverage specified. Sandblasting equipment shall be provided as required for cleaning surfaces to be painted. Hand-operated spray guns shall be provided for use in areas where push-type machines cannot be used.

1.6 MAINTENANCE OF TRAFFIC

1.6.1 Airfield

The performance of work in the controlled zones of airfields shall be coordinated with the Contracting Officer and with the Flight Operations Officer. Verbal communications shall be maintained with the control tower before and during work in the controlled zones of the airfield. The control tower shall be advised when the work is completed. A radio for this purpose will be provided by the Government or the Contractor and approved by the Contracting Officer.

1.6.2 Roads, Streets, and Parking Areas

When traffic must be rerouted or controlled to accomplish the work, the necessary warning signs, flagpersons, and related equipment for the safe passage of vehicles shall be provided.

1.7 WEATHER LIMITATIONS FOR REMOVAL

Pavement surface shall be free of snow, ice, or slush. Surface temperature shall be at least 5 degrees C 40 degrees F and rising at the beginning of operations, except those involving shot or sand blasting. Operation shall cease during thunderstorms. Operation shall cease during rainfall, except for waterblasting and removal of previously applied chemicals. Waterblasting shall cease where surface water accumulation alters the effectiveness of material removal.

PART 2 PRODUCTS

2.1 PAINT

The paint shall be homogeneous, easily stirred to smooth consistency, and shall show no hard settlement or other objectionable characteristics during a storage period of 6 months. Paints for airfields shall conform to AASHTO M 248, FS TT-P-1952, color as indicated. Paint for roads and streets shall conform to AASHTO M 248, or KS M 5333, color as indicated. Pavement marking paints shall comply with applicable state and local laws enacted to ensure compliance with Federal Clean Air Standards.Paint materials shall conform to the restrictions of the local Air Pollution Control District.

2.2 THERMOPLASTIC COMPOUNDS

The thermoplastic reflectorized pavement marking compound shall be extruded or sprayed in a molten state onto a primed pavement surface. Following a surface application of glass beads and upon cooling to normal pavement temperatures, the marking shall be an adherent reflectorized strip of the specified thickness and width that is capable of resisting deformation by traffic.

2.2.1 Composition Requirements

The binder component shall be formulated as a hydrocarbon resin. The pigment, beads and filler shall be uniformly dispersed in the binder resin. The thermoplastic composition shall be free from all skins, dirt, and foreign objects and shall comply with the following requirements:

	Percent by Weight	
Component	White	Yellow
Binder	17 min.	17 min.
Titanium dioxide	10 min.	-
Glass beads	20 min.	20 min.
Calcium carbonate & inert fillers	49 max.	*
Yellow pigments	-	*

*Amount and type of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, providing the other composition requirements of this specification are met.

2.2.2 Physical Properties

2.2.2.1 Color

The color shall be as indicated.

2.2.2.2 Drying Time

When installed at 20 degrees C (70 degrees F) and in thickness between 3 and 5 mm, (1/8 and 3/16 inch), the composition shall be completely solid and shall show no damaging effect from traffic after curing 15 minutes.

2.2.2.3 Softening Point

The composition shall have a softening point of not less than 90 degrees C (194 degrees F) when tested in accordance with ASTM E 28.

2.2.2.4 Specific Gravity

The specific gravity of the composition shall be between 1.9 and 2.2 as determined in accordance with ASTM D 792.

2.2.3 Asphalt Concrete Primer

The primer for asphalt concrete pavements shall be a thermosetting adhesive with a solids content of pigment reinforced synthetic rubber and synthetic plastic resin dissolved and/or dispersed in a volatile organic solvent. The solids content shall not be less than 10 percent by weight at 20 degrees C (70 degrees F) and 60 percent relative humidity. A wet film thickness of 0.10 mm (0.005 inch) plus or minus 0.025 mm (0.001 inch), shall dry to a tack-free condition in less than 5 minutes.

2.2.4 Portland Cement Concrete Primer

The primer for portland cement concrete pavements shall be an epoxy resin primer. The primer shall be of the type recommended by the manufacturer of the thermoplastic composition. Epoxy primers recommended by the manufacturer shall be approved by the Contracting Officer prior to use. Requests for approval shall be accompanied with technical data, instructions for use, and a 1 liter (1 quart) sample of the primer material.

2.3 PREFORMED TAPE

The preformed tape shall be an adherent reflectorized strip in accordance with ASTM D 4505 Type I or IV, Class optional.

2.4 RAISED REFLECTIVE MARKERS

Either metallic or nonmetallic markers of the button or prismatic reflector type may be used. Markers shall be of permanent colors as specified for pavement marking, and shall retain the color and brightness under the action of traffic. Button markers shall have a diameter of not less than 100 mm (4 inches), and shall be spaced not more than 12 meters (40 feet) apart on solid longitudinal lines. Broken centerline marker spacing shall be in segments indicated with gaps indicated between segments. Markers shall have rounded surfaces presenting a smooth contour to traffic and shall not project more than 19 mm (3/4 inch) above level of pavement. Pavement markers and adhesive epoxy shall conform to ASTM D 4280.

2.5 REFLECTIVE MEDIA

Reflective media for airfields shall conform to FS TT-B-1325, Type III. Reflective media for roads and streets shall conform to FS TT-B-1325, Type I, Gradation A, or AASHTO M 247, Type I.

2.6 SAMPLING AND TESTING

Materials proposed for use shall be stored on the project site in sealed and labeled containers, or segregated at source of supply, sufficiently in advance of needs to allow 60 days for testing. Upon notification by the Contractor that the material is at the site or source of supply, a sample shall be taken by random selection from sealed containers by the Contractor in the presence of a representative of the Contracting Officer. Samples shall be clearly identified by designated name, specification number, batch number, manufacturer's formulation number, project contract number, intended use, and quantity involved. Materials will be sampled and tested by the Government. No material shall be used at the project prior to receipt by the Contractor of written notice that the materials meet the laboratory requirements. The cost of initial testing of samples from each lot of materials will be borne by the Government. If the sample fails to meet specification requirements, the material represented by the sample shall be replaced and the new material will be tested. Cost of sampling and testing the new material will be borne by the Contractor. Testing shall be performed in an approved independent laboratory. If materials are approved based on reports furnished by the Contractor, samples will be retained by the Government for possible future testing should the material appear defective during or after application.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Surfaces to be marked shall be thoroughly cleaned before application of the pavement marking material. Dust, dirt, and other granular surface deposits shall be removed by sweeping, blowing with compressed air, rinsing with water or a combination of these methods as required. Rubber deposits, surface laitance, existing paint markings, and other coatings adhering to the pavement shall be completely removed with scrapers, wire brushes, sandblasting, approved chemicals, or mechanical abrasion as directed. Areas of old pavement affected with oil or grease shall be scrubbed with several applications of trisodium phosphate solution or other approved detergent or degreaser, and rinsed thoroughly after each application. After cleaning, oil-soaked areas shall be sealed with cut shellac to prevent bleeding through the new paint. Pavement surfaces shall be allowed to dry, when water is used for cleaning, prior to striping or marking. Surfaces shall be recleaned, when work has been stopped due to rain.

3.1.1 Pretreatment for Early Painting

Where early painting is required on rigid pavements, a pretreatment with an aqueous solution containing 3 percent phosphoric acid and 2 percent zinc chloride shall be applied to prepared pavement areas prior to painting.

3.1.2 Cleaning Existing Pavement Markings

In general, markings shall not be placed over existing pavement marking patterns. Existing pavement markings that are in good condition that interfere with or conflict with the newly applied marking patterns shall be removed. Deteriorated or obscured markings that are not misleading or confusing or interfere with the adhesion of the new marking material do not require removal. New preformed and thermoplastic pavement markings shall not be applied over existing preformed or thermoplastic markings. Whenever grinding, scraping, sandblasting or other operations are performed the work must be conducted in such a manner that the finished pavement surface is not damaged or left in a pattern that is misleading or confusing. When these operations are completed the pavement surface shall be blown off with compressed air to remove residue and debris resulting from the cleaning work.

3.1.3 Cleaning Concrete Curing Compounds

On new portland cement concrete pavements, cleaning operations shall not begin until a minimum of 30 days after the placement of concrete. All new concrete pavements shall be cleaned by either sandblasting or water blasting. When water blasting is performed, thermoplastic and preformed markings shall be applied no sooner than 24 hours after the blasting has been completed. The extent of the blasting work shall be to clean and prepare the concrete surface as follows:

a. There is no visible evidence of curing compound on the peaks of the textured concrete surface.

b. There are no heavy puddled deposits of curing compound in the valleys of the textured concrete surface.

c. All remaining curing compound is intact; all loose and flaking material is removed.

d. The peaks of the textured pavement surface are rounded in profile and free of sharp edges and irregularities.

e. The surface to be marked is dry.

3.2 APPLICATION

All pavement markings and patterns shall be placed as shown on the plans.

3.2.1 Paint

Paint shall be applied to clean, dry surfaces, and only when air and pavement temperatures are above 5 degrees C (40 degrees F) and less than 35 degrees C (95 degrees). Paint temperature shall be maintained within these same limits. New asphalt pavement surfaces and new portland concrete cement shall be allowed to cure for a period of not less than 30 days before applications of paint. Paint shall be applied pneumatically with approved equipment at rate of coverage specified herein. The Contractor shall provide guide lines and templates as necessary to control paint application. Special precautions shall be taken in marking numbers, letters, and symbols. Edges of markings shall be sharply outlined.

3.2.1.1   Rate of Application

Reflective Markings: Pigmented binder shall be applied evenly to the pavement area to be coated at a rate of 10 plus or minus 0.5 square meter per liter (105 plus or minus 5 square feet per gallon). Glass spheres shall be applied uniformly to the wet paint on airfield pavement at a rate of 1.2 plus or minus 0.06 kilograms of glass spheres per liter of paint and on road and street pavement at a rate of 0.76 plus or minus 0.06 kilograms of glass spheres per liter of paint. Non reflective Markings: Paint shall be applied evenly to the pavement surface to be coated at a rate of 10 plus or minus 0.5 square meter per liter (105 plus or minus 5 square feet per gallon).

3.2.1.2   Drying

The maximum drying time requirements of the paint specifications will be strictly enforced to prevent undue softening of bitumen, and pickup, displacement, or discoloration by tires of traffic. If there is a delay in drying of the markings, painting operations shall be discontinued until cause of the slow drying is determined and corrected.

3.2.2   Thermoplastic Compounds

Thermoplastic pavement markings shall be placed upon dry pavement; surface dry only shall not be considered an acceptable condition. At the time of installation, the pavement surface temperature shall be a minimum of 5 degrees C (40 degrees F) and rising. Thermoplastics, as placed, shall be free from dirt or tint.

3.2.2.1   Longitudinal Markings

All centerline, skipline, edgeline, and other longitudinal type markings shall be applied with a mobile applicator. All special markings, crosswalks, stop bars, legends, arrows, and similar patterns shall be placed with a portable applicator, using the extrusion method.

3.2.2.2   Primer

After surface preparation has been completed the asphalt and/or concrete pavement surface shall be primed. The primer shall be applied with spray equipment. Primer materials shall be allowed to "set-up" prior to applying the thermoplastic composition. The asphalt concrete primer shall be allowed to dry to a tack-free condition, usually occurring in less than 10 minutes. The portland cement concrete primer shall be allowed to dry in accordance with the thermoplastic manufacturer's recommendations. To shorten the curing time of the epoxy resins an infrared heating device may be used on the concrete primer.

Asphalt Concrete Primer: Primer shall be applied to all asphalt concrete pavements at a wet film thickness of 0.10 mm (0.005 inch), plus or minus 0.025 mm (0.001 inch) 25-40 square meters per liter (265-400 square feet per gallon).

Portland Cement Concrete Primer: Primer shall be applied to all concrete pavements (including concrete bridge decks) at a wet film thickness of between 1.0 to 1.3 mm (0.04 to 0.05 inch) 30-40 square meters per liter (320-400 square feet per gallon).

3.2.2.3 Markings

After the primer has "set-up" the thermoplastic shall be applied at temperatures no lower than 190 degrees C (375 degrees F) nor higher than 220 degrees C (425 degrees F) at the point of deposition. Immediately after installation of the marking, drop-on glass spheres shall be mechanically applied such that the spheres are held by and imbedded in the surface of the molten material.

Extruded Markings: All extruded thermoplastic markings shall be applied at the specified width and at a thickness of not less than 3.0 mm (0.125 inch) nor more than 5.0 mm (0.190 inch).

Sprayed Markings: All sprayed thermoplastic markings shall be applied at the specified width and the thickness designated in the contract plans. If the plans do not specify a thickness, centerline markings shall be applied at a wet thickness of 2.0 mm (0.090 inch), plus or minus 0.10 mm (0.005 inch), and edge line markings at a wet thickness of 1.5 mm (0.60 inch), plus or minus 0.10 mm (0.005 inch).

Reflective Glass Spheres: Immediately following application, reflective glass spheres shall be dropped onto the molten thermoplastic marking at the rate of 1 kilogram (1 pound) per 2 square meters (20 square feet) of compound.

3.2.3 Preformed Tape

The pavement surface temperature shall be a minimum of 15 degrees C (60 degrees F) and the ambient temperature shall be a minimum of 15 degrees C (60 degrees F) and rising. The preformed markings shall be placed in accordance with the manufacturer's written instructions.

3.2.4 Raised Reflective Markers

Prefabricated markers shall be aligned carefully at the required spacing and permanently fixed in place by means of epoxy resin adhesives. To insure good bond, pavement in areas where markers will be set shall be thoroughly cleaned by sandblasting and use of compressed air prior to applying adhesive.

3.2.5 Reflective Media

Application of reflective media shall immediately follow application of pigmented binder. Drop-on application of glass spheres shall be accomplished to insure that reflective media is evenly distributed at the specified rate of coverage. Should there be malfunction of either paint applicator or reflective media dispenser, operations shall be discontinued immediately until deficiency is corrected.

3.3 MARKING REMOVAL

Pavement marking, including plastic tape, shall be removed in the areas shown on the drawings. Removal of marking shall be as complete as possible without damage to the surface. Aggregate shall not be exposed by the removal process. After the markings are removed, the cleaned pavement surfaces shall exhibit adequate texture for remarking as specified in paragraph SURFACE PREPARATION. Contractor shall demonstrate removal of pavement marking in an area designated by the Contracting Officer. The demonstration area will become the standard for the remainder of the work.

3.3.1 Equipment Operation

Equipment shall be controlled and operated to remove markings from the pavement surface, prevent dilution or removal of binder from underlying pavement, and prevent emission of blue smoke from asphalt or tar surfaces.

3.3.2 Cleanup and Waste Disposal

The worksite shall be kept clean of debris and waste from the removal operations. Cleanup shall immediately follow removal operations in areas subject to air traffic. Debris shall be disposed of at approved sites.

SECTION 02584

FUEL-RESISTANT SEALING

TABLE OF CONTENTS

PART 1 GENERAL

This specification covers the requirements for fuel-resistant sealer for parking and maintenance areas.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 136 (1996a) Sieve Analysis of Fine and Coarse Aggregates

ASTM C 142 (1978; R 1997) Clay Lumps and Friable Particles in Aggregates

ASTM D 75 (1987; R 1997) Sampling Aggregates

ASTM D 140 (2000) Sampling Bituminous Materials

ASTM D 466 (1942; R 1989) Films Deposited from Bituminous Emulsions

ASTM D 747 (1993) Apparent Bending Modulus of Plastics by Means of a Cantilever Beam

ASTM D 2939 (1998) Emulsified Bitumen Used as Protective Coatings

ASTM D 2983 (1987; R 1993) Low-Temperature Viscosity of Automotive Fluid Lubricants Measured by Brookfield Viscometer

ASTM D 2995 (1993) Determining Application Rate of Bituminous Distributors

ASTM D 3320 (1990) Emulsified Coal-Tar Pitch (Mineral Colloid Type)

ASTM D 3699 (1992) Kerosene

ASTM D 5727 (1998) Emulsified Coal-Tar Pitch (Mineral Colloid Type)

1.2 SUBMITTALS

Indicate submittal classification using "GA" when the submittal requires Government approval or "FIO" when the submittal is for information only. Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES.

SD-01 Data

Mix Proportions; FIO.

A copy of the mixture proportions that meet all the requirements of this specification

SD-09 Reports

Sealer Materials; GA.

At least 30 days prior to the beginning of work. No material will be allowed to be used until it has been approved.

1.3 EQUIPMENT

Machines, tools, and equipment used in the performance of the work will be approved before the work is started and shall be maintained in satisfactory condition.

1.3.1 Applicator

Manufacturer's recommendations should also be followed when determining application methods, equipment and tools based on the surface condition of the pavement and to determined sand to be added for the purpose of the work. A spreader box shall be attached to the delivery tank or portable mixing plant truck to place the slurry. The truck shall be provided with or without a water tank, pump, and spray bar for fogging the pavement surface ahead of the spreader box. A variable-width mechanical-type squeegee spreader box shall be attached to the sealer mixing machine. The spreader box shall be equipped and maintained with flexible material in contact with the pavement surface to prevent loss of seal mixture from the spreader box on varying grades and crown. The spreader box shall be capable of adjustments to ensure uniform spread. Where the spreader box is wider than 3.05 m (10 feet) it shall be equipped for lateral distribution of the sealer mixture within the spreader. The spreader box shall be kept clean, and buildup of sealer and aggregate on the squeegee and spreader box shall not be permitted. The spray vehicle may be either self-propelled or towed, designed and equipped to apply a uniform mixture of sealer and aggregate at rates ranging from 0.45 to 3.17 liters per square meter (0.10 to 0.70 gallons per square yard) Sprayer equipment shall include a separate power unit, agitated tank, spray bar, hand spray wand, and suitable pump and plumbing for handling sealer and aggregate.

1.3.2 Distributor

This paragraph may be deleted where a spray vehicle is used for sealer application and can apply a tack coat, if required. The distributor shall be self-propelled and shall be designed and equipped to distribute sealer uniformly on various surface widths at readily determined and controlled rates ranging from 0.23 to 2.26 liters per square meter (0.05 to 0.5 gallons per square yard) Allowable variation from any specified rate shall not exceed 5 percent.

1.3.3 Cleaning Equipment

Cleaning equipment shall consist of power brooms, power blowers, power vacuums, air compressors, hand brooms, and other equipment as needed. The equipment shall be suitable for cleaning the surface and cracks in the existing pavement.

1.3.4 Hand Tools

Hand tools shall consist of hand squeegees, shovels, and other equipment as necessary to perform the work.

1.4 SAMPLING AND TESTING

1.4.1 Sampling

Aggregate samples shall be furnished in accordance with ASTM D 75. Samples of binder, unless otherwise specified, shall be in accordance with ASTM D 140. Additional samples of materials shall be furnished as required.

1.4.2 Testing

Materials shall be tested to establish compliance with the specified requirements. Quality control testing shall be performed by an approved commercial testing laboratory or by Contractor testing, subject to approval.

1.4.3 Calibration Test

Equipment, materials and labor shall be furnished as necessary to calibrate equipment used to place the sealer. Calibrations shall be made with the approved job materials prior to applying the sealer materials to the prepared surface.

1.4.3.1 Applicator

The equipment shall be calibrated to ensure that it will produce a sealed surface that complies with the requirements of this specification. All commercial equipment shall be provided with a method of calibration by the manufacturer.

1.4.3.2 Distributor

Calibration of the distributor shall be in accordance with ASTM D 2995. A copy of the calibration test results shall be submitted before the sealer distributor is used on the job.

1.4.4 Trial Application

Prior to applying the sealer mixture, a test section at least 30 m (100 feet) long and 6 m (20 feet) wide shall be placed by the Contractor using the approved materials and equipment. The sealer mixture shall be placed in accordance with the specified requirements. The rate of application shall be determined for compliance to specification requirements. If the test section does not conform to the specification requirements, necessary adjustments shall be made, and additional test sections shall be constructed for conformance to the specifications. Where test sections do not conform to the specification requirements, the sealer mixture shall be removed by milling, grinding, or another approved method. Test sections that conform to all specification requirements may become part of the sealed surface.

1.5 DELIVERY AND STORAGE

Materials delivered to the site shall be inspected for contamination and damage, unloaded, and stored with a minimum of handling. Aggregates shall be stockpiled to prevent segregation, contamination, or accumulation of excess moisture. Sealer materials shall be stored according to the manufacturer's recommendations. Materials determined by the Contracting Officer to be contaminated, segregated, damaged, or which fail to meet specification requirements shall be removed from the job-site and replaced at no additional cost to the Government.

1.6 WEATHER LIMITATIONS

Sealer shall not be applied if air or pavement temperatures are below 10 degrees C (50 degrees F) or if there is any possibility that the sealer will freeze before it has cured, unless otherwise directed by the Contracting Officer. No sealer shall be placed when rain or other impending weather conditions will prevent proper curing of the sealer mixture.

PART 2 PRODUCTS

2.1 SEALER MATERIALS

The Polyurethane Highmolecule substance base normal-temperature applied type sealer material shall be used and the properties of the material shall meet the requirements as specified in TABLE 1.

TABLE 1. PHYSICAL PROPERTIES OF SEALER MIXTURES
(normal temp. Applied material)

Property	Requirement

Time required for non-viscose	within 3 hours
Elasticity (Ball point)	penetrate 0.05~0.2cm, rebounding rate: 75% or more
Flow	0 mm, detaching and cracks should not be took placed
Elongation	15mm and more

TABLE 1a. PHYSICAL PROPERTIES OF SEALER MIXTURES (for Coal tar)

Property	Requirement	Referenced Test Method
Curing Time, firm set:	8 hours maximum	ASTM D 2939
Resistance to Heat:	No blistering, sagging or Slipping	ASTM D 2939
Resistance to Water:	No blistering, or tendency to re-emulsify	ASTM D 466
Resistance to Kerosene:	No penetration or loss of adhesion	ASTM D 466
Stiffness:	Computed stiffness shall not increase more than 30 percent after 14 days of additional cure	ASTM D 747
Viscosity of Sealer: (all constituents added, excluding sand)	Viscosity shall be a minimum of 700 Brookfield viscosity at 23 degrees C	ASTM D 2983

The requirement of tendency to re-emulsify pertains only to emulsified sealers.

2.1.1 Coal-Tar Emulsion

The base coal-tar emulsion (mineral colloid type) shall meet the requirements of ASTM D 5727.

2.1.2 Polymer Additive

The polymer additive used shall be the type and make as recommended by the coal-tar emulsion manufacturer

2.1.3 Water

The water added to the sealer mixture shall be potable. The temperature of the water added during mixing shall be at least 10 degrees C. (50 degrees F.)

The pH of the water shall conform to the requirements of the coal tar emulsion manufacturer.

2.2 AGGREGATE

The aggregate shall be either a natural or manufactured angular aggregate and shall be composed of clean, hard, durable, uncoated particles free from clay and other objectionable material when tested in accordance with ASTM C 142. The aggregate shall meet the gradation in TABLE 2, when tested in accordance with ASTM C 136.

TABLE 2. AGGREGATE GRADATION RANGES AND CORRESPONDING MINIMUM SEALER MIXTURE APPLICATION RATES

SIEVE SIZE	PERCENT PASSING		
	COARSE	MEDIUM	FINE
1.180 mm (No. 16)	100	100	100
0.850 mm (No. 20)	85-100	98-100	100
0.600 mm (No. 30)	25-85	85-100	98-100
0.425 mm (No. 40)	5-25	25-85	85-100
0.300 mm (No. 50)	2-10	5-25	25-85
0.212 mm (No. 70)	--	2-10	5-25
0.150 mm (No. 100)	0-2	0-4	2-10
0.106 mm (No. 140)	--	0-2	0-2
Note: Minimum sealer mixture application rate liter/square meter (gallon/square yard)	0.30	0.20	0.15

2.3 SEALER MIXTURE

2.3.1 Composition

The exact proportions of binderlatex, water, and aggregate to be used in the preparation of the seal shall be determined by laboratory mix design and shall be furnished by the Contractor from an approved laboratory, unless otherwise directed by the Contracting Officer.

2.3.2 Properties

The sealer mixture shall meet all the applicable requirements as outlined in TABLE 1. And Table 1a.

2.4 TEST METHODS

Unless specified otherwise, all material preparation and testing shall occur at normal laboratory conditions of 23 degrees C (73.4 plus or minus 3.6 degrees F) and at 50 plus or minus 5 percent relative humidity.

2.4.1 Curing Time

Curing time shall be determined in accordance with paragraph 14 (Firm Set) of ASTM D 2939, except as noted. The sealer shall be cured for the time as recommended by the manufacturer. In preparing the specimens, the mask may remain in place until sealer has set.

2.4.2 Resistance to Heat

Resistance to heat shall be determined in accordance with paragraph 15(Heat Test) of ASTM D 2939.

2.4.3 Resistance to Water

Resistance to water shall be determined in accordance with paragraphs 5 and 6 (Resistance to Water Action) of ASTM D 466 using distilled water.

2.4.4 Resistance to Kerosene

Resistance to kerosene shall be determined in accordance with paragraphs 5 and 6 (Resistance to Water Action) of ASTM D 466, except the mixture shall be applied in three coats. The residual material thickness accumulated on the tile shall be a minimum of 1.3 mm (0.05 inch). Masks may be brass or plexiglass. Components of the sealer mixture shall be mixed according to the manufacturer's recommendations and applied in three coats, using one mask for the first coat and 2 masks stacked together for the second and third coat. The masks shall be left in place for the initial drying period of each coat, usually 24 hours. The second mask shall be positioned on top of the first to pour the second and third coat. The initial 3.2 mm (1.8 inch mask may be removed and replaced with a 6.4 mm (1/4 inch) mask to achieve the required 6.4 mm (1/4 inch) thickness. All coats shall be spread evenly with the top of the mask using a spatula or other straightedge. The first two coats shall contain sealer and the desired sand content while the final coat shall contain only plain sealer. Each coat shall be cured for 96 hours. After curing the final coat, the metal ring must be sealed to the surface with a fuel resistant adhesive material, such as silicone rubber sealant. The metal ring shall be filled with kerosene conforming to ASTM D 3699 for 24 hours. The kerosene shall then be removed from the ring and blotted dry from the sealer. Sealer shall be examined at normal laboratory conditions for softness and loss of adhesion. When the tile is broken in half, visible evidence of leakage or discoloration shall constitute failure of the tests.

2.4.5 Stiffness

Sealer shall be tested in accordance with ASTM D 747, except as noted. A total of 10 test specimens shall be cast in plastic or brass masks (molds) 3.2 mm (1.8-inch) thick, 25.4 mm (1-inch) wide, and 102 mm (4-inch) long. The masks shall be removed after the sealer has set and, if required, the edges shall be trimmed even. The sealer shall be prepared as for the previous tests; however, no sand shall be added. More than one coating may be applied in order to obtain a minimum thickness ratio of 1:15 (thickness to span). Span width of the test device can be set at either 12.7 or 25.4 mm (1/2 or 1 inch) but shall remain constant for all tests on a particular sealer. The completed test specimens shall be cured for Minimum 4 days before testing. The average stiffness of 5 test specimens shall be reported for the initial testing. Five additional test specimens shall be tested 14 days after the initial tests. The change in stiffness shall be within the requirements of TABLE 1.a

2.4.6 Viscosity

Viscosity shall be determined in accordance with ASTM D 2983. The viscosity shall meet the requirements of TABLE 1a.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Prior to application of the sealer mixture, the existing pavement surface shall be cleaned and unsatisfactory areas repaired. Failed pavement, base, subbase, or subgrade material shall be removed and replaced with new materials. Areas patched or repaired with asphalt cold mix should be cured for 90 days, while those repaired with hot-mix asphalt should cure for 30 days prior to seal coating the surface.

3.1.1 Cracks

Cracks in the surface not due to structural deficiencies shall be treated as outlined below: Cracks less than or equal to 6 millimeters 1/4 inch wide should be cleaned with compressed air. Cracks larger than 6 millimeters 1/4 inch but less than 19 millimeters 3/4 inch in width shall be cleaned with compressed air and filled with an approved crack sealer. Cracks larger than 19 millimeters 3/4 inch wide shall be cleaned with compressed air and filled by squeegeeing in a mixture of aggregate and sealer. The final surface of the filled cracks shall be flush or up to 3 millimeters 1/8 inch below the pavement surface. Any excess materials shall be removed from the pavement surface.

3.1.2 Vegetation

Vegetation existing in the cracks shall be removed by a heat lance, sand blasting, water blasting or a power driven brush and the cracks treated with a herbicide. The type of herbicide and method of application will require approval by the Contracting Officer.

3.1.3 Oil or Fuel Contaminated Areas

Grease-contaminated and oil-contaminated areas shall be cleaned or removed and replaced with new asphalt pavement as directed by the Contracting Officer. Areas not removed shall be cleaned by scrubbing with a detergent and flushing with water. Areas, which cannot be satisfactorily cleaned by this manner, may be primed with material especially manufactured to provide a surface suitable for sealing.

3.1.4 Tack Coat

Delete this paragraph where application of a tack coat is not part of the manufacturer's recommended procedure. Tack coats are normally used only on very dry and porous pavement surfaces. The pavement surface shall be prepared as specified above and sprayed with a thin coat of 3 parts water to 1 part coal-tar emulsion. The tack coat shall be applied at a rate of 0.23 to 0.45 liters per square meter (0.05 to 0.10 gallons per square yard).

3.1.5 Wetting Pavement Surface

Wetting of the surface is recommended on hot, sunny days, generally when the pavement surface temperature approaches or exceeds 38°C (100°F). Eliminate this paragraph when the emulsion manufacturer recommends against it. Immediately prior to application of the sealer mixture, the surface of the pavement shall be moistened with a fog spray of water from the spray bar on the sealer machine. No free water shall be on the surface of the pavement following the fog spray. The rate of application of the fog spray shall be adjusted during the day to suit pavement temperature, surface texture, humidity, and dryness of the pavement surface.

3.1.6 Joints

Longitudinal joint between adjacent lanes shall have no visible overlaps, pinholes, or uncovered areas. Thick spots caused by overlapping shall be smoothed immediately with hand squeegees before the sealer mixture cures. Overlaps, which occur at transverse joints, shall also be smoothed before the sealer mixture cures, so that a uniform surface is obtained which contains no breaks or discontinuities. Joints should be made while the first coat is still workable. If fresh working is not possible, the previous coat must be cured sufficiently to support the spreader box.

3.2 PREPARATION AND APPLICATION OF SEALER

3.2.1 Preparation

The sealer mixture shall be prepared in a suitable mixing plant, subject to approval by the Contracting Officer.

3.2.1.1 Mechanical

The sealer shall be mixed in a suitable plant as described in paragraph EQUIPMENT. The sealer mixture shall be of the desired consistency with no segregation when deposited on the surface of the pavement. No additional elements shall be added. The sealer mixture shall show no signs of uncoated aggregate, or segregation, or premature breaking of emulsion when applied to the pavement surface. Wording in the brackets shall be deleted when an emulsion is not used.

3.2.1.2 Hand Mixing

Where small amounts of sealer are required, making mechanical mixing uneconomical, mixing may be accomplished by hand. The preparation requirements are the same as given in the preceding paragraph for mechanical mixing.

3.2.2 Application

Sufficient quantities of the sealer mixture shall be fed into the spreader box to obtain a uniform and complete pavement coverage. The spreader box shall be operated at such a forward speed that the amount of sealer mixture in the spreader box shall remain essentially constant. The sealer shall be applied in such a manner that the minimum thickness will not be less than the maximum thickness of the largest aggregate in the mix. Three coats shall be applied, the first with sand at a minimum application rate of 1.58 liters per square meter (0.35 gallons per square yard) and a final coat of plain sealer applied at a rate to achieve a minimum residual application thickness of 0.25 mm (0.01 inch). The final residual cumulative thickness of all coatings shall be a minimum of 1.25 mm (0.05 inch). Each application shall be thoroughly cured before another application is placed. No oversized aggregate particles shall be allowed in the sealer mixture, and no buildup of cured sealer mixture shall be allowed to collect in the spreader box. Streaks shall not be left in the finished surface. Spraying equipment shall be operated to provide a total final coating with a minimum thickness equal to the maximum thickness of the largest aggregate in the mix. The sealer shall be applied in three coatings at a rate of 1.58 liters per square meter, (0.35 gallons per square yard,) with an allowable variation in specified rate of not more than plus or minus 5 percent. Each coating shall be thoroughly cured before another coating is applied.

3.2.2.1 Joints

Longitudinal joint between adjacent lanes shall have no visible overlaps, pinholes, or uncovered areas. Thick spots caused by overlapping shall be smoothed immediately with hand squeegees before the sealer mixture cures. Overlaps which occur at transverse joints shall also be smoothed before the sealer mixture cures, so that a uniform surface is obtained which contains no breaks or discontinuities. Joints should be made while the first coat is still workable. If fresh working is not possible, the previous coat must be cured sufficiently to support the spreader box.

3.2.2.2 Stability of Mixture

Sealer mixture shall possess sufficient stability so that segregation or premature breaking of emulsion in the spreader box does not occur. Mixture shall be homogeneous following mixing and spreading, free of water or emulsion bleeding. When an emulsion is not used, the wording in the bracket should be deleted.

3.2.2.3 Hand Application

Areas which cannot be reached with the application equipment, or areas with minor defects shall have the sealers applied with hand squeegees or shall be sprayed by the wand to provide complete and uniform coverage. These areas shall be tacked and fogged as required prior to placing sealer by hand.

3.3 CURING

Sealed pavement shall be protected from traffic by barricades and markers until the seal has cured a minimum of 24 hours or the period recommended by the manufacturer whichever is longer. Areas which are damaged by traffic or from other causes shall be repaired by the Contractor at no cost to the Government.

3.4 RETEST AND REJECTION

If the results of any test do not conform to the requirements of this specification, the sealer shall be rejected. Retesting of nonconforming materials or new materials shall be at the Contractor's expense and at the Contracting Officer's discretion.

3.5 CLEANUP

On completion of work, all trash, discarded seal material, or other refuse shall be collected and removed from the site and disposed of as approved by the Contracting Officer at the contractor's expense.

SECTION 02593

COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS

TABLE OF CONTNTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in this text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 2628	(1991; R 1998) Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D 2835	(1989; R 1998) Lubricant for Installation of Preformed Compression Seals in Concrete Pavements

CORPS OF ENGINEERS (COE)

COE CRD-C 548	(1988) Jet-Fuel and Heat Resistant Preformed Polychloroprene Elastomeric Joint Seals for Rigid Pavements

1.2 SAFETY

Compression joint seals shall not be placed within 7.5 meters (25 feet) of liquid oxygen (LOX) equipment, LOX storage, or LOX piping.

1.3 SUBMITTAL

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES:

SD-01 DATA

Test Results; GA.

Certified copies of test results shall be provided 30 days prior to use of material on the project.

Equipment List; GA.

List of proposed equipment to be used in the performance of construction work, including descriptive data shall be provided 30 days prior to use on the project.

Manufacturer's Instructions; GA.

Where installation procedures are required in accordance with the manufacturer's recommendations, printed copies of manufacturers' instructions, 30 days prior to use on the project.

SD-14, Samples

Compression Seals; GA.

Regardless of testing responsibility, 1.2 meter (4-feet) long samples of the materials shall be submitted for approval 60 days prior to use on the project. Printed directions from the manufacturer on recommended installation criteria shall be furnished with the samples plus the manufacturer's certification that the selected seal is recommended for the installation on this project.

1.4 TEST REQUIREMENTS

Each lot of compression joint seal and lubricant/adhesive shall be sampled, identified, and tested for conformance with the applicable material specification. A lot of compression seal shall consist of 1 day's production or 6,000 meters (20,000 linear feet) for each cross section, whichever is less. A lot of lubricant/adhesive shall consist of 1 day's production. Testing of the compression joint seal and lubricant/adhesive material shall be the responsibility of the Contractor and shall be performed in an approved independent laboratory, and certified copies of the test reports shall be submitted for approval 60 days prior to the use of the materials at the jobsite. Samples of each lot of material shall also be submitted and will be retained by the Government for possible future testing should the materials appear defective during or after application. The Contractor shall furnish additional samples of materials, in sufficient quantity to be tested, upon request. Final acceptance will be based on conformance to the specified test requirements and the performance of the in-place materials.

1.5 EQUIPMENT

Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and shall be maintained in satisfactory condition at all times.

1.5.1 Joint Cleaning Equipment

1.5.1.1 Concrete Saw

A self-propelled power saw with water-cooled diamond saw blades shall be provided for cutting joints to the depths and widths specified and for removing filler, existing old joint seal, or other material embedded in the joints or adhered to the joint faces.

1.5.1.2 Sandblasting Equipment

Sandblasting equipment shall include an air compressor, hose, and a long-wearing venturi-type nozzle of proper size, shape, and opening. The maximum nozzle opening should not exceed 6.35 mm (1/4 inch). The air compressor shall be portable and shall be capable of furnishing not less than 4200 liters (150 cubic feet) per minute and maintaining a line pressure of not less than 620 kPa (90 psi) at the nozzle while in use. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint about 25 mm (1 inch) above the pavement surface and will direct the blast to clean the joint walls. The height, angle of inclination, and the size of the nozzle shall be adjusted as necessary to ensure satisfactory results.

1.5.1.3 Water-blasting Equipment

Water-blasting equipment shall include a trailer-mounted water tank, pumps, high-pressure hose, a wand with safety release cutoff controls, nozzle, and auxiliary water resupply equipment. The water tank and auxiliary water resupply equipment shall be of sufficient capacity to permit continuous operations. The pumps, hoses, wand, and nozzle shall be of sufficient capacity to permit the cleaning of both walls of the joint and the pavement surface for a width of at least 12 mm (1/2 inch) on either side of the joint. A pressure gauge mounted at the pump shall show at all times the pressure in pounds per square inch at which the equipment is operating.

1.5.2 Sealing Equipment

Equipment used to install the compression seal shall place the compression seal to the prescribed depths within the specified tolerances without cutting, nicking, twisting, or otherwise damaging the seal. The equipment shall be capable of placing the seal with not more than two percent longitudinal stretch or compression of the seal during installation. The machine shall be an automatic self-propelled joint seal application equipment and engine powered. The machine shall include a reservoir for the lubricant/adhesive, a device for conveying the lubricant/adhesive in the proper quantities to the sides of the compression seal or the sidewalls of the joints, a reel capable of holding one full spool of compression seal, and a power-driven apparatus for feeding the joint seal through a compression device and inserting the seal into the joint. The equipment shall also include a guide to maintain the proper course along the joint being sealed. For road, parking lot, and street pavements less than 1800 square meters (2,000 square yards), and for airfield and tracked pavements less than 450 square meters (500 square yards) in area, the hand operated joint seal application equipment can be used. The hand operated joint seal application equipment shall be a two-axle, four-wheel machine that shall include means for compressing and inserting the compression seal into the joint and a reel capable of holding one full spool of compression seal. Auxiliary equipment shall be provided to coat both sides of the joint or the seal with lubricant/adhesive just prior to the installation of the compression seal. The machine shall at all times be operated by an experienced operator.

1.6 TRIAL JOINT SEAL AND LUBRICANT/ADHESIVE INSTALLATION

Prior to the cleaning and sealing of the joints for the entire project, a test section at least 69 meters (200 feet) long shall be prepared at a designated location in the project pavement using the specified materials and the approved equipment, so as to demonstrate the proposed joint preparation and sealing of all types of joints in the project. Following the completion of the trial length and before any other joint is sealed, the trial joints will be inspected by the Government to determine that the materials and installation meet the requirements specified. If materials or installation do not meet requirements, the materials shall be removed, and the joints shall be recleaned and resealed at no cost to the Government. No other joints shall be sealed until the test installation has been approved. If the trial section is approved, it may be incorporated into the permanent work. Other joints shall be sealed in the manner approved for sealing the trial joint.

1.7 DELIVERY AND STORAGE

Materials delivered to the jobsite shall be inspected for defects, unloaded, and stored with a minimum of handling to avoid damage. Storage facilities shall protect materials from weather and shall maintain materials at temperatures recommended by the manufacturer.

1.8 ENVIRONMENTAL CONDITIONS

The ambient temperature and the pavement temperature within the joint wall shall be at least of 2.0 degrees C (35 degrees F) and rising at the time of installation of the materials. Sealant installation will not be allowed if moisture or foreign material is observed in the joint.

PART 2 PRODUCTS

2.1 SEALANT

Compression joint seal materials shall be a vulcanized elastomeric compound using polychloroprene as the only base polymer. The material and manufactured seal shall conform to ASTM D 2628, or ASTM D 2628 and COE CRD-C 548 where jet fuel and/or heat blast resistance is required. Where the project is less than 1200 meters (4,000 linear feet) of compression joint seal material, the joint seal shall be a labyrinth type seal. The uncompressed depth of the face of the compression seal (that is to be bonded to the joint wall) shall be greater than the uncompressed width of the seal, except that for seals 25 mm (1 inch) or greater in width, the depth need be only 1 inch or greater. The actual width of the uncompressed seal shall be twice the width of the seal reservoir with a tolerance of plus 3.2 mm or minus 1.6 mm.

2.2 LUBRICANT/ADHESIVE

Lubricant/adhesive used for the compression elastomeric joint seal shall be a one-component compound conforming to ASTM D 2835.

PART 3 EXECUTION

3.1 PREPARATION OF JOINTS

Immediately before installation of the compression joint seal, the joints shall be thoroughly cleaned to remove laitance, filler, existing sealer, foreign material and protrusions of hardened concrete from the sides and upper edges of the joint space to be sealed. Cleaning shall be by sandblasting or water-blasting and shall extend along pavement surfaces at least 12 mm (1/2 inch) on either side of the joint. After final cleaning and immediately prior to sealing, the joints shall be blown out with compressed air and left completely free of debris and water. The Contractor shall demonstrate that the selected cleaning operation meets the cleanliness requirements. Any irregularity in the joint face which would prevent uniform contact between the joint seal and the joint face shall be corrected prior to the installation of the joint seal.

3.1.1 Sawing

Joints shall be cleaned and to opened to the specified width and depth by sawing. Immediately following the sawing operation, the joint faces and opening shall be thoroughly cleaned using a water jet to remove saw cuttings or debris remaining on the faces or in the joint opening. Compression seal shall be installed within 3 calendar days of the time the joint cavity is sawed. Depth of the joint cavity will be as recommended by the seal manufacturer. The saw cut for the joint seal cavity shall be centered over the joint line. The nominal width of the sawed joint seal cavity shall be as follows; the actual width shall be within a tolerance of plus or minus 1.6 mm (1/16 inch):

a. If a nominal 20.6 mm (13/16 inch) wide compression seal is furnished, the nominal width of the saw cut shall be 12.7mm when the pavement temperature at the time of sawing is between 4 and 27 Degree C. If the pavement temperature at the time of sawing is above this range, the nominal width of the saw cut shall be decreased 1.6 mm (1/16 inch). If the pavement temperature at the time of sawing is below this range, the nominal width of the saw cut shall be increased 1.6 mm (1/16 inch).

b. If a nominal 25.4 mm (1 inch) wide compression seal is furnished, the nominal width of the saw cut shall be 14.3mm when the pavement temperature at the time of sawing is between 4 and 60 degree C. If the pavement temperature at the time of sawing is above this range, the nominal width of the saw cut shall be decreased 1.6 mm (1/16) inch. If the pavement temperature at the time of sawing is below this range, the nominal width of the saw cut shall be increased (1/16 inch).

3.1.2 Sandblast Cleaning

A multiple pass sandblasting technique shall be used until the surfaces are free of dust, dirt, curing compound, or any residue that might prevent ready insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete.

3.1.3 Water-blast Cleaning

A multiple pass water-blast technique shall be used until the surfaces are free of dust, dirt, curing compound, or any residue that might prevent ready insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete.

3.1.4 Rate of Progress

Sandblasting or waterblasting of joint faces shall be limited to the length of joint that can be sealed during the same workday.

3.2 INSTALLATION OF THE COMPRESSION SEAL

3.2.1 Time of Installation

Joints shall be sealed immediately within 3 calendar days of sawing the joint seal cavity and following concrete cure and the final cleaning of the joint walls. Open joints ready for sealing that cannot be sealed under the specified conditions shall be provided with an approved temporary seal to prevent infiltration of foreign material. When rain interrupts the sealing operations, the joints shall be washed, air pressure cleaned, and allowed to dry prior to installing the lubricant/adhesive and compression seal.

3.2.2 Sequence of Installation

Longitudinal joints shall be sealed first, followed by transverse joints. Seals in longitudinal joints shall be installed so that all transverse joint seals will be intact from edge to edge of the pavement. Intersections shall be made monolithic by use of joint seal adhesive and care in fitting the intersection parts together. Extender pieces of seal shall not be used at intersections. Any seal falling short at the intersection shall be removed and replaced with new seal at no additional cost to the Government. Seals that are required to change direction by more than 20 degrees, may require a poured sealant at the intersection. Poured sealant shall be as recommended by the compression seal manufacturer.

3.3 SEALING OF JOINTS

The sides of the joint seal or the sides of the joint shall be covered with a coating of lubricant/adhesive and the seal installed in such a manner as to conform to all requirements specified. Butt joints and seal intersections shall be coated with liberal applications of lubricant/ adhesive. Lubricant/adhesive spilled on the pavement shall be removed immediately to prevent setting on the pavement. The in-place joint seal shall be in an upright position and free from twisting, distortion, and cuts. Adjustments shall be made to the installation equipment and procedure, if the stretch or compression exceeds 2 percent. Any seal exceeding 2 percent stretch or compression shall be removed and replaced. The joint seal shall be placed at a uniform depth within the tolerances specified. In-place joint seal which fails to meet the specified requirements shall be removed and replaced with new joint seal at no cost to the Government. The compression joint seal shall be placed to a depth of 6.4 mm (1/4 inch) plus or minus 3.2 mm (1/8 inch),for wheeled vehicles, or 10 mm plus or minus 3 mm for tracked vehicles, below the pavement surface except when the joint is beveled or has a radius at the surface, or unless otherwise directed. For beveled joints or joints with a radius at the surface, the compression joint seal shall be installed at a depth of 3.2 mm (1/8 inch), plus or minus 3.2 mm (1/8 inch), below the bottom of the edge of the bevel or radius. No part of the seal shall be allowed to project above the surface of the pavement or above the edge of the bevel or radius. The seal shall be installed in the longest practicable lengths in longitudinal joints and shall be cut at the joint intersections to provide continuous installation of the seal in the transverse joints. The lubricant/adhesive in the longitudinal joints shall be allowed to set for 1 hour prior to cutting at the joint intersections to reduce the possibility of shrinkage. For all transverse joints, the minimum length of the compression joint seal shall be the pavement width from edge to edge.

3.4 CLEAN-UP

Upon completion of the project, all unused materials shall be removed from the site, any lubricant/adhesive on the pavement surface shall be removed, and the pavement shall be left in clean condition.

3.5 QUALITY CONTROL PROVISIONS

3.5.1 Equipment

The application equipment shall be inspected to assure uniform application of lubricant/adhesive to the sides of the compression joint seal or the walls of the joint. If any equipment causes cutting, twisting, nicking, excessive stretching or compressing of the seal, or improper application of the lubricant/adhesive, the operation will be suspended until causes of the deficiencies are determined and corrected.

3.5.2 Procedures

3.5.2.1 Quality Control Inspection

Quality control provisions shall be provided during the joint cleaning process to prevent or correct improper equipment and cleaning techniques that damage the concrete in any manner. Cleaned joints shall be approved by the Government prior to installation of the lubricant/adhesive and compression joint seal.

3.5.2.2 Conformance to Stretching and compression Limitations

Conformance to stretching and compression limitations shall be determined. The top surface of the compression seal shall be marked at 1 foot intervals in a manner clear and durable to enable length determinations of the seal. After installation, the distance between the marks shall be measured on the seal. If the stretching or compression exceeds 2 percent, the seal shall be removed and replaced with new joint at no additional cost to the Government. The seal shall be removed up to the last correct measurement. The seal shall be inspected a minimum of once per 30 meters (100 feet) of seal for compliance to the shrinkage or compression requirements. Measurements shall also be made at the same interval to determine conformance with depth and width of installation requirements. Compression seal that is not in conformance with specification requirements shall be removed and replaced with new joint seal at no additional cost to the Government.

3.5.2.3 Pavement Temperature

The pavement temperature shall be determined by placing a thermometer in the initial saw cut for the joint and the reading shall be recorded. The thermometer shall remain in the joint for an adequate time to provide a control reading.

3.5.3 Product

The joint sealing system (compression seal and lubricant/adhesive) shall be inspected for proper rate of cure and bonding to the concrete, cuts, twists, nicks and other deficiencies. Seals exhibiting any defects, at any time prior to final acceptance of the project, shall be removed from the joint, wasted, and replaced in a satisfactory manner.

SECTION 02660

WATER DISTRIBUTION SYSTEM

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN RAILWAY ENGINEERING ASSOCIATION (AREA)

AREA Manual (1999) Manual for Railway Engineering (4 Vol.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36 (1997ae1) Carbon Structural Steel

ASTM A 53 (1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

ASTM B 88/ 88M (1996) Seamless Copper Water Tube

ASTM C 76/ 76M (1999) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

ASTM D 1599	(1999) Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings
ASTM D 1784	(1999a) Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds
ASTM D 1785	(1999) Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2241	(1996b) Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D 2464	(1999) Threaded Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D 2466	(1999) Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2467	(1999) Socket-Type Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D 2564	(1996a) Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Piping Systems
ASTM D 2657	(1997) Heat-Joining Polyolefin Pipe and Fittings
ASTM D 2774	(1994) Underground Installation of Thermoplastic Pressure Piping
ASTM D 2855	(1996) Making Solvent-Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings
ASTM D 2996	(1995) Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D 2997	(1995) Centrifugally Cast "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe
ASTM D 3839	(1998) Underground Installation of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe
ASTM D 4161	(1996) "Fiberglass"(Glass-Fiber-Reinforced Thermosetting Resin) Pipe Joints Using Elastomeric Seals
ASTM F 477	(1999) Elastomeric Seals (Gaskets) for Joining Plastic Pipe

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(1983; R 1992) Pipe Threads, General Purpose (Inch)
ASME B16.1	(1989) Cast Iron Pipe Flanges and Flanged Fittings
ASME B16.3	(1992) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes

ASME B36.10M	(1996) Welded and Seamless Wrought Steel Pipe

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA B300	(1992) Hypochlorites
AWWA B301	(1992) Liquid Chlorine
AWWA C104	(1995) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105	(1993) Polyethylene Encasement for Ductile-Iron Pipe Systems.
AWWA C110	(1993) Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (75 mm through 1200 mm), for Water and Other Liquids
AWWA C111	(1995) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115	(1996) Flanged Ductile-Iron Pipe with Threaded Flanges
AWWA C151	(1996) Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids
AWWA C153	(1994; Errata Nov 1996) Ductile-Iron Compact Fittings, 3 In. Through 16 In., for Water and Other Liquids
AWWA C200	(1997) Steel Water Pipe - 6 In. (150 mm) and Larger
AWWA C203	(1997) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C205	(1995) Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. and Larger - Shop Applied
AWWA C207	(1994) Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
AWWA C208	(1996) Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C300	(1997) Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids
AWWA C301	(1992) Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids
AWWA C303	(1995) Reinforced Concrete Pressure Pipe, Steel Cylinder Type, Pretensioned, for Water and Other Liquids
AWWA C500	(1993; C500a) Metal Sealed Gate Valves for Water Supply Service
AWWA C502	(1994; C502a) Dry-Barrel Fire Hydrants

AWWA C504 (1994) Rubber-Seated Butterfly Valves

AWWA C509 (1994) Resilient-Seated Gate Valves for Water Supply Service.

AWWA C600 (1993) Installation of Ductile-Iron Water Mains and Their Appurtenances

AWWA C606 (1997) Grooved and Shouldered Joints

AWWA C651 (1992) Disinfecting Water Mains

AWWA C700 (1995) Cold-Water Meters - Displacement Type, Bronze Main Case

AWWA C701 (1988) Cold-Water Meters - Turbine Type, for Customer Service

AWWA C702 (1992) Cold-Water Meters - Compound Type

AWWA C703 (1996) Cold-Water Meters - Fire Service Type

AWWA C704 (1992) Cold-Water Meters - Propeller Type for Main Line Applications

AWWA C706 (1996) Direct-Reading Remote-Registration Systems for Cold-Water Meters

AWWA C707 (1982; R 1992) Encoder-Type Remote-Registration Systems for Cold-Water Meters

AWWA C800 (1989) Underground Service Line Valves and Fittings

AWWA C900 (1997; C900a) Polyvinyl Chloride (PVC) Pressure Pipe, 4 In. Through 12 In., for Water Distribution

AWWA C901 (1996) Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. Through 3 In., for Water Service

AWWA C905 (1997) Polyvinyl Chloride (PVC) Water Transmission Pipe, Nominal Diameters 14 In. Through 36 In.

AWWA C909 (1998) Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 IN through 12 IN (100 mm through 300 mm), for Water Distribution

AWWA C950 (1995) Fiberglass Pressure Pipe

AWWA M23 (1980) Manual: PVC Pipe - Design and Installation

ASBESTOS CEMENT PIPE PRODUCERS ASSOCIATION (ACPPA)

ACPPA-Work Practice (1988) Recommended Work Practices for A/C Pipe

DUCTILE IRON PIPE RESEARCH ASSOCIATION (DIPRA)

DIPRA-Restraint Design	(1997) Thrust Restraint Design for Ductile Iron Pipe

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(1997) Bronze Gate, Globe, Angle and Check Valves

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 24	(1995) Installation of Private Fire Service Mains and Their Appurtenances
NFPA 49	(1994) Hazardous Chemicals Data
NFPA 325-1	(1994) Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids
NFPA 704	(1996) Identification of the Fire Hazards of Materials
NFPA 1961	(1997) Fire Hose

NSF INTERNATIONAL (NSF)

NSF Std 14	(1998) Plastics Piping System Components and Related Materials
NSF 61	(1999) Drinking Water System Components - Health Effects (Sections 1-9)

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 21	(1991) White or Colored Silicone Alkyd Paint
SSPC Paint 25	(1991) Red Iron Oxide, Zinc Oxide, Raw Linseed Oil and Alkyd Primer (without Lead and Chromate Pigments)

KOREAN STANDARD (KS)

KS D 4308	(2001) Ductile Iron Fittings
KS D 4311	(1999) Ductile Iron Pipes

KOREAN WATER WORKS ASSOCIATION (KWWA)

KWWA D 100	(1989) Stainless Steel Pipe for Water Works
KWWA D 101	(1989) Stainless Steel Fittings for Water Works

1.2 PIPING

This section covers water supply, distribution, service lines, and connections to building service at a point approximately 1.5 m (5 feet) outside buildings and structures to which service is required. The Contractor shall have a copy of the manufacturer's recommendations for each material or procedure to be utilized available at the construction site at all times.

1.2.1 Service Lines

Piping for water service lines less than 80 mm (3 inches) in diameter shall be galvanized steel, polyvinyl chloride (PVC) plastic, polyethylene, stainless steel or copper tubing, unless otherwise shown or specified. Piping for water service lines for sizes 80 mm (3 inches) and larger shall be ductile iron, polyvinyl chloride (PVC) plastic through 300 mm (12 inch) nominal diameter, filament-wound or centrifugally cast reinforced thermosetting resin, reinforced plastic mortar pressure pipe or steel, unless otherwise shown or specified.

1.2.2 Distribution Lines 80 mm (3 Inches) or Larger

Piping for water distribution lines 80 mm (3 inches) or larger shall be ductile iron, polyvinyl chloride (PVC) plastic through 300 mm (12 inch) nominal diameter, filament-wound or centrifugally cast reinforced thermosetting resin, reinforced plastic mortar pressure pipe, or reinforced concrete, unless otherwise shown or specified.

1.2.3 Supply Lines 80 mm (3 Inches) or Larger

Piping for water supply lines 80 mm (3 inches) (3 inches) or larger shall be ductile iron, polyvinyl chloride (PVC) plastic through 900 mm (36 inch) nominal diameter, filament-wound reinforced or centrifugally cast reinforced thermosetting resin, reinforced plastic mortar pressure pipe, steel, or reinforced concrete, unless otherwise shown or specified.

1.2.4 Sprinkler Supply Lines

Piping for water lines supplying sprinkler systems for building fire protection shall conform to NFPA 24 from the point of connection with the water distribution system to the building 1.5 m (5 foot) line.

1.2.5 Potable Water Lines

Piping and components of potable water systems which come in contact with the potable water shall conform to NSF 61.

1.2.6 Plastic Piping System

All plastic piping system components (PVC, polyethylene, thermosetting resin and reinforced plastic mortar pressure) intended for transportation of potable water shall comply with NSF Std 14 or approve equal and shall be legibly marked with their symbol

1.2.7 Excavation, Trenching, and Backfilling

Excavation, trenching, and backfilling shall be in accordance with the applicable provisions of Section 02222: EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES.

1.3 MANUFACTURER'S REPRESENTATIVE

The Contractor shall negotiate to have a manufacturer's field representative present at the job-site during the installation and testing of PE, RTRP, and/or RPMP pipe to provide technical assistance and to verify that the materials are being installed in accordance with the manufacturer's prescribed procedures. When the representative feels that the Contractor is installing and testing the PE, RTRP, and/or RPMP pipe in a satisfactory manner, certification shall be written to note which individuals employed by the Contractor are capable of properly installing the pipe. The field representative shall advise the Contractor of unsatisfactory conditions immediately when they occur. Unsatisfactory conditions include improper diameter of pipe ends, damaged interior liner, poorly prepared joints, improper curing of joints, moving pipe before joints are cured, bending pipe to follow abrupt changes in trench contours, leaving pipe ends open in trench overnight, not properly drying joints after rain storms, exceeding effective adhesive life, sharp objects in trench bed, backfill that could damage pipe, improper procedure for concrete encasement of pipe, omission of thrust blocks at changes in direction. Unsatisfactory conditions include any other condition which could have an adverse effect on the satisfactory completion and operation of the piping system.

1.4 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES.

SD-06 Instructions

Installation; GA.

The manufacturer's recommendations for each material or procedure to be utilized.

SD-08 Statements

Waste Water Disposal Method; GA.

The method proposed for disposal of wastewater from hydrostatic tests and disinfection, prior to performing hydrostatic tests.

Satisfactory Installation; FIO.

A statement signed by the principal officer of the contracting firm stating that the installation is satisfactory and in accordance with the contract drawings and specifications and the manufacturer's prescribed procedures and techniques, upon completion of the project and before final acceptance.

SD-09 Reports

Bacteriological Disinfection; GA.

Test results from commercial laboratory verifying disinfection.

SD-13 Certificates

Manufacturer's Representative; GA.

The name and qualifications of the manufacturer's representative and written certification from the manufacturer that the representative is technically qualified in all phases of PE, RTRP, and/or RPMP pipe laying and jointing and experienced to supervise the work and train the Contractor's field installers, prior to commencing installation.

Installation; FIO.

A statement signed by the manufacturer's field representative certifying that the Contractor's personnel are capable of properly installing the pipe on the project.

Meters; GA.

Manufacturer's certificate stating that each meter furnished has been tested for accuracy of registration and compliance with the accuracy and capacity requirements of the appropriate AWWA standard.

1.5 HANDLING

Pipe and accessories shall be handled so as to ensure delivery to the trench in sound, undamaged condition. Particular care shall be taken not to injure the pipe coating or lining. If the coating or lining of any pipe or fitting is damaged, the Contractor at his expense shall make the repair in a satisfactory manner. No other pipe or material of any kind shall be placed inside a pipe or fitting after the coating has been applied. Pipe shall be carried into position and not dragged. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe. The interior of pipe and accessories shall be thoroughly cleaned of foreign matter before being lowered into the trench and shall be kept clean during laying operations by plugging or other approved method. Before installation, the pipe shall be inspected for defects. Material found to be defective before or after laying shall be replaced with sound material without additional expense to the Government. Rubber gaskets that are not to be installed immediately shall be stored in a cool and dark place.

1.5.1 Coated and Wrapped Steel Pipe

Coated and wrapped steel pipe shall be handled in conformance with AWWA C203.

1.5.2 Polyethylene (PE) Pipe

PE pipe, fittings, and accessories shall be handled in conformance with AWWA C901.

1.5.3 Miscellaneous Plastic Pipe and Fittings

Polyvinyl Chloride (PVC), Reinforced Thermosetting Resin Pipe (RTRP), and Reinforced Plastic Mortar Pressure (RPMP) pipe and fittings shall be handled and stored in accordance with the manufacturer's recommendations. Storage facilities shall be classified and marked in accordance with NFPA 704, with classification as indicated in NFPA 49 and NFPA 325M.

PART 2 PRODUCTS

2.1 PIPE

Pipe shall conform to the respective specifications and other requirements specified below.

2.1.1 Reinforced and Prestressed Concrete Pipe

Publication	Range of Diameter Size mm (Inches)
AWWA C303 (Reinforced)	250-1050 (10-42)
AWWA C300 (Reinforced)	600-3600 (24-144)
AWWA C301 (Prestressed)	400-3600 (16-144)

In certain localities 150 mm and 200 mm (6- and 8-inch) prestressed concrete pipe is available. When such pipe is available, require it to conform to AWWA C303 with the following exceptions:

Nominal inside diameter of pipe, mm	150	200
(inches)	(6)	(8)
Nominal lining thickness, mm	6.6	6.6
(inch)	(1/4)	(1/4)
Nominal coating thickness, mm	25	25
(inch)	(1)	(1)
Class 150		
Total steel area per meter, square mm	1990	1990
(per foot, square inch)	(0.94)	(0.94)
Minimum cylinder thickness, mm	1.519	1.519
(gauge)	16	16

Steel-cylinder reinforced concrete pipe shall conform to AWWA C300, AWWA C301, or AWWA C303 and shall be designed to withstand a working pressure of not less than 1.03 MPa (150 psi) unless otherwise shown or specified.

2.1.2 Plastic Pipe

2.1.2.1 Polyethylene Plastic (PE)

Pipe, tubing, and heat-fusion fittings shall conform to AWWA C901.

2.1.2.2 Polyvinyl Chloride (PVC) Plastic Pipe

Pipe, couplings and fittings shall be manufactured of material conforming to ASTM D 1784, Class 12454B.

a. Pipe Less Than 100 mm (4 inch) Diameter:

(1) Screw-Joint: Pipe shall conform to dimensional requirements of ASTM D 1785 Schedule 80, with joints meeting requirements of 1.03 MPa (150 psi) working pressure, 1.38 MPa (200 psi) hydrostatic test pressure, unless otherwise shown or specified. Pipe couplings when used, shall be tested as required by ASTM D 2464.

(2) Elastomeric-Gasket Joint: Pipe shall conform to dimensional requirements of ASTM D 1785. Schedule 40 with joints meeting the requirements of 1.03 MPa (150 psi) working pressure, 1.38 MPa (200 psi) hydrostatic test pressure, unless otherwise shown or specified, or it may be pipe conforming to requirements of ASTM D 2241, elastomeric joint, with the following applications:

SDR	Maximum Working Pressure MPa	Minimum Hydrostatic Pressure MPa
26	0.689	0.917
21	0.827	1.103
17	1.034	1.379
13.5	1.379	1.834

SDR	Maximum Working Pressure psi	Minimum Hydrostatic Pressure psi
26	100	133
21	120	160
17	150	200
13.5	200	266

(3) Solvent Cement Joint: Pipe shall conform to dimensional requirements of ASTM D 1785 or ASTM D 2241 with joints meeting the requirements of 1.03 MPa (150 psi) working pressure and 1.38 MPa (200 psi) hydrostatic test pressure.

b. Pipe 100 mm (4 inch) through 300 mm (12 Inch)

Diameter: Pipe, couplings and fittings shall conform to AWWA C900, Class 150, CIOD pipe dimensions, elastomeric-gasket joint, unless otherwise shown or specified.

c. Pipe 350 mm (14 Inch) through 900 mm (36 Inch)

Diameter: Pipe shall conform to AWWA C905 unless otherwise shown or specified.

2.1.3 Reinforced Plastic Mortar Pressure (RPMP) Pipe

RPMP shall be produced by centrifugal casting and shall have an OD 304 to 1219 mm 12 to 48 inches equal to ductile-iron, with a 1034 kPa 150 psi pressure rating and with a minimum pipe stiffness of 248 kPa 36 psi. RPMP shall be in accordance with AWWA C950.

2.1.4 Reinforced Thermosetting Resin Pipe (RTRP)

Pipe shall have a quick-burst strength greater than or equal to four times the normal working pressure of the pipe. The quick-burst strength test shall conform to the requirements of ASTM D 1599.

2.1.4.1 RTRP-I

RTRP-I shall conform to ASTM D 2996, except pipe shall have an outside diameter equal to cast iron outside diameter or standard weight steel pipe. The pipe shall be suitable for a normal working pressure of 1.03 MPa (150 psi) at 23 degrees C. (73 degrees F.) The inner surface of the pipe shall have a smooth uniform continuous resin-rich surface liner conforming to ASTM D 2996.

2.1.4.2 RTRP-II

RTRP-II shall conform to ASTM D 2997. Pipe shall have an outside diameter equal to standard weight steel pipe.

2.1.5 Ductile-Iron Pipe

Ductile-iron pipe shall conform to AWWA C151, or KS D 4311 working pressure not less than 1.03 MPa (150 psi) unless otherwise shown or specified. Pipe shall be cement-mortar lined in accordance with AWWA C104. Linings shall be standard. When installed underground, pipe shall be encased with 8 mil thick polyethylene in accordance with AWWA C105. Flanged ductile iron pipe with threaded flanges shall be in accordance with AWWA C115.

2.1.6 Steel Pipe

2.1.6.1 Galvanized-Steel Pipe

Galvanized-steel pipe shall conform to ASTM A 53, standard weight. Protective Materials for Steel Pipe Protective materials for steel pipe, except as otherwise specified, shall be mechanically applied in a factory or plant especially equipped for the purpose. The materials shall, unless otherwise indicated on the drawings, consist of one of the following for the indicated pipe material and size:

a. Pipe and fittings less than 80 mm (3 inches) in diameter shall be thoroughly cleaned of foreign material by wire brushing and solvent cleaning, and then given one coat of coal-tar primer and two coats of coal-tar enamel conforming to AWWA C203; threaded ends of pipe and fittings shall be adequately protected prior to coating.

b. Pipe 80 mm (3 Inches) or Larger, Not Galvanized:

(1) Cement-mortar coating and lining shall conform to and shall be applied in conformity with AWWA C205. Cement-mortar coating and linings shall not be used for pipe less than 100 mm (4 inches) in diameter.

(2) Coal-tar enamel lining, coating and wrapping shall conform to AWWA C203 for materials, method of application, tests and handling. Non-asbestos material shall be used for the outerwrap.

(3) Cement-mortar lining, in lieu of coal-tar enamel lining, may be used with coal-tar enamel coating and wrapping. Cement-mortar lining shall conform to and shall be applied in conformity with AWWA C205.

2.1.6.2 STAINLESS STEEL PIPE

Stainless -steel pipe shall conform to KWWA D-100, STS 316-TPD, or AWWA C-220, working pressure not less than 1.03 MPa (150 psi) unless otherwise shown or specified.

2.1.7 Copper Tubing

Copper tubing shall conform to ASTM B 88, Type K, annealed.

2.2 FITTINGS AND SPECIALS

2.2.1 Reinforced Concrete Pipe System

Reinforced Concrete Pipe Fittings and specials required for closures, curves, bends, branches and connections to valves, pipe, or structures shall be approved by the Contracting Officer and conform to the details furnished by the manufacturer and to AWWA C300, AWWA C301, or AWWA C303 as applicable.

2.2.2 Polyvinyl Chloride (PVC) Pipe

a. For pipe less than 100 mm (4 inch) diameter:

Fittings for threaded pipe shall conform to requirements of ASTM D 2464, threaded to conform to the requirements of ASME B1.20.1 for use with Schedule 80 pipe and fittings, fittings for solvent cement jointing shall conform to ASTM D 2466 or ASTM D 2467, and fittings for elastomeric-gasket joint pipe shall be iron conforming to AWWA C110 or AWWA C111. Iron fittings and specials shall be cement-mortar lined (standard thickness) in accordance with AWWA C104.

b. For pipe 100 mm (4 inch) (4 inch) diameter and larger:

Fittings and specials shall be iron, bell end in accordance with AWWAC110, 1.03 MPa (150 psi) pressure rating unless otherwise shown or specified, except that profile of bell may have special dimensions as required by the pipe manufacturer; or may be fittings and specials of the same material as the pipe with elastomeric gaskets, all in conformance with AWWA C900. Iron fittings and specials shall be cement-mortar lined (standard thickness) in accordance with AWWA C104. Fittings shall be bell and spigot or plain end pipe, or as applicable. Ductile iron compact fittings shall be in accordance with AWWA C153.

2.2.3 RTRP and RPMP Pipe

Fittings and specials shall be compatible with the pipe supplied. Filament wound or molded fittings up to 150 mm (6 inches) shall conform to AWWA C950. Iron fittings shall be cement-mortar lined in accordance with AWWA C104 and shall conform to AWWA C110 and AWWA C111. Fittings shall be suitable for working and testing pressures specified for the pipe.

2.2.4 Ductile-Iron Pipe

Fittings and special shall be suitable for 1.03 MPa (150 psi) pressure rating, unless otherwise specified. Fittings and specials for mechanical joint pipe shall conform to AWWA C110 or KS D 4308. Fittings and specials for use with push-on joint pipe shall conform to AWWA C110 and AWWA C111 or KS D 4308. Fittings and specials for grooved and shouldered end pipe shall conform to AWWA C606. Fittings and specials shall be cement-mortar lined (standard thickness) in accordance with AWWA C104 or KS D 4308. Ductile iron compact fittings shall conform to AWWA C153.

2.2.5 Steel Pipe

2.2.5.1 Steel Pipe Not Galvanized

Fittings and specials shall be made of the same material as the pipe. Specials and fittings may be made of standard steel tube turns or segmentally welded sections, with ends to accommodate the type of couplings or joints specified for the pipe. Dimensions of steel-pipe fittings shall be in accordance with AWWA C208. The thickness and pressure rating of pipe fittings and specials shall be not less than the thickness specified and the pressure rating calculated for the pipe with which they are used. Protective materials for fittings and specials shall be as specified for the pipe. Specials and fittings that cannot be mechanically lined, coated, and wrapped shall be lined, coated, and wrapped by hand, using the same material used for the pipe with the same number of applications of each material carefully and smoothly applied.

2.2.5.2 Galvanized-Steel Pipe

Steel fittings shall be galvanized. Screwed fittings shall conform to ASME B16.3. Flanged fittings shall conform to AWWA C207.

2.2.5.3 Stainless-steel pipe

Stainless steel pipe fittings and specials shall conform to KWWA D-101, or AWWA C220, working pressures not less than 1,03Mpa. For connection to dissimilar metallic piping, see paragraph 2.2.5.4.

2.2.5.4 Dielectric Fittings

Dielectric fittings shall be installed between threaded ferrous and nonferrous metallic pipe, fittings and valves, except where corporation stops join mains. Dielectric fittings shall prevent metal-to-metal contact of dissimilar metallic piping elements and shall be suitable for the required working pressure.

2.2.6 Copper Tubing

Fittings and specials shall be flared and conform to ASME B16.26.

2.3 JOINTS

2.3.1 Reinforced Concrete Pipe

Rubber-gasket joints shall be of the type using a bell-and-spigot joint design of steel. The gaskets shall conform to AWWA C300, AWWA C301, or AWWA C303, as applicable.

2.3.2 Plastic Pipe

2.3.2.1 Polyethylene (PE) Pipe

Joints for pipe fittings and couplings shall be strong tight joints as specified for PE in Paragraph INSTALLATION. Joints connecting pipe of differing materials shall be made in accordance with the manufacturer's recommendation as approved by the Contracting Officer.

2.3.2.2 Polyvinyl Chloride Pipe

Joints, fittings, and couplings shall be as specified for PVC pipe. Joints connecting pipe of differing materials shall be made in accordance with the manufacturer's recommendations as approved by the Contracting Officer.

2.3.3 RPMP Pipe

Joints shall be mechanical or bell and spigot type with elastomeric gasket.

2.3.4 RTRP

2.3.4.1 RTRP-I, Grade I and 2 Joints shall be bell and spigot with elastomeric gasket, mechanical coupling with elastomeric gasket, threaded and bonded coupling, or tapered bell and spigot with compatible adhesive. All RTRP-I materials shall be products of a single manufacturer.

2.3.4.2 RTRP-II, Grade 1 and 2

Joints shall be the bell and spigot type with elastomeric gasket, bell and spigot with adhesive, butt-jointed with adhesive bonded reinforced overlay, mechanical, flanged, threaded or commercially available proprietary joints, provided they are capable of conveying water at the pressure and temperature of the pipe.

2.3.5 Ductile-Iron Pipe

a. Mechanical joints shall be of the stuffing box type and shall conform to AWWA C111.

b. Push-on joints shall conform to AWWA C111.

c. Rubber gaskets and lubricant shall conform to the applicable requirements of AWWA C111.

2.3.6 Steel Pipe

2.3.6.1 Steel Pipe, Not Galvanized

a. Mechanical couplings shall be as hereinafter specified.

b. Bell-and-spigot joints for use with rubber gaskets shall conform to AWWA C200, as appropriate for the type of pipe. Rubber gaskets shall conform to applicable requirements of AWWA C200.

c. Flanges shall conform to AWWA C207, and shall be used only in above ground installation or where shown on the drawings, or when approved.

2.3.6.2 Mechanical Couplings

Mechanical couplings for steel pipe shall be the sleeve type, or when approved, the split-sleeve type and shall provide a tight flexible joint under all reasonable conditions, such as pipe movements caused by expansion, contraction, slight setting or shifting in the ground, minor variations in trench gradients, and traffic vibrations. Couplings shall be of strength not less than the adjoining pipeline.

2.3.6.3 Stainless-steel pipe

Stainless steel pipe joints shall conform to KWWA D-101, or AWWA C220, working pressures not less than 1,03Mpa. For connection to dissimilar metallic piping, see paragraph 2.3.8.

2.3.7 Bonded Joints

Where indicated, a metallic bond shall be provided at each joint, including joints made with flexible couplings, caulking, or rubber gaskets, of ferrous-metallic piping to effect continuous conductivity. The bond wire shall be Size 1/0 copper conductor suitable for direct burial shaped to stand clear of the joint. The bond shall be of the thermal weld type.

2.3.8 Isolation Joints

Isolation joints shall be installed between non-threaded ferrous and nonferrous metallic pipe, fittings and valves. Isolation joints shall consist of a sandwich-type flange isolation gasket of the dielectric type, isolation washers, and isolation sleeves for flange bolts. Isolation gaskets shall be full faced with outside diameter equal to the flange outside diameter. Bolt isolation sleeves shall be full length. Units shall be of a shape to prevent metal-to-metal contact of dissimilar metallic piping elements.

a. Sleeve-type couplings shall be used for joining plain end pipe sections. The two couplings shall consist of one steel middle ring, two steel followers, two gaskets, and the necessary steel bolts and nuts to compress the gaskets.

b. Split-sleeve type couplings may be used in aboveground installations when approved in special situations and shall consist of gaskets and a housing in two or more sections with the necessary bolts and nuts.

2.3.9 Copper Tubing

Joints shall be compression-pattern flared and shall be made with fittings hereinafter specified.

2.4 VALVES

2.4.1 Check Valves

Check valves shall be designed for a minimum working pressure of 1.03 Mpa (150 psi) or as indicated. Valves shall have a clear waterway equal to the full nominal diameter of the valve. Valves shall open to permit flow when inlet pressure is greater than the discharge pressure, and shall close tightly to prevent return flow when discharge pressure exceeds inlet pressure. The size of the valve, working pressure, manufacturer's name, initials, or trademark shall be cast on the body of each valve. Valves 50 mm (2 inches) and larger shall be spring loaded or other special loaded type.

a. Valves 50 mm (2 inches) and smaller shall be all bronze designed for screwed fittings, and shall conform to MSS SP-80, Class 150, Types 3 and 4 as suitable for the application.

b. Valves larger than 50 mm (2 inches) shall be iron body, bronze mounted, shall have flanged ends, and shall be the non-slam type. Flanges shall be the Class 125 type conforming to ASME B16.1.

2.4.2 Gate Valves

Gate valves shall be designed for a working pressure of not less than 1.03 MPa (150 psi). Valve connections shall be as required for the piping in which they are installed. Valves shall have a clear waterway equal to the full nominal diameter of the valve, and shall be opened by turning counterclockwise. The operating nut or wheel shall have an arrow, cast in the metal, indicating the direction of opening.

a. Valves smaller than 80 mm (3 inches) shall be all bronze and shall conform to MSS SP-80, Type 1, Class 150.

b. Valves 80 mm (3 inches) and larger shall be iron body, bronze mounted, and shall conform to AWWA C500. Flanges shall not be buried. An approved pit shall be provided for all flanged connections.

c. Resilient-Seated Gate Valves: For valves 80 to 300 mm (3 to 12 inches) in size, resilient-seated gate valves shall conform to AWWA C509.

2.4.3 Rubber-Seated Butterfly Valves

Rubber-seated butterfly valves shall conform to the performance requirements of AWWA C504. Wafer type valves conforming to the performance requirements of AWWA C504 in all respects, but not meeting laying length requirements will be acceptable if supplied and installed with a spacer providing the specified laying length. All tests required by AWWA C504 shall be met. Flanged-end valves shall be installed in an approved pit and provided with a union or sleeve-type coupling in the pit to permit removal. Mechanical-end valves 80 mm (3 inches) through 250 mm (10 inches) in diameter may be direct burial if provided with a suitable valve box, means for manual operation, and an adjacent pipe joint to facilitate valve removal. Valve operators shall restrict closing to a rate requiring approximately 60 seconds, from fully open to fully closed.

2.4.4 Pressure Reducing Valves

Pressure reducing valves shall maintain a constant downstream pressure regardless of fluctuations in demand. Valves shall be suitable for the operating pressure on the inlet side, with outlet pressure indicated on the drawing or indicated by the COR. The valves shall be of the hydraulically-operated, pilot controlled, globe or angle type, and may be actuated either by diaphragm or piston. The pilot control shall be the diaphragm-operated, adjustable, spring-loaded type, designed to permit flow when controlling pressure exceeds the spring setting. Ends shall be threaded or flanged. Valve bodies shall be bronze, cast iron or cast steel with bronze trim. Valve stem shall be stainless steel. Valve discs and diaphragms shall be synthetic rubber. Valve seats shall be bronze. Pilot controls shall be bronze with stainless steel working parts.

2.4.5 Vacuum and Air Relief Valves

Vacuum and air relief valves shall be of the size shown and shall be of a type that will release air and prevent the formation of a vacuum. The valves shall automatically release air when the lines are being filled with water and shall admit air into the line when water is being withdrawn in excess of the inflow. Valves shall be iron body with bronze trim and stainless steel float.

2.4.6 Indicator Post for Valves

Each valve shown on the drawings with the designation "P.I.V." shall be equipped with indicator post conforming to the requirements of NFPA 24. Operation shall be by a wrench which will be attached to each post.

2.5 VALVE BOXES

Valve boxes shall be cast iron or concrete, except that concrete boxes may be installed only in locations not subjected to vehicular traffic. Cast-iron boxes shall be extension type with slide-type adjustment and with flared base. The minimum thickness of metal shall be 5 mm. (3/16 inch.) Concrete boxes shall be the standard product of a manufacturer of precast concrete equipment. The word "WATER" shall be cast in the cover. The box length shall adapt, without full extension, to the depth of cover required over the pipe at the valve location.

2.6 VALVE PITS

Valve pits shall be constructed at locations indicated or as required above and in accordance with the details shown. Concrete shall have compressive strength of 21 MPa (3000 psi, 210 Kg/square centi-meter) in accordance with Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

2.7 FIRE HYDRANTS

Hydrants shall be wet-barrel type conforming to AWWA C503, with either an automatic breakoff check valve or an auxiliary gate valve on hydrant branch. Hydrants shall have a 150 mm (6 inch)) bell connection, two 65 mm (2-1/2 inch) hose connections and one 115 mm (4-1/2 inch) pumper connection. Outlets shall have American National Standard fire-hose coupling threads. Working parts shall be bronze. Design, material, and workmanship shall be similar and equal to the latest stock pattern ordinarily produced by the manufacturer. Hydrants shall be painted with one coat of red iron oxide, zinc oxide primer conforming to SSPC Paint 25 and two finish coats of silicone alkyd paint conforming to SSPC Paint 21, color in accordance with NFPA recommendations. Suitable bronze adapter for each outlet, with caps, shall be furnished.

2.8 FIRE-HYDRANT HOSE HOUSES

Hose houses conforming to the requirements of NFPA 24 shall be furnished at each fire hydrant indicated on the drawings to have a fire-hydrant hose house. The following equipment, in addition to that listed in NFPA 24, paragraph 5-6.1, shall be furnished with each hose house:

60 m (200 feet) of 65 mm (2-1/2 inch) woven jacketed, rubber lined hose conforming to NFPA 1961 with a minimum service test pressure of 2.06 MPa (300 psi.)

30 m (100 feet) of 40 mm (1-1/2 inch), woven jacketed, rubber lined hose conforming to NFPA 1961 with a minimum service test pressure of 2.06 MPa (300 psi).

One gated 65 mm (2-1/2 inch) by 40 mm (1-1/2 inch) by 40 mm (1-1/2 inch) wye.

One playpipe for 65 mm (2-1/2 inch) hose with 25 mm (1 inch) shutoff nozzle tip.

One playpipe for 40 mm (1-1/2 inch) hose with 15 mm (1/2 inch) shutoff nozzle or combination nozzle.

Two adapter fittings, 65 mm (2-1/2 inch) to 40 mm (1-1/2 inch.)

Two spanners for 40 mm (1-1/2 inch) hose.

2.9 MISCELLANEOUS ITEMS

2.9.1 Service Clamps

Service clamps shall have a pressure rating not less than that of the pipe to be connected and shall be either the single or double flattened strap type. Clamps shall have a galvanized malleable-iron body with cadmium plated straps and nuts. Clamps shall have a rubber gasket cemented to the body.

2.9.2 Corporation Stops

Corporation stops shall have standard corporation stop thread conforming to AWWA C800 on the inlet end, with flanged joints, compression pattern flared tube couplings, or wiped joints for connections to goosenecks.

2.9.3 Goosenecks

Copper tubing for gooseneck connections shall conform to the applicable requirements of ASTM B 88, Type K, annealed. Length of cable requirement connections shall be in accordance with standard practice.

2.9.4 Service Stops

Service stops shall be water-works inverted-ground-key type, oval or round flow way, tee handle, without drain. Pipe connections shall be suitable for the type of service pipe used. All parts shall be of bronze with female iron-pipe-size connections or compression-pattern flared tube couplings, and shall be designed for a hydrostatic test pressure not less than 1.375 MPa (200 psi).

2.9.5 Tapping Sleeves

Tapping sleeves of the sizes indicated for connection to existing main shall be the cast gray, ductile, or malleable-iron, split-sleeve type with flanged or grooved outlet, and with bolts, follower rings and gaskets on each end of the sleeve. Construction shall be suitable for a maximum working pressure of 1.03 MPa ([150 psi.) Bolts shall have square heads and hexagonal nuts. Longitudinal gaskets and mechanical joints with gaskets shall be as recommended by the manufacturer of the sleeve. When using grooved mechanical tee, it shall consist of an upper housing with full locating collar for rigid positioning which engages a machine-cut hole in pipe, encasing an elastomeric gasket which conforms to the pipe outside diameter around the hole and a lower housing with positioning lugs, secured together during assembly by nuts and bolts as specified, pre-torqued to 67.8 Newton meters (50 foot-pound.)

2.9.6 Service Boxes

Service boxes shall be cast iron or concrete and shall be extension service boxes of the length required for the depth of the line, with either screw or slide-type adjustment. The boxes shall have housings of sufficient size to completely cover the service stop or valve and shall be complete with identifying covers.

2.9.7 Disinfection

Chlorinating materials shall conform to the following:

Chlorine, Liquid: AWWA B301.

Hypochlorite, Calcium and Sodium: AWWA B300.

2.9.8 Meters

Meters shall be the type and size shown on the drawings or specified herein. Meters of each of the various types furnished and installed under this contract shall be supplied by one manufacturer.

2.9.8.1 Displacement Type

Displacement type meters shall conform to AWWA C700. Registers shall be straight-reading and shall read in cubic meters, U.S. gallons, or cubic feet. Meters in sizes 13 mm (1/2 inch) through 25 mm (1 inch) shall be frost-protection design. Connections shall be suitable to the type of pipe and conditions encountered. Register type shall be a direct-reading remote register designed in accordance with AWWA C706 or an encoder-type remote register designed in accordance with AWWA C707. Meters shall comply with the accuracy and capacity requirements of AWWA C700.

2.9.8.2 Turbine Type

Turbine type meters shall conform to AWWA C701 Class I or Class II. The main casing shall be bronze or cast iron protected by corrosion resistant coating with stainless steel external fasteners. Registers shall be straight-reading type, shall be permanently sealed open and shall read in cubic meters, U.S. gallons or cubic feet. Connections shall be suitable to the type of pipe and conditions encountered. Register type shall be a direct-reading remote register designed in accordance with AWWA C706 or an encoder-type remote register designed in accordance with AWWA C707. Meters shall comply with the accuracy and capacity requirements of AWWA C701.

2.9.8.3 Compound Type

Compound type meters shall conform to AWWA C702 and shall be furnished with strainers. The main casing shall be bronze or cast iron protected by corrosion resistant coating] with stainless steel external-fasteners. The main casing shall be tapped for field testing purposes. Registers shall be straight-reading type, shall be permanently sealed and shall read in cubic meters, U.S. gallons or cubic feet as designated by the COR. The meter shall or shall not be equipped with a coordinating register. Connections shall be suitable to the type of pipe and conditions encountered. Register type shall be a direct-reading remote register designed in accordance with AWWA C706 or an encoder-type remote register designed in accordance with AWWA C707. Meters shall comply with the accuracy and capacity requirements of AWWA C702.

2.9.8.4 Fire Service Type

Fire service type meters shall be proportional type or turbine type conforming to AWWA C703 as directed by the COR and shall or shall not be furnished with strainers as directed by the COR. The main casing shall be bronze or cast iron protected by corrosion resistant coating] with stainless steel external fasteners. Registers shall be straight-reading type, shall be permanently sealed and shall read in cubic meters, U.S. gallons or cubic feet. The meter shall or shall not be equipped with a coordinating register as indicated by the designer. Connections shall be suitable to the type of pipe and conditions encountered. Register type shall be a direct-reading remote register designed in accordance with AWWA C706 or an encoder-type remote register designed in accordance with AWWA C707. Meters shall comply with the accuracy and capacity requirements of AWWA C703. When turbine type main line meters are used, the meter shall be supplied with a separate check valve, as a unit.

2.9.8.5 Propeller Type

Propeller type meters shall conform to AWWA C704. Registers shall be straight-reading type, shall be [permanently sealed] [open] and shall read in [cubic meters] [U.S. gallons] [cubic feet]. Connections shall be suitable to the type of pipe and conditions encountered. Register type shall be [a direct-reading remote register designed in accordance with AWWA C706 or an encoder-type remote register designed in accordance with AWWA C707. Meters shall comply with the accuracy and capacity requirements of AWWA C703.

2.9.9 Meter Boxes

Meter boxes shall be of cast iron, concrete, or plastic. The boxes shall be of sufficient size to completely enclose the meter and shut-off valve or service stop. Meter boxes set in paved areas subject to vehicular traffic shall be cast iron, or concrete with cast iron lid and cast iron meter reader lid. Boxes set in sidewalks, not subject to vehicular traffic, shall use concrete covers with cast iron meter reader lids. Plastic boxes and lids shall be used in unpaved areas or grass areas not subject to vehicular traffic. Box height shall extend from invert of the meter to final grade at the meter location. The lid shall have the word "WATER" cast in it.

2.10 Meter Vaults

Large meters shall be installed in reinforced concrete vaults in accordance with the details shown on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Cutting of Pipe

Cutting of pipe shall be done in a neat and workmanlike manner without damage to the pipe. Unless otherwise recommended by the manufacturer and authorized by the Contracting Officer, cutting shall be done with an approved type mechanical cutter. Wheel cutter shall be used when practicable. Copper tubing shall be cut square and all burrs shall be removed. Squeeze type mechanical cutters shall not be used for ductile iron.

3.1.2.1 Sewer Lines

Where the location of the water pipe is not clearly defined in dimensions on the drawings, the water pipe shall not be laid closer horizontally than 3 m (10 feet) from a sewer except where the bottom of the water pipe will be at least 300 mm (12 inches) above the top of the sewer pipe. In that case, the water pipe shall not be laid closer horizontally than 1.8 m (6 feet) from the sewer. Where water lines cross under gravity-flow sewer lines, the sewer pipe for a distance of at least 3 m (10 feet) each side of the crossing shall be fully encased in concrete or shall be made of pressure pipe with no joint located within 900 mm (3 feet) horizontally of the crossing. Water lines shall in all cases cross above sewage force mains or inverted siphons and shall be not less than 600 mm (2 feet) above the sewer main. Joints in the sewer main, closer horizontally than 900 mm (3 feet) to the crossing, shall be encased in concrete.

3.1.2.2 Water Lines

Water lines shall not be laid in the same trench with sewer lines, gas lines, fuel lines, or electric wiring.

3.1.2.3 Copper Tubing

Copper tubing shall not be installed in the same trench with ferrous piping materials.

3.1.2.4 Nonferrous Metallic Pipe

Where nonferrous metallic pipe, e.g. copper tubing, crosses any ferrous piping material, a minimum vertical separation of 300 mm (12 inches) shall be maintained between pipes.

3.1.2.5 Casing Pipe

Water pipe shall be encased in a sleeve of rigid conduit for the lengths shown. Sleeves under railroads shall be in accordance with [the Korean railroad company requirements or the criteria contained in AREA-03, Part 5. Where sleeves are required, in all other cases, the pipe sleeve shall be steel, manufactured in accordance with AWWA C200, ASTM A 36, with a minimum wall thickness of 150 mm (6 inches) or reinforced concrete in accordance with ASTM C 76, Class V as specified for storm drains in Section 02720: STORM-DRAINAGE SYSTEM. A minimum clearance of at least 50 mm (2 inches) between the inner wall of the sleeve and the maximum outside diameter of the sleeved pipe and joints shall be provided. Sand bedding or suitable pipe support shall be provided for the water pipe through the sleeve. Sleeves of ferrous material shall be provided with corrosion protection as required in Section: 16640 CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE).

3.1.2.6 Structures

Where water pipe is required to be installed within 1 m (3 feet) of existing structures, the water pipe shall be sleeved as required in Paragraph "Casing Pipe". The Contractor shall take proper precautions during installation of the water pipe and sleeve to ensure that there will be no damage to the structures and no settlement or movement of foundations or footings.

3.1.3 Joint Deflection

3.1.3.1 Reinforced Concrete Pipe

Maximum allowable deflections from a straight line or grade, as required by vertical curves, horizontal curves, or offsets, shall be 5 degrees for reinforced concrete pipe unless a lesser amount is recommended by the manufacturer. Long radius curves in reinforced concrete pipe shall be formed by straight pipe in which spigot rings are placed on a bevel. Slight deflections may be made by straight pipe, provided that the maximum joint opening caused by such deflections does not exceed the maximum recommended by the pipe manufacturer. Short-radius curves and closures shall be formed by shorter lengths of pipe, bevels, or fabricated specials specified.

3.1.3.2 Flexible Plastic Pipe

Maximum offset in alignment between adjacent pipe joints shall be as recommended by the manufacturer and approved by the Contracting Officer, but in no case shall it exceed 5 degrees.

3.1.3.3 Ductile-Iron Pipe

The maximum allowable deflection shall be as given in AWWA C600. If the alignment requires deflection in excess of the above limitations, special bends or a sufficient number of shorter lengths of pipe shall be furnished to provide angular deflections within the limit set forth.

3.1.3.4 Steel Pipe

For pipe with bell-and-spigot rubber-gasket joints, maximum allowable deflections from a straight line or grade, as required by vertical curves, horizontal curves, or offsets shall be 5 degrees unless a lesser amount is recommended by the manufacturer. Short-radius curves and closures shall be formed by short lengths of pipe or fabricated specials specified.

3.1.4 Placing and Laying

Pipe and accessories shall be carefully lowered into the trench by means of derrick, ropes, belt slings, or other authorized equipment. Under no circumstances shall any of the water-line materials be dropped or dumped into the trench. Care shall be taken to avoid abrasion of the pipe coating. Except where necessary in making connections with other lines or as authorized by the Contracting Officer, pipe shall be laid with the bells facing in the direction of laying. The full length of each section of pipe shall rest solidly upon the pipe bed, with recesses excavated to accommodate bells, couplings, and joints. Pipe that has the grade or joint disturbed after laying shall be taken up and relaid. Pipe shall not be laid in water or when trench conditions are unsuitable for the work. Water shall be kept out of the trench until joints are complete. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no trench water, earth, or other substance will enter the pipes or fittings. Where any part of the coating or lining is damaged, the repair shall be made by the Contractor at his expense in a satisfactory manner. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored, as shown.

3.1.4.1 Reinforced Concrete Pipe Installation

Reinforced concrete pipe shall be installed in accordance with recommendations of the pipe manufacturer. Before laying reinforced concrete pipe, the outside surface of the spigot and the inside surface of the bell shall be cleaned and an acceptable vegetable-compound lubricant applied to the inside surface of the bell and to the rubber gasket. Where prescribed by the pipe manufacturer, the gasket shall be placed in the groove on the end of the pipe before the pipe is placed in the trench. After the pipe has been forced together, the position of the rubber gasket shall be checked with a feeler gauge in accordance with the pipe manufacturer's recommendations. Tapping of reinforced concrete cylinder pipe shall be done in accordance with the manufacturer's approved recommendations. Where the manufacturer recommends that the taps be made by attaching the rubber-gasketed saddle to the outside of the pipe using U-bolts, the saddle shall be grouted in if necessary, the mortar coating shall be chipped away even with the hole in the saddle plate. The exposed circumferential wires shall be removed and the cylinder and concrete core drilled out, and the steel saddle and U-bolts shall be protected by concrete encasement.

3.1.4.2 Plastic Pipe Installation

RTRP shall be installed in accordance with ASTM D 3839. RPMP shall be installed in accordance with the recommendations of the manufacturer. PE Pipe shall be installed in accordance with ASTM D 2774. PVC pipe shall be installed in accordance with AWWA M23.

3.1.4.3 Connections

Where connections are made between new work and existing mains, the connections shall be made by using specials and fittings to suit the actual conditions. When made under pressure, these connections shall be installed using standard methods as approved by the Contracting Officer. Connections to existing asbestos-cement pipe shall be made in accordance with ACPPA-01.

3.1.4.4 Penetrations

Pipe passing through walls of valve pits and structures shall be provided with ductile-iron or Schedule 40 steel wall sleeves. Annular space between walls and sleeves shall be filled with rich cement mortar. Annular space between pipe and sleeves shall be filled with mastic.

3.1.4.5 Flanged Pipe

Flanged pipe shall only be installed above ground or with the flanges in valve pits.

3.1.5 Jointing

3.1.5.1 Reinforced-Concrete Pipe

The inside and outside annular spaces between abutting sections of concrete pipe shall be filled with rich cement mortar in accordance with the recommendations of the pipe manufacturer. Excess mortar shall be removed from interior annular spaces, leaving a smooth and continuous surface between pipe sections. Exposed portions of steel joint rings shall be protected from corrosion by a metallic coating or by an approved nonmetallic coating. Rubber gaskets shall be handled, lubricated where necessary, and installed in accordance with the recommendations of the pipe manufacturer.

3.1.5.2 Polyethylene (PE) Pipe

Jointing shall comply with ASTM D 2657, Technique I-Socket Fusion or Technique II-Butt Fusion.

3.1.5.3 Polyvinyl Chloride (PVC) Plastic Pipe

a. Pipe less than 100 mm (4 inch) diameter: Threaded joints shall be made by wrapping the male threads with approved thread tape or applying an approved lubricant, then threading the joining members together. The joint shall be tightened using strap wrenches to prevent damage to the pipe and/or fitting. To avoid excessive torque, joints shall be tightened no more than one thread past hand-tight. Preformed rubber-ring gaskets for elastomeric-gasket joints shall be made in accordance with requirements of ASTM F 477 and as required herein. All pipe ends for push-on joints shall be beveled to facilitate assembly and marked to indicate when the pipe is fully seated. The gasket shall be prelubricated to prevent displacement. The gasket and ring groove in the bell or coupling shall match. The manufacturer of the pipe or fitting shall supply the elastomeric gasket. Couplings shall be provided with stops or centering rings to assure that the coupling is centered on the joint. Solvent cement joints shall use sockets conforming to the requirements of ASTM D 2467. The solvent cement used shall meet the requirements of ASTM D 2564; the joint assembly shall be made in accordance with ASTM D 2855 and the manufacturer's specific recommendations.

b. Pipe 100 mm (4 inch) through 300 mm (12 inch) diameter: Joints shall be elastomeric-gasket as specified in AWWA C900. Jointing procedure shall be as specified for pipe less than 100 mm (4 inch) diameter with configuration using elastomeric ring gasket.

C. Pipe 350 mm (14 inch) through 900 mm (36 inch): Joints shall be elastomeric-gasket push-on joints made in accordance with AWWA M23.

3.1.5.4 RTRP I, RTRP II and RPMP Pipe

RTRP I: Assembly of the pipe shall be done in strict conformance with the manufacturer's written instruction and installation procedures. Field joints shall be prepared as specified by the pipe manufacturer. Several pipe joints having interference-fit type couplings may be field bonded and cured simultaneously. However, the pipe shall not be moved nor shall additional joints be made until the previously laid joints are completely cured. Joints not having interference-fit type coupling shall be fitted with a clamp which shall hold the joint rigidly in place until the joint cement has completely cured. The clamps shall have a protective material on the inner surface to prevent damage to the plastic pipe when the clamp is tightened in place. The pipe manufacturer shall provide a device or method to determine when the joint is pulled against the pipe stop. Additionally, the pipe manufacturer shall furnish a gauge to measure the diameter of the spigot ends to ensure the diameter conforms to the tolerances specified by the manufacturer. All pipe ends shall be gauged. Factory certified tests shall have been satisfactorily performed to verify that short-term rupture strength is 10.3 MPa (1,500 psi) or greater when carried out in accordance with ASTM D 1599. All field bonded epoxy-cemented joints, regardless of ambient temperature, shall be cured with a self-regulating thermostatically temperature controlled electrical heating blanket for the time and temperature recommended by the manufacturer for the applicable size and type of joint, or by an alternate heating method recommended by the manufacturer and approved by the Contracting Officer. The joint sections shall not be moved during heating or until the joint has cooled to ambient temperature.

b. RTRP II: A reinforced overlay joint shall be used to join sections together through a placement of layers of reinforcement fiberglass roving, mat, tape or fabric thoroughly saturated with compatible catalyzed resin.

c. Fittings and Specials for RTRP and RPMP Pipe: Metal to RTRP and RPMP pipe connections shall be made by bolting steel flanges to RTRP and RPMP pipe flanges. Cast-iron fitting with gasket bell or mechanical joint may be used with RTRP if pipe has cast iron outside diameter. Steel flanges shall be flat-faced type. Where raised-face steel flanges are used, spacer rings shall be used to provide a flat-face seat for RTRP and RPMP pipe flanges. A full-face Buna "N" gasket 3.2 mm (1/8 inch) thick with a shore hardness of 50-60 shall be used between all flanged connections. The RTRP and RPMP pipe flange shall have raised sealing rings. Flat washers shall be used under all nuts and bolts on RTRP and RPMP pipe flanges. Bolts and nuts shall be of noncorrosive steel and torqued to not more than 135 Newton meters. (100 foot pounds.) Flanges shall not be buried. A concrete pit shall be provided for all flanged connections.

3.1.5.5 Ductile-Iron Pipe

Mechanical and push-on type joints shall be installed in accordance with AWWA C600 for buried lines or AWWA C606 for grooved and shouldered pipe above ground or in pits.

3.1.5.6 Steel Pipe, Not Galvanized

a. Mechanical Couplings: Mechanical couplings shall be installed in accordance with the recommendations of the couplings manufacturer.

b. Rubber Gaskets: Rubber gaskets shall be handled, lubricated where necessary, and installed in accordance with the recommendations of the pipe manufacturer.

3.1.5.7 Galvanized-Steel Pipe

Screw joints shall be made tight with a stiff mixture of graphite and oil, inert filler and oil, or with an approved graphite compound, applied with a brush to the male threads only. Compounds shall not contain lead.

3.1.5.8 Copper Tubing

Joints shall be made with flared fittings. The flared end tube shall be pulled tightly against the tapered part of the fitting by a nut which is part of the fitting, so there is metal-to-metal contact.

3.1.5.9 Bonded Joints

Bonded joints shall be installed in accordance with details specified for joints in paragraph JOINTS.

3.1.5.10 Isolation Joints and Dielectric Fittings

Isolation joints and dielectric fittings shall be installed in accordance with details specified in paragraph JOINTS. Dielectric unions shall be encapsulated in a field-poured coal-tar covering, with at least 3 mm (1/8 inch) thickness of coal tar over all fitting surfaces.

3.1.5.11 Transition Fittings

Connections between different types of pipe and accessories shall be made with transition fittings approved by the Contracting Officer.

3.1.6 Service Lines

Service lines shall include the pipeline connecting building piping to water distribution lines to the connections with the building service at a point approximately 1.5 m (5 feet) outside the building where such building service exists. Where building services are not installed, the Contractor shall terminate the service lines approximately 1.5 m (5 feet) from the site of the proposed building at a point designated by the Contracting Officer. Such service lines shall be closed with plugs or caps. All service stops and valves shall be provided with service boxes. Service lines shall be constructed in accordance with the following requirements:

3.1.6.1 Service Lines 50 mm (2 Inches) and Smaller Service lines 50 mm (2 inches) and smaller shall be connected to the main by a directly-tapped corporation stop or by a service clamp. A corporation stop and a copper gooseneck shall be provided with either type of connection. Maximum sizes for directly-tapped corporation stops and for outlets with service clamps shall be as in TABLE I. Where 2 or more gooseneck connections to the main are required for an individual service, such connections shall be made with standard branch connections. The total clear area of the branches shall be at least equal to the clear area of the service which they are to supply.

TABLE I. SIZE OF CORPORATION STOPS AND OUTLET

Pipe Size mm (Inches)	Corporation Stops, mm (Inches) For Ductile-Iron Pipe	Outlets w/Service Clamps, mm (Inches) Single & Double Strap
80 (3)	--	25 (1)
100 (4)	25 (1)	25 (1)
150 (6)	32 (1-1/4)	40 (1-1/2)
200 (8)	40 (1-1/2)	50 (2)
250 (10)	40 (1-1/2)	50 (2)
300 (12) & larger	50 (2)	50 (2)

3.1.6.2 Service Lines 40 mm (1-1/2 Inch.) and Smaller Service lines 40 mm (1-1/2 inches) and smaller shall have a service stop.

3.1.6.3 Service Lines 50 mm (2 Inches) in Size Service lines 50 mm (2 inches) in size shall have a gate valve.

3.1.6.4 Service Lines Larger than 50 mm (2 Inches) Service lines larger than 50 mm (2 inches) shall be connected to the main by a tapped saddle, tapping sleeve and valve, service clamp or reducing tee, depending on the main diameter and the service line diameter, and shall have a gate valve. Lines 80 mm (3 inches) and larger may use rubber-seated butterfly valves as specified above, or gate valves.

3.1.6.5 Service Lines for Sprinkler Supplies

Water service lines used to supply building sprinkler systems for fire protection shall be connected to the water distribution main in accordance with NFPA 24.

3.1.7 Field Coating and Lining of Pipe

3.1.7.1 Steel Pipe 80 mm (3 In.) and Larger, Not Galvanized

a. Cement-mortar coating and lining: Field jointing shall conform to Appendix, AWWA C205. Any defective area found in the coating and/or lining of pipe and joints shall be removed to the pipe wall and repaired. The repaired areas shall be at least equal in thickness to the minimum coating and/or lining required for the pipe. Steel reinforcement in the coating shall be repaired or replaced as necessary to assure a complete and soundly reinforced coating.

b. Coal-tar enamel coating, lining and wrapping: Field jointing shall conform to AWWA C203. The applied materials shall be tested by means of a spark-type electrical inspection device in accordance with the requirements of AWWA C203. Any flaws or holidays found in the coating and/or lining of pipe and joints shall be repaired by patching or other approved means. The repaired areas shall be at least equal in thickness to the minimum coating and/or lining required for the pipe.

3.1.7.2 Galvanized-Steel Pipe

Field joints shall be given one coat of coal-tar primer and two coats of coal-tar enamel conforming to AWWA C203. The tests of the coating shall conform to AWWA C203, and any flaws or holidays found in the coating of pipe and joints shall be repaired by patching or other approved means such that the repaired areas will be at least equal in thickness to the minimum coating required for the pipe.

3.1.8 Setting of Fire Hydrants, Meters, Valves and Valve Boxes

3.1.8.1 Location of Fire Hydrants

Fire hydrants shall be located and installed as shown. Each hydrant shall be connected to the main with a 150 mm (6 inch) branch line having at least as much cover as the distribution main. Hydrants shall be set plumb with pumper nozzle facing the roadway, with the center of the lowest outlet not less than 450 mm (18 inches) above the finished surrounding grade, and the operating nut not more than 1.2 m (48 inches) above the finished surrounding grade. Fire hydrants designated on the drawings as low profile shall have the lowest outlet not less than 450 mm (18 inches) above the finished surrounding grade, the top of the hydrant not more than 600 mm (24 inches) above the finished surrounding grade. Except where approved otherwise, the backfill around hydrants shall be thoroughly compacted to the finished gradeline immediately after installation to obtain beneficial use of the hydrant as soon as practicable. The hydrant shall be set upon a slab of concrete not less than 100 mm (4 inches) thick and 400 mm (15 inches) square. Not less than 2 cubic meters (7 cubic feet) of free-draining broken stone or gravel shall be placed around and beneath the waste opening of dry barrel hydrants to ensure drainage.

3.1.8.2 Location of Meters

Meters and meter boxes or Vaults shall be installed at the locations shown on the drawings. The meters shall be centered in the boxes or vaults to allow for reading and ease of removal or maintenance.

3.1.8.3 Location of Valves

After delivery, valves, including those in hydrants, shall be drained to prevent freezing and shall have the interiors cleaned of all foreign matter before installation. Stuffing boxes shall be tightened and hydrants and valves shall be fully opened and fully closed to ensure that all parts are in working condition. Check, pressure reducing, vacuum, and air relief valves shall be installed in valve pits. Valves and valve boxes shall be installed where shown or specified, and shall be set plumb. Valve boxes shall be centered on the valves. Boxes shall be installed over each outside gate valve unless otherwise shown. Where feasible, valves shall be located outside the area of roads and streets. Earth fill shall be carefully tamped around each valve box or pit to a distance of 1.2 m (4 feet) on all sides of the box, or the undisturbed trench face if less than 1.2 m. (4 feet.)

3.1.8.4 Location of Service Boxes

Where water lines are located below paved streets having curbs, the boxes shall be installed directly back of the curbs. Where no curbing exists, service boxes shall be installed in accessible locations, beyond the limits of street surfacing, walks and driveways.

3.1.9 Tapped Tees and Crosses

Tapped tees and crosses for future connections shall be installed where shown.

3.1.10 Thrust Restraint

Plugs, caps, tees and bends deflecting 11-1/4 degrees or more, either vertically or horizontally, on waterlines 100 mm (4 inches) in diameter or larger, and fire hydrants shall be provided with thrust restraints. Valves shall be securely anchored or shall be provided with thrust restraints to prevent movement. Thrust restraints shall be either thrust blocks or, for ductile-iron pipes, restrained joints.

3.1.10.1 Thrust Blocks

Thrust blocking shall be concrete of a mix not leaner than: 1 cement, 2-1/2 sand, 5 gravel; and having a compressive strength of not less than 14 MPa (2,000 psi) after 28 days. Blocking shall be placed between solid ground and the hydrant or fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of thrust blocks shall be poured directly against undisturbed earth. The sides of thrust blocks not subject to thrust may be poured against forms. The area of bearing shall be as shown or as directed. Blocking shall be placed so that the fitting joints will be accessible for repair. Steel rods and clamps, protected by galvanizing or by coating with bituminous paint, shall be used to anchor vertical down bends into gravity thrust blocks.

3.1.10.2 Restrained Joints

For ductile-iron pipe, restrained joints shall be designed by the Contractor or the pipe manufacturer in accordance with DIPRA-01.

3.2 HYDROSTATIC TESTS

Where any section of a water line is provided with concrete thrust blocking for fitting or hydrants, the hydrostatic tests shall not be made until at least 5 days after installation of the concrete thrust blocking, unless otherwise approved.

3.2.1 Pressure Test

After the pipe is laid, the joints completed, fire hydrants permanently installed, and the trench partially backfilled leaving the joints exposed for examination, the newly laid piping or any valved section of piping shall, unless otherwise specified, be subjected for 1 hour to a hydrostatic pressure test of 1.38 MPa (200 psi). Water supply lines designated on the drawings shall be subjected for 1 hour to a hydrostatic pressure test of 1.38 MPa (200 psi) Each valve shall be opened and closed several times during the test. Exposed pipe, joints, fittings, hydrants, and valves shall be carefully examined during the partially open trench test. Joints showing visible leakage shall be replaced or remade as necessary. Cracked or defective pipe, joints, fittings, hydrants and valves, discovered in consequence of this pressure test shall be removed and replaced with sound material, and the test shall be repeated until the test results are satisfactory. The requirement for the joints to remain exposed for the hydrostatic tests may be waived by the Contracting Officer when one or more of the following conditions is encountered:

a. Wet or unstable soil conditions in the trench.

b. Compliance would require maintaining barricades and walkways around and across an open trench in a heavily used area that would require continuous surveillance to assure safe conditions.

c. Maintaining the trench in an open condition would delay completion of the contract.

The Contractor may request a waiver, setting forth in writing the reasons for the request and stating the alternative procedure proposed to comply with the required hydrostatic tests. Backfill placed prior to the tests shall be placed in accordance with the requirements of Section 02222: EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS.

3.2.2 Leakage Test

Leakage test shall be conducted after the pressure tests have been satisfactorily completed. The duration of each leakage test shall be at least 2 hours, and during the test the water line shall be subjected to not less than 1.38 MPa (200 psi) pressure. Water supply lines designated on the drawings shall be subjected to a pressure equal to 1.38 MPa (200 psi) Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or any valved or approved section thereof, necessary to maintain pressure within 34.5 kPa (5 psi) of the specified leakage test pressure after the pipe has been filled with water and the air expelled. No piping installation will be accepted if leakage exceeds the allowable leakage which is determined by the following formula:

L = 0.0001351ND(P raised to 1/2 power)

L = Allowable leakage in gallons per hour

N = Number of joints in the length of pipeline tested

D = Nominal diameter of the pipe in inches

P = Average test pressure during the leakage test, in psi gauge

Should any test of pipe disclose leakage greater than that calculated by the above formula, the defective joints shall be located and repaired until the leakage is within the specified allowance, without additional cost to the Government.

3.2.3 Time for Making Test

Except for joint material setting or where concrete thrust blocks necessitate a 5-day delay, pipelines jointed with rubber gaskets, mechanical or push-on joints, or couplings may be subjected to hydrostatic pressure, inspected, and tested for leakage at any time after partial completion of backfill. Cement-mortar lined pipe may be filled with water as recommended by the manufacturer before being subjected to the pressure test and subsequent leakage test.

3.2.4 Concurrent Hydrostatic Tests

The Contractor may elect to conduct the hydrostatic tests using either or both of the following procedures. Regardless of the sequence of tests employed, the results of pressure tests, leakage tests, and disinfection shall be satisfactory as specified. All replacement, repair or retesting required shall be accomplished by the Contractor at no additional cost to the Government.

a. Pressure test and leakage test may be conducted concurrently.

b. Hydrostatic tests and disinfection may be conducted concurrently, using the water treated for disinfection to accomplish the hydrostatic tests. If water is lost when treated for disinfection and air is admitted to the unit being tested, or if any repair procedure results in contamination of the unit, disinfection shall be re-accomplished.

3.3 DISINFECTION

3.3.1 Bacteriological Disinfection

Before acceptance of potable water operation, each unit of completed waterline shall be disinfected as prescribed by AWWA C651 or as specified herein. After pressure tests have been made, the unit to be disinfected shall be thoroughly flushed with water until all entrained dirt and mud have been removed before introducing the chlorinating material. The chlorinating material shall be either liquid chlorine, calcium hypochlorite, or sodium hypochlorite, conforming to paragraph MISCELLANEOUS ITEMS. The chlorinating material shall provide a dosage of not less than 50 ppm and shall be introduced into the water lines in an approved manner. Polyvinyl Chloride (PVC) pipe lines shall be chlorinated using only the above specified chlorinating material in solution. In no case will the agent be introduced into the line in a dry solid state. The treated water shall be retained in the pipe long enough to destroy all non-spore-forming bacteria. Except where a shorter period is approved, the retention time shall be at least 24 hours and shall produce not less than 25 ppm of free chlorine residual throughout the line at the end of the retention period. All valves on the lines being disinfected shall be opened and closed several times during the contact period. The line shall then be flushed with clean water until the residual chlorine is reduced to less than 1.0 ppm. During the flushing period, each fire hydrant on the line shall be opened and closed several times. From several points in the unit, personnel from the Contractor's commercial laboratory shall take at least 3 water samples from different points, approved by the Contracting Officer, in proper sterilized containers and perform a bacterial examination in accordance with state approved methods. The commercial laboratory must be certified by the state's approving authority for examination of potable water. The disinfection shall be repeated until tests indicate the absence of pollution for at least 2 full days. The unit will not be accepted until satisfactory bacteriological results have been obtained.

3.3.2 Lead Residual

Following the bacteriological disinfection and testing, the system shall be flushed with a sufficient velocity of water and sufficient tests performed at each hot- and cold-water discharge point until no more than 15 ppb lead residuals remain in the system. All tests and samples shall be performed in accordance with state and, if applicable, Federal regulations. Samples for testing are to be collected after a 6-hour continuous period of no flushing, and will be considered first draw samples. The commercial laboratory must be certified by the state's approving authority for examination of potable water. Lead residual test results are to be submitted to the Contracting Officer. The system will not be accepted until satisfactory bacteriological results and lead residual test results have been obtained. All flushing and testing for lead residuals, including all costs, are the responsibility of the Contractor.

3.4 CLEANUP

Upon completion of the installation of water lines, and appurtenances, all debris and surplus materials resulting from the work shall be removed.

SECTION 02720

STORM-DRAINAGE SYSTEM

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

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AASHTO M 190 (1995) Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches

AASHTO M 198 (1998) Joints for Circular Concrete Sewer and Culvert Pipe ` Using Flexible Watertight Gaskets

AASHTO M 219 (1992; R 1995) Aluminum Alloy Structural Plate for Field Bolted Conduits

AASHTO M 243 (1996) Field Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches

AASHTO M 294 (1998) Corrugated Polyethylene Pipe, 300 to 1200 mm Diameter

AASHTO MP7 (1997) Corrugated Polyethylene Pipe, 1350 and 1500 mm Diameter

AMERICAN CONCRETE INSTITUTE (ACI)

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ASTM A 536 (1999e1) Ductile Iron Castings

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ASTM B 745/B 745M	(1997) Corrugated Aluminum Pipe for Sewers and Drains
ASTM C 12	(1998e1) Installing Vitrified Clay Pipe Lines
ASTM C 14	(1999) Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C 14M	(1999) Concrete Sewer, Storm Drain, and Culvert Pipe Metric)
ASTM C 32	(1999e1) Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C 55	(1999) Concrete Building Brick
ASTM C 62	(1997a) Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C 76	(1999) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C 76M	(1999a) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C 139	(1999) Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C 231	(1997e1) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 270	(1997) Mortar for Unit Masonry
ASTM C 425	(1998b) Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C 443	(1998) Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
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ASTM C 924	(1998) Concrete Pipe Sewer Lines by Low-Pressure Air Test Method
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ASTM D 1557	(1998) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu.ft. (2,700 kN-m/cu.m.))

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ASTM D 1752	(1984; R 1996e1) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 1784	(1999a) Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D 2167	(1999a) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2321	(1989; R 1995) Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D 2922	(1996e1) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017	(1988; R 1996e1) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 3034	(1998) Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D 3212	(1996a) Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D 3350	(1998a) Polyethylene Plastic Pipe and Fittings Materials
ASTM F 477	(1999) Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F 679	(1995) Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F 714	(1997) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F 794	(1999) Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F 894	(1998a) Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F 949	(1999) Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings
ASTM F 1417	(1992; R 1998) Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air

KOREAN INDUSTRIAL STANDARD (KS)

KS D 8308	(2001) Zinc Hot Dip Galvanizings

KS F 4401 (1998) Concrete Pipes and Reinforced Concrete Pipes

KS F 4403 (2001) Reinforced Spun Concrete Pipe.

KS L 5201 (1989) Portland Cement

KS M 3401 (1995) Unplasticized Polyvinyle Chloride Pipes for Water Works.

KS M 3404 (2001) Unplasticized Polyvinyle Chloride Pipes for General Service.

1.2 SUBMITTALS

1.2.1 Samples

Samples of the following materials shall be submitted to the Contracting Officer and approved before work is started.

a. Filter fabric material.

b. Perforated pipe.

1.2.2 Manufacturer's Recommendations

Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed four (4) printed copies of these recommendations shall be furnished to the Contracting Officer prior to installation.

1.2.3 CERTIFICATION

Certified copies of test reports demonstrating conformance to applicable pipe specifications shall be delivered to the Contracting Officer before pipe is installed.

a. Resin Certification; FIO

b. Pipeline Testing; FIO

c. Hydrostatic Test on Watertight Joints; FIO

d. Determination of Density; FIO

e. Frame and Cover for Gratings; GA

f. Certification on the ability of frame and cover or gratings for rust protection and to carry the imposed live load.

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Gasket materials and plastic materials shall be protected from any environment that would result in damage or deterioration to the material. The Contractor shall have a copy of the manufacturer's instructions available at the construction site at all times and shall follow these instructions unless directed otherwise by the Contracting Officer. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.3.2 Handling

Materials shall be handled in such a manner as to insure delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

2.1.1 Concrete Pipe

2.1.1.1 Reinforced concrete pipe

ASTM C 76, Class II, III, IV or V, or ASTM C 655M, D-Load, or KS F 4401 or KS F 4403, Class as indicated.

2.1.1.2 Nonreinforced Pipe

ASTM C 14, Class 1, 2 or 3, or KS F 4401.

2.1.1.3 Corrugated metal pipe

ASTM A 760/A 760M, zinc coated, or aluminum (Type 2) coated pipe of either:

a. Type I or II pipe with annular or helical 68 by 13 mm corrugations.

b. Type IR or IIR pipe with helical 19 by 19 by 190 mm corrugations

2.1.1.4 Fully Bituminous Coated

AASHTO M 190 Type C and ASTM A 760/A 760M zinc or aluminum (Type 2) coated pipe of either:

a. Type I or II pipe with annular, helical 68 by 13 mm corrugations.

b. Type IR or IIR pipe with helical 19 by 19 by 190 mm corrugations.

2.1.1.5   Half Bituminous Coated, Part Paved

AASHTO M 190 Type B and ASTM A 760 zinc coated or aluminum (Type 2) coated Type I or II pipe with annular or helical 68 by 13 mm corrugations.

2.1.1.6   Fully Bituminous Coated, Part Paved

AASHTO M 190 Type D and ASTM A 760/A 760M zinc or aluminum (Type 2) coated Type I or II pipe with annular or helical 68 by 13 mm corrugations.

2.1.1.6   Fully Bituminous Coated, Fully Paved

AASHTO M 190 Type D and ASTM A 760 zinc coated, aluminum coated or aluminum-zinc alloy coated Type I or II corrugated steel pipe with annular or helical corrugations.

2.1.1.7   Concrete-Lined

ASTM A 760/A 760M zinc coated Type I corrugated steel pipe with annular or helical 68 by 13 mm 2-2/3 by 1/2 inch corrugations and a concrete lining in accordance with ASTM A 849.

2.1.1.8   Polymer Pre-coated

ASTM A 762/A 762M corrugated steel pipe fabricated from ASTM A 742/A 742M Grade 250/250 10/10 polymer precoated sheet of either:

Type I or II pipe with annular or helical 68 by 13 mm corrugations.

Type IR or IIR pipe with helical 19 by 19 by 190 mm corrugations.

2.1.1.9 Pre-coated, Part Paved

ASTM A 762/A 762M corrugated steel pipe and AASHTO M 190 Type B

(modified), paved invert only, fabricated from ASTM A 762/A 762M Grade 250/250 (10/10) polymer pre-coated sheet with annular or helical 68 by 13 mm corrugations.

2.1.1.10 Polymer Pre-coated, Fully Paved

ASTM A 762/A 762M Type I II or IIR corrugated steel pipe and AASHTO M 190 Type D (modified), fully paved only, fabricated from ASTM A 742/A 742M Grade 250/250(10/10) polymer pre-coated sheet with annular or helical 68 by 13 mm corrugations.

2.1.2 Corrugated Aluminum Alloy Pipe

ASTM B 745/B 745M corrugated aluminum alloy pipe of either:

Type I or II pipe with annular or helical corrugations.

Type IA IIA or IIR pipe with helical corrugations.

2.1.2.1 Aluminum Fully Bituminous Coated

AASHTO M 190 Type A and ASTM B 745/B 745M corrugated aluminum alloy pipe of either:

Type I or II pipe with annular or helical corrugations.

Type IA, IR, IIA or IIR pipe with helical corrugations.

2.1.2.2 Fully Bituminous Coated, Part Paved

AASHTO M 190 Type C and ASTM B 745/B 745M corrugated aluminum alloy pipe of either:

Type I or II pipe with annular or helical corrugations.

Type IIR pipe with helical corrugations.

2.1.3 Structural Plate, Steel Pipe, Pipe Arches and Arches

Assembled with galvanized steel nuts and bolts, from galvanized corrugated steel plates conforming to AASHTO M 167. Pipe coating, when required, shall conform to the requirements of AASHTO M 190 Type A or AASHTO M 243. Thickness of plates shall be as indicated.

2.1.4 Structural Plate, Aluminum Pipe, Pipe Arches and Arches

Assembled with either aluminum alloy, aluminum coated steel, stainless steel or zinc coated steel nuts and bolts. Nuts and bolts, and aluminum alloy plates shall conform to AASHTO M 219. Pipe coating, when required, shall conform to the requirements of AASHTO M 190, Type A or AASHTO M 243. Thickness of plates shall be as indicated.

2.1.5 Ductile Iron Culvert Pipe

ASTM A 716. or approved equal.

2.1.6 PVC Pipe

The pipe stiffness shall be greater than or equal to 735/D for cohesionless material pipe trench backfills and greater than or equal to 1240/D for cohesive material pipe trench backfills or installation in an embankment or fill. D is the pipe diameter in inches.

2.1.6.1 Type PSM PVC Pipe

KS M 3401 or ASTM D 3034, cell class 13364-B with fittings cell class 13343-C by ASTM D 3915 for pressure pipe and KS M3404 or ASTM D 4396 for non-pressure pipe, Type PSM, SDR 23.5.

2.1.6.2 profile PVC Pipe

ASTM F 794 produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, minimum cell class 12454B.

2.1.6.3 Smooth Wall PVC Pipe

KS M 3401 or ASTM F 679 produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, minimum cell class 12454B.

2.1.6.4 Corrugated PVC Pipe

Corrugated PVC pipe ASTM F 949 produced from PVC certified by the compounder as meeting the requirements of ASTM 1784, minimum cell class 12454B.

2.1.7 PE Pipe

The pipe manufacturer's resin certification indicating the cell classification of PE used to manufacture the pipe shall be submitted prior to installation of the pipe. The minimum cell classification for polyethylene plastic shall apply to each of the seven primary properties of the cell classification limits in accordance with ASTM D 3350.

2.1.7.1 Smooth Wall PE Pipe

ASTM F 714, maximum DR of 21 for pipes 80 to 600 mm (3 to 24 inches) in diameter and maximum DR of 26 for pipes 650 to 1200 mm (26 to 48 inches) in diameter. Pipe shall be produced from PE certified by the resin producer as meeting the requirements of ASTM D 3350, minimum cell class 335434C.

2.1.7.2 Corrugated PE Pipe

Corrugated PE pipe culverts and storm drains shall not be installed beneath airfield pavements, Class A, B, or C roads, or road pavements with a design index of 6 or greater AASHTO M 294, Type S, produced from PE certified by the resin producer as meeting the requirements of ASTM D 3350, minimum cell class 315412C or or 324420C. Pipe walls shall have the following properties:

Nominal Size mm)	Minimum Wall Area (square mm/m)	Minimum Moment of Inertia of Wall Section (mm to the 4th/mm)
300	3200	390
375	4000	870
450	4900	1020
600	6600	1900
750	8300	2670
900	9500	3640

1050	9900	8900
1200	10900	8900
1350	12000	13110
1500	13650	13110

Nominal Size (inch)	Minimum Wall Area (square in/ft)	Minimum Moment of Inertia of Wall Section (in to the 4th/in)
12	1.50	0.024
15	1.91	0.053
18	2.34	0.062
24	3.14	0.116
30	3.92	0.163
36	4.50	0.222
42	4.69	0.543
48	5.15	0.543
54	5.67	0.800
60	6.45	0.800

2.1.9.3 Profile Wall PE Pipe

ASTM F 894, RSC 160, produced from PE certified by the resin producer as meeting the requirements of ASTM D 3350, minimum cell class 334433C Pipe walls shall have the following properties:

Nominal Size (mm)	Minimum Wall Area (square mm/m)	Minimum Moment of Inertia of Wall Section (mm to the 4th/mm)

		Cell Class 334433C	Cell Class 335434C
450	6300	850	620
525	8800	1150	840
600	9900	1330	970
675	12500	2050	1490
750	12500	2050	1490
825	14800	2640	2160
900	17100	3310	2700
1050	16500	4540	3720
1200	18700	5540	4540

Nominal Size (in)	Minimum Wall Area (square in/ft)	Minimum Moment of Inertia of Wall Section (in to the 4th/in) Cell Class 334433C	Cell Class 335434C
18	2.96	0.052	0.038
21	4.15	0.070	0.051
24	4.66	0.081	0.059
27	5.91	0.125	0.091
30	5.91	0.125	0.091
33	6.99	0.161	0.132
36	8.08	0.202	0.165
42	7.81	0.277	0.227
48	8.82	0.338	0.277

2.2 DRAINAGE STRUCTURES

2.2.1 Manholes and Inlets

Construction shall be of reinforced concrete, precast reinforced concrete or complete with frames and covers or gratings and with fixed galvanized steel ladders where indicated or specified.

2.2.2 Walls and Headwalls

Construction shall be as indicated.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Concrete

Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements for 20.6 MPa (3000 psi, 210 Kg/square centimeter) concrete under Section 03300 CONCRETE FOR BUILDING CONSTRUCTION. The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 37.5 mm (1-1/2 inches). Air content shall be determined in accordance with ASTM C 231. The concrete covering over steel reinforcing shall not be less than 25 mm (1 inch) thick for covers and not less than 40 mm (1-1/2 inches) thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 75 mm (3 inches) between steel and ground. Expansion-joint filler material shall conform to ASTM D 1751, or ASTM D 1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D 1752.

2.3.2 Mortar

Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to ASTM C 270, Type M, except the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar. Water shall be clean and free of harmful acids, alkalies, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

2.3.3 Curb Inlets

Curb inlets shall be constructed as indicated. The inlet structure top slabs and openings shall match sidewalk and curb lines and slopes.

2.3.4 Grated Inlets

Grated inlet top elevations shall be set as indicated and below normal finish grade to insure positive drainage flow into the inlets from surrounding surfaces and connecting drainage facilities. In open graded and unpaved areas, inlet grates shall be two inches below normal finish grades unless otherwise indicated or directed. In paved areas, inlet grates shall be not less than 12.7 mm (one-half inch) nor more than 25.4 mm (one inch) below normal finished grades unless otherwise indicated or directed. Structure top slab and surrounding pavement shall be sloped to drain and provide a smooth riding connection as indicated or directed.

2.3.5 Precast Reinforced Concrete Manholes

Precast reinforced concrete manholes shall conform to ASTM C 478. Joints between precast concrete risers and tops shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure, or shall be made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph JOINTS.

2.3.6 Prefabricated Corrugated Metal Manholes

Manholes shall be of the type and design recommended by the manufacturer. Manholes shall be complete with frames and cover, or frames and gratings.

2.3.7 Frame and Cover for Gratings

Frame and cover for gratings shall be cast gray iron, ASTM A 48, Class 35B; cast ductile iron, ASTM A 536, Grade 65-45-12; or cast aluminum, ASTM B 26, Alloy 356.OT6 or galvanized steel grating, KS D 8308, Grade2, HDZ55. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans.

2.4 STEEL LADDER

Steel ladder shall be provided where the depth of the manhole exceeds 3.66 m (12 feet). These ladders will be not less than 406 mm (16 inches) in width, with 19 mm (3/4 inch) diameter rungs spaced 305 mm (12 inches) apart. The two stringers shall be a minimum 9.5 mm (3/8 inch) thick and 63.5 mm (2-1/2 inches) wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A 123 or KS D 8308 grade 2, HDZ55/HDZ61.

2.5 DOWNSPOUT BOOTS

Boots used to connect exterior down-spouts to the storm-drainage system shall be of gray cast iron conforming to ASTM A 48, Class 30B or 35B. Shape and size shall be as indicated.

2.6 HYDROSTATIC TEST ON WATERTIGHT JOINTS

2.6.1 Concrete, Clay, PVC and PE Pipe

A hydrostatic test shall be made on the watertight joint types as proposed. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Performance requirements for joints in reinforced and nonreinforced concrete pipe shall conform to AASHTO M 198 or ASTM C 443. Test requirements for joints in clay pipe shall conform to ASTM C

425. Test requirements for joints in PVC and PE plastic pipe shall conform to ASTM D 3212.

2.6.2 Corrugated Steel and Aluminum Pipe

A hydrostatic test shall be made on the watertight joint system or coupling band type proposed. The moment strength required of the joint is expressed as 15 percent of the calculated moment capacity of the pipe on a transverse section remote from the joint by the AASHTO-01 (Division 2, Section 23). The pipe will be supported for the hydrostatic test so that the joint is located at the point which develops 15 percent of the moment capacity of the pipe based on the allowable span in meters (feet) for the pipe flowing full or 54,233 Newton meters (40,000 foot-pounds), whichever is less. Performance requirements shall be met at an internal hydrostatic pressure of 69 kPa (10 psi) for a 10 minute period for both annular corrugated metal pipe and helical corrugated metal pipe with factory reformed ends.

2.7 FILTER FABRIC

Filter fabric shall be a approved sheet of polyester, nylon or polypropylene filaments woven or otherwise formed into a uniform pattern with distinct and measurable openings. The filter fabric shall provide an Equivalent Opening Size (EOS) no finer than the US Standard Sieve No. 100 and no coarser than the US Standard Sieve No. 30. EOS is defined as the number of the US Standard sieve having openings closest in size to the filter fabric openings.

PART 3 EXECUTION

3.1 EXCAVATION FOR PIPE CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavation of trenches and for appurtenances and backfilling for culverts and storm drains shall be in accordance with the applicable portions of Section 02222 EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS and Section 02225 EARTHWORK FOR ROADWAYS, RAILROADS, AND AIRFIELDS and the requirements specified below.

3.1.1 Trenching

The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 600 mm (24 inches) to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheeting and bracing where required shall be placed within the trench width as specified. Care shall be taken not to overexcavate. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures shall be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

3.1.2 Removal of Rock

Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe of at least 200 mm (8 inches) or 85 mm (1/2 inch) for each meter (foot) of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined in Section 02222 EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS.

3.1.3 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor in his performance of shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the government.

3.2 BEDDING

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe. When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded carefully in a soil foundation accurately shaped and rounded to conform to the lowest one-fourth of the outside portion of circular pipe or to the lower curved portion of pipe arch for the entire length of the pipe or pipe arch. When necessary, the bedding shall be tamped. Bell holes and depressions for joints shall be only of such length, depth, and width as required for properly making the particular type of joint. Bedding for clay pipe shall be as specified by ASTM C 12. Bedding for corrugated metal pipe and pipe arch shall be in accordance with ASTM A 798. It is not required to shape the bedding to the pipe geometry. However, for pipe arches, it is recommended to either shape the bedding to the relatively flat bottom arc or fine grade the foundation to a shallow V-shape. Bedding for corrugated structural plate pipe shall meet requirements of ASTM A 807. Bedding for ductile iron culvert pipe shall meet requirements of ASTM A 716. Bedding for PVC and PE pipe shall meet the requirements of ASTM D 2321 for Class I, II and III materials.

3.3 PLACING PIPE

Each pipe shall be carefully examined before being laid, and defective or damaged pipe shall not be used. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated metal pipe shall be placed in the same vertical plane as the major axis of the pipe. Under no circumstances shall pipe be laid in water, and no pipe shall be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. All pipe in place shall be inspected before backfilling, and those pipes damaged during placement shall be removed and replaced.

3.3.1 Concrete, Clay, PVC, Ribbed PVC and Ductile Iron Pipe

Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.2 Corrugated PE Pipe

Laying shall be with the separate sections joined firmly on a bed shaped to line and grade and shall follow manufacturer's recommendations.

3.3.3 Multiple Culverts

Where multiple lines of pipe are installed, adjacent sides of pipe shall be at least half the nominal pipe diameter or 1 meter (3 feet) apart, whichever is less.

3.3.4 Jacking Pipe Through Fills

Methods of operation and installation for jacking pipe through fills shall conform to requirements specified in Vol. I, Chapter 8 of the AREA-01 Manual.

3.4 JOINTS

3.4.1 Concrete and Clay Pipe

3.4.1.1 Cement-Mortar Bell-and-Spigot Joint

The first pipe shall be bedded to the established gradeline, with the bell end placed upstream. The interior surface of the bell shall be carefully cleaned with a wet brush and the lower portion of the bell filled with mortar to such depth as to bring inner surfaces of abutting pipes flush and even. The spigot end of each subsequent pipe shall be cleaned with a wet brush and uniformly matched into a bell so that sections are closely fitted. After each section is laid, the remainder of the joint shall be filled with mortar, and a bead shall be formed around the outside of the joint with sufficient additional mortar. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint shall be wrapped or bandaged with cheesecloth to hold mortar in place.

3.4.1.2 Cement-Mortar Oakum Joint for Bell-and-Spigot Pipe

A closely twisted gasket shall be made of jute or oakum of the diameter required to support the spigot end of the pipe at the proper grade and to make the joint concentric. Joint packing shall be in one piece of sufficient length to pass around the pipe and lap at top. This gasket shall be thoroughly saturated with neat cement grout. The bell of the pipe shall be thoroughly cleaned with a wet brush, and the gasket shall be laid in the bell for the lower third of the circumference and covered with mortar. The spigot of the pipe shall be thoroughly cleaned with a wet brush, inserted in the bell, and carefully driven home. A small amount of mortar shall be inserted in the annular space for the upper two-thirds of the circumference. The gasket then shall be lapped at the top of the pipe and driven home in the annular space with a caulking tool. The remainder of the annular space then shall be filled completely with mortar and beveled at an angle of approximately 45 degrees with the outside of the bell. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint thus made shall be wrapped with cheesecloth. Placing of this type of joint shall be kept at least five joints behind laying operations.

3.4.1.3 Cement-Mortar Diaper Joint for Bell-and-Spigot Pipe

The pipe shall be centered so that the annular space is uniform. The annular space shall be caulked with jute or oakum. Before caulking, the inside of the bell and the outside of the spigot shall be cleaned.

a. Diaper Bands: Diaper bands shall consist of heavy cloth fabric to hold grout in place at joints and shall be cut in such lengths that they will extend one-eighth of the circumference of pipe above the spring line on one side of the pipe and up to the spring line on the other side of the pipe. Longitudinal edges of fabric bands shall be rolled and stitched around two pieces of wire. Width of fabric bands shall be such that after fabric has been securely stitched around both edges on wires, the wires will be uniformly spaced not less than 200 mm (8 inches) apart. Wires shall be cut into lengths to pass around pipe with sufficient extra length for the ends to be twisted at top of pipe to hold the band securely in place; bands shall be accurately centered around lower portion of joint.

b. Grout: Grout shall be poured between band and pipe from only the high side of band, until grout rises to the top of band at the spring line of pipe, or as nearly so as possible, on the opposite side of pipe, to insure a thorough sealing of joint around the portion of pipe covered by the band. Silt, slush, water, or polluted mortar grout forced up on the lower side shall be carefully forced out by pouring and removed.

c. Remainder of Joint: The remaining unfilled upper portion of the joint shall then be filled with mortar and a bead formed around the outside of this upper portion of the joint with a sufficient amount of additional mortar. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind actual laying of pipe. No backfilling around joints shall be done until joints have been fully inspected and approved.

3.4.1.4 Cement-Mortar Tongue-and-Groove Joint

The first pipe shall be bedded carefully to the established gradeline with the groove upstream. A shallow excavation shall be made underneath the pipe at the joint and filled with mortar to provide a bed for the pipe. The grooved end of the first pipe shall be carefully cleaned with a wet brush, and a layer of soft mortar applied to the lower half of the groove. The tongue of the second pipe shall be cleaned carefully with a wet brush; while in horizontal position, a layer of soft mortar shall be applied to the upper half of the tongue. The tongue end of the second pipe then shall be inserted in the grooved end of the first pipe until mortar is squeezed out on interior and exterior surfaces. Sufficient mortar shall be used to fill the joint completely and to form a bead on the outside.

3.4.1.5 Cement-Mortar Diaper Joint for Tongue-and-Groove Pipe

The joint shall be of the type described for cement-mortar tongue-and-groove joint in this paragraph, except that the shallow excavation directly beneath the joint shall not be filled with mortar until after a gauze or cheesecloth band dipped in cement mortar has been wrapped around the outside of the joint. The cement-mortar bead at the joint shall be at least 15 mm (1/2 inch thick), and the width of the diaper band shall be at least 200 mm (8 inches). The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind the actual laying of the pipe. No backfilling around the joints shall be done until the joints have been fully inspected and approved.

3.4.1.6 Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe

Sealing compounds shall follow the recommendation of the particular manufacturer in regard to special installation requirements. Surfaces to receive lubricants, primers, or adhesives shall be dry and clean. Sealing compounds shall be affixed to the pipe not more than 3 hours prior to installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Sealing compounds shall be inspected before installation of the pipe, and any loose or improperly affixed sealing compound shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pulled together. If, while making the joint with mastic-type sealant, a slight protrusion of the material is not visible along the entire inner and outer circumference of the joint when the joint is pulled up, the pipe shall be removed and the joint remade. After the joint is made, all inner protrusions will be cut off flush with the inner surface of the pipe. If nonmastic-type sealant material is used, the "Squeeze-Out" requirement above shall be waived.

3.4.1.7 Flexible Watertight Joints

Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

3.4.1.8 External Sealing Band Joint for Noncircular Pipe

Surfaces to receive sealing bands shall be dry and clean. Bands shall be installed in accordance with manufacturer's recommendations.

3.4.2 Corrugated Metal Pipe

3.4.2.1 Field Joints

Transverse field joints shall be of such design that the successive connection of pipe sections will form a continuous line free of appreciable irregularities in the flow line. In addition, the joints shall meet the general performance requirements described in ASTM A 798. Suitable transverse field joints which satisfy the requirements for one or more of the joint performance categories can be obtained with the following types of connecting bands furnished with suitable band-end fastening devices: corrugated bands,

bands with projections, flat bands, and bands of special design that engage factory reformed ends of corrugated pipe. The space between the pipe and connecting bands shall be kept free from dirt and grit so that corrugations fit snugly. The connecting band, while being tightened, shall be tapped with a soft-head mallet of wood, rubber or plastic, to take up slack and insure a tight joint. The annular space between abutting sections of part paved, and fully paved pipe and pipe arch, in sizes 750 mm (30 inches) or larger, shall be filled with a bituminous material after jointing. Field joints for eachtype of corrugated metal pipe shall maintain pipe alignment during construction and prevent infiltration of fill material during the life of the installations. The type, size, and sheet thickness of the band and the size of angles or lugs and bolts shall be as indicated or where not indicated, shall be as specified in the applicable standards or specifications for the pipe.

3.4.2.2 Flexible Watertight, Gasketed Joints

Installation shall be as recommended by the gasket manufacturer for use of lubricants and cements and other special installation requirements. The gasket shall be placed over one end of a section of pipe for half the width of the gasket. The other half shall be doubled over the end of the same pipe. When the adjoining section of pipe is in place, the doubled-over half of the gasket shall then be rolled over the adjoining section. Any unevenness in overlap shall be corrected so that the gasket covers the end of pipe sections equally. Connecting bands shall then be centered over adjoining sections of pipe, and rods or bolts placed in position and nuts tightened. Band Tightening: The band shall be tightened evenly, even tension being kept on the rods or bolts, and the gasket shall be closely observed to see that it is seating properly in the corrugations. Watertight joints shall remain uncovered for a period of time designated, and before being covered, tightness of the nuts shall be measured with a torque wrench. If the nut has tended to loosen its grip on the bolts or rods, the nut shall be retightened with a torque wrench and remain uncovered until a tight, permanent joint is assured.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

Construction shall be of reinforced concrete, plain concrete, brick, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal, complete with frames and covers or gratings and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated.

3.5.2 Walls and Headwalls

Construction shall be as indicated.

3.6 STEEL LADDER

Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 1.83 m (6 feet) vertically, and shall be so installed as to provide at least 152 mm (6 inches) of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

3.7 BACKFILLING

3.7.1 Backfilling Pipe in Trenches

After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 150 mm (6 inches) in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation of at least 300 mm (12 inches) above the top of the pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 300 millimeters (12 inches). Tests for density will be made as necessary to insure conformance to the compaction requirements specified elsewhere in this paragraph. Where it is necessary in the opinion of the Contracting Officer, any sheeting or portions of bracing used shall be left in place and the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

3.7.2 Backfilling Pipe in Fill Sections

For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified elsewhere in this paragraph. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 150 mm (6 inches) in compacted depth, and shall be compacted by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 300 mm (12 inches) above the top of the pipe shall extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 4 m (12 feet), whichever is less. After the backfill has reached at least 300 mm (12 inches) above the top of the pipe, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 200 mm (8 inches).

3.7.3 Movement of Construction Machinery

In compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.7.4 Compaction

3.7.4.1 General

Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

3.7.4.2 Minimum Density

Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density (densities) which will be determined as specified in this paragraph.

a. Under airfield and heliport pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.

b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.

c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.7.5 Determination of Density

Testing shall be the responsibility of the Contractor and performed at no additional cost to the Government. Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to insure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D 1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D 2167 or ASTM D 2922. When ASTM D 2922 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D 2922 results in a wet unit weight of soil and when using this method ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D 3017 or ASTM D 2922. Test results shall be furnished the Contracting Officer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

3.8 PIPELINE TESTING

Lines shall be tested for leakage by low pressure air or water testing or exfiltration tests as appropriate. Low pressure air testing for vitrified clay pipes shall conform to ASTM C 828. Low pressure air testing for concrete pipes shall conform to ASTM C 924. Low pressure air testing for plastic pipes shall conform to ASTM F 1417. Low pressure air testing procedures for other pipe materials shall use the pressures and testing times prescribed in ASTM C 828 or ASTM C 924, after consultation with the pipe manufacturer. pipes shall conform to ASTM C 828. Testing of individual joints for leakage by low pressure air or water shall conform to ASTM C 1103. Lines shall be tested for leakage by exfiltration tests. Prior to testing for leakage the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 600 mm (2 feet) or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the Contracting Officer. An exfiltration test shall be made by filling the line to be tested with water so that a head of at least 600 mm (2 feet) is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed 23.2 liters per mm in diameter per kilometer (250 gallons per inch in diameter per mile) of pipeline per day. When leakage exceeds the maximum amount specified, satisfactory correction shall be made and retesting accomplished. Testing, correcting, and retesting shall be made at no additional cost to the Government.

3.9 CONTRACTOR QUALITY CONTROL

The Contractor shall establish and maintain a quality control procedure to assure compliance of the installed storm-drainage systems with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to, the following:

a. Furnishing specified materials.

b. Excavation, trenching, and bedding.

c. Pipe laying.

d. Backfilling pipe.

e. Compaction.

f. Curb inlet top slab pour.

g. Grated inlet top elevation setting.

3.9.1 Contractor Quality Control (CQC) Procedure

The CQC procedure for storm-drainage system installation shall be submitted to the Contracting Officer for approval prior to the start of storm-drainage system course work.

SECTION 02730

SANITARY SEWERS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN RAILWAY ENGINEERING ASSOCIATION (AREA)

AREA-03 (1994) Manual for Railway Engineering (Fixed Properties): Chapter 1, Roadway and Ballast

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 74 (1998) Cast Iron Soil Pipe and Fittings

ASTM A 123/A 123M (2000) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM C 14 (1999) Concrete Sewer, Storm Drain, and Culvert Pipe

ASTM C 33 (1999) Concrete Aggregates

ASTM C 76	(2000) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C 94/C 94M	(2000) Ready-Mixed Concrete
ASTM C 150	(1999a) Portland Cement
ASTM C 260	(2000) Air-Entraining Admixtures for Concrete
ASTM C 270	(2000) Mortar for Unit Masonry
ASTM C 425	(2000) Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C 443	(1994) Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
ASTM C 478	(1998) Precast Reinforced Concrete Manhole Sections
ASTM C 478M	(1997) Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C 564	(1997) Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C 700	(2000) Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM C 828	(1998) Low-Pressure Air Test of Vitrified Clay Pipe Lines
ASTM C 924	(1998) Concrete Pipe Sewer Lines by Low-Pressure Air Test Method
ASTM C 924M	Concrete Pipe Sewer Lines by Low-Pressure Air Test Method (Metric)
ASTM C 972	(2000) Test Method for Compression-Recovery of Tape Sealant
ASTM D 412	(1998a) Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension
ASTM D 624	(1991) Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D 1784	(2000) Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds
ASTM D 2680	(1995a) Acrylonitrile-Butadiene-Styrene (ABS) and Poly Vinyl Chloride (PVC) Composite Sewer Piping
ASTM D 2751	(1996a) Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings
ASTM D 2996	(1995) Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

ASTM D 2997	(1999) Centrifugally Cast "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe
ASTM D 3034	(1998) Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
ASTM D 3212	(1996a) Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D 3262	(1996) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe
ASTM D 3350	(1999) Polyethylene Plastics Pipe and Fittings Materials
ASTM D 3753	(1999) Glass-Fiber-Reinforced Polyester Manholes
ASTM D 3840	(1999) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Fittings for Non-pressure Applications
ASTM D 4161	(1996)”Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe Joints Using Flexible elastomeric Seals
ASTM F 402	(1993; R1999) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F 477	(1999) Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F 714	(2000) Polyethylene (PE) Plastic pipe (SDR-PR) Based on Outside Diameter
ASTM F 794	(1999) Poly Vinyl Chloride (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F 894	(1998a) Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F 949	(2000) Poly Vinyl Chloride (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C105	(1999) Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids
AWWA C110	(1998) Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (75 mm through 1200 mm), for Water and Other Liquids
AWWA C111	(2000) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115	(1999) Flanged Ductile-Iron Pipe with Threaded Flanges
AWWA C151	(1996) Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 49	(1994) Hazardous Chemicals Data
NFPA 325-1	(1994) Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids
NFPA 704	(1996) Identification of the Fire Hazards of Materials

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-6	(1990) Recommended Practice for the Low-Pressure Air Testing of Installed Sewer Pipe
UBPPA UNI-B-9	(1990; Addenda 1994) Recommended Performance Specification for Polyvinyl Chloride (PVC) Profile Wall Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter (Nominal Pipe Sizes 4-48 inch)

Korean Industrial Standards (KS):

KS D 2302	(1976) Pig Lead
KS D 4307	(1999) Cast-Iron Soil Pipes and Fittings
KS D 4308	(2001) Ductile Iron Fittings
KS D 4311	(1999) Ductile Iron
KS D 4316	(2002) Mortar Lining of Ductile Iron Pipes Centrifugally Cast for Water Works
KS D 8308	(2001) Zinc Hot Dip Galvanizing
KS F 2560	(1997) Chemical Admixtures for Concrete
KS F 4002	(1997) Hollow Concrete Block
KS F 4009	(1999) Ready Mixed Concrete
KS F 4401	(1998) Concrete Pipes and Reinforced Concrete Pipes
KS F 4402	(2000) Vibrated and Rolled Concrete Pipe
KS F 4403	(2001) Centrifugal Reinforced Concrete Pipe
KS L 5201	(1989) Portland Cement
KS M 3401	(1995) Unplasticized Polyvinyl Chloride Pipes for Water Works
KS M 3402	(1995) Rigid Polyvinyl Chloride Pipes Fittings for Water Works Service
KS M 3404	(2001) Rigid Polyvinyl Chloride Pipes for General Service

KS M 3407	(1983) Polyethylene Pipe for General Service
KS M 3408	(2001) Polyethylene Pipes for Water Works
KS M 3410	(1997) Unplasticized Polyvinyl Chloride Pipes Fittings for Drain
KS M 3411	(2001) Unplasticized Polyvinyl Chloride Pipes Fittings for Water Work Service
KS M 3500	(1992) Large Diameter Pipes of High Density Polyethylene with Profiled Wall and Smooth Inside Pipe Surface
KS M 6613	(1983) Rubber Goods for Water Work Service

1.2 GENERAL REQUIREMENTS

The construction required herein shall include appurtenant structures and building sewers to points of connection with the building drains 1.5 m (5 feet) outside the building to which the sewer system is to be connected. The Contractor shall replace damaged material and redo unacceptable work at no additional cost to the Government. Excavation and backfilling is specified in Section 02222 EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS. Backfilling shall be accomplished after inspection by the Contracting Officer. Force mains and inverted siphons are specified in Section 02732 FORCE MAINS AND INVERTED SIPHONS; SEWER. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. The Contractor shall have a copy of the manufacturer's instructions available at the construction site at all times and shall follow these instructions unless directed otherwise by the Contracting Officer. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install the plastic pipe shall be stored in accordance with the manufacturer's recommendation and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.3 MEASUREMENT AND PAYMENT

Measurements and payments will be based on completed work performed in accordance with the drawings, specifications, and the contract payment schedules. No payment will be made under this section for excavation, backfilling, or grading. Payment for such work will be made under Section 02222 EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS.

1.3.1 Pipe

The length of pipe installed will be measured from center to center of manholes and from the center of sewer to the end of the service connections without deduction for fittings or diameters of manholes and will be paid for according to the applicable contract unit price per meter (foot) for the size of pipe. No extra payment will be made for bends.

1.3.2 Manholes

The depth of manholes will be measured from the top of the cover to the invert of the outlet pipe. Manholes will be paid for according to the applicable contract price each for the depth of manhole indicated in the payment schedule. No extra payment will be made for drop manholes except that the concrete used for encasing the drop connection will be measured and paid for according to the contract unit price per cubic meter (yard) of concrete for encasement, and no extra payment will be made for pipe fittings required to make connections to manholes.

1.3.3 Concrete

Concrete used for pipe encasement, cradles, and similar supports, indicated or required for reasons other than faulty construction methods or negligence of the Contractor, will be measured and paid for according to the contract unit price for concrete for encasement and cradles.

1.3.4 Connections to Existing Manholes

Connections to existing manholes will be paid for according to the applicable contract unit price per connection for each required size of pipe, which shall be full compensation for all necessary cutting, shaping, pipe fittings, and concrete, except that concrete required for encasing or cradling pipe outside the manhole will be measured and paid for according to the contract unit price for such concrete.

1.3.5 Wye Branches

Wye branches installed in new sewers will be paid for according to the applicable contract unit price for the size indicated in the payment schedule. This will be in addition to the price per meter (foot) of straight pipe.

1.3.6 Connections to Existing Sewers

Connections to existing sewers where new wye branches to cut-ins are required will be paid for according to the contract unit price for such connection. The price will be considered as full compensation for material and labor required for the removal and replacement of the pipe as necessary. Excavation, backfill, and concrete connected with such work will be paid for according to the applicable contract unit prices. Connections of this type made to sewers installed under this contract, if ordered after the sewer has been installed, will be paid for as connection to existing sewers.

1.4 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES.

SD-13 Certificates

Portland Cement; GA.

Certificates of compliance stating the type of cement used in manufacture of concrete pipe, fittings and precast manholes.

Oil Resistant Material; GA

Certificates of compliance stating that the fittings or gaskets used for waste drains or lines designated on the plans as are oil resistant.

PART 2 PRODUCTS

2.1 PIPE

Pipe shall conform to the respective specifications and other requirements specified below.

2.1.1 Concrete Pipe

Concrete pipe 600 mm (24 inches) or less in diameter, unless otherwise shown or specified, shall be non-reinforced and conform to ASTM C 14, Class 1 or 2. Concrete pipe greater than 600 mm (24 inches) in diameter shall be reinforced and conform to ASTM C 76, Class I, or KS F 4401. Pipe less than 900 mm (36 inches) in diameter shall be bell and spigot type. Pipe 900 mm (36 inches) or greater in diameter shall be bell and spigot type, tongue and groove type, or modified tongue and groove type.

2.1.2 Plastic Pipe

Acrylonitrile-butadiene-styrene (ABS) and polyvinyl chloride (PVC) composite sewer piping shall conform to ASTM D 2680 or KS M 3404. Size 200 mm (8 inch) through 380 mm (15 inch) diameter.

2.1.2.1 ABS Pipe

ASTM D 2751.

2.1.2.2 PVC Pipe

ASTM D 3034, Type PSM with a maximum SDR of 35 or KS M 3404, VG1, Size 380 mm (15 inches) or less in diameter. ASTM F 949 for corrugated sewer pipes with a smooth interior. UBPPA UNI-B-9 and ASTM F 794, Series 46, for ribbed sewer pipe with smooth interior, size 200 mm (8 inch) through 1200 mm (48 inch) diameters. PVC shall be certified by the compounder as meeting the requirements of ASTM D 1784, cell Class 12454B or KS M 3155, Compound Type 3231. The pipe stiffness shall be greater than or equal to 735/D for cohesionless material pipe trench backfills.

2.1.2.3 High Density Polyethylene Pipe

KS M 3500, RSC 63, or ASTM F 894, Class 63, size 450 mm (18 inch) through 3000 mm (120 inch). ASTM F 714, or KS M 3407, Type 2, size 100 mm (4 inch) through 1200 mm (48 inch). The polyethylene shall be certified by the resin producer as meeting the requirements of ASTM D 3350, cell Class 334433C, or KS M 3353, Type 3, Class 1. The pipe stiffness shall be greater than or equal to 1170/D for cohesionless material pipe trench backfills.

2.1.3 Reinforced Plastic Mortar Pipe (RPMP)

ASTM D 3262.

2.1.4 Reinforced Thermosetting Resin Pipe (RTRP)

ASTM D 3262.

2.1.4.1 Filament Wound RTRP-I

RTRP-I shall conform to ASTM D 2996, except pipe shall have an outside diameter equal to cast iron outside diameter or standard weight steel pipe. The pipe shall be suitable for a normal working pressure of 1.03 MPa (150 psi) at 22.8 degrees C (73 degrees F). The inner surface of the pipe shall have a smooth uniform continuous resin-rich surface liner conforming to ASTM D 2996.

2.1.4.2 Centrifugally Cast RTRP-II

RTRP-II shall conform to ASTM D 2997. Pipe shall have an outside diameter equal to standard weight steel pipe.

2.1.5 Ductile Iron Pipe

Pipe shall conform to AWWA C151 or KS D 4311 unless otherwise shown or specified.

2.1.6 Cast Iron Soil Pipe

ASTM A 74, Class SV or KS D 4307 except Class XH where indicated. Lines indicated as acid resistant shall be Class XH and contain not less than 12 percent silicon.

2.1.7 Clay Pipe

ASTM C 700. Where indicated, pipe shall be acid resistant.

2.2 FITTINGS

Fittings shall be compatible with the pipe supplied and shall have a strength not less than that of the pipe. Fittings shall conform to the respective specifications and other requirements specified below.

2.2.1 Concrete Pipe

KS F 4401 or ASTM C 14 for pipe 600 mm (24 inches) or less in diameter. ASTM C 76 for pipe greater than 600 mm (24 inches) in diameter.

2.2.2 Plastic Pipe

ABS and PVC composite sewer pipe fittings shall conform to ASTM D 2680, KS M 3368, or KS M 3402.

2.2.2.1 ABS Pipe

ASTM D 2751 or KS M 3368.

2.2.2.2 PVC Pipe

KS M 3410, KS M 3411 or ASTM D 3034 for type PSM pipe. KS M 3411 or ASTM F 949 for corrugated sewer pipe with a smooth interior. UBPPA UNI-B-9 and ASTM F 794, Series 46, for ribbed sewer pipe with smooth interior.

2.2.2.3 High Density Polyethylene Pipe

KS M 3407, KS M 3408 or ASTM F 894.

2.2.3 RPMP

ASTM D 3840.

2.2.4 RTRP

ASTM D 3262.

2.2.5 Ductile Iron Pipe

Mechanical fittings shall conform to KS D 4308 or AWWA C110, rated for 1.03 MPa (150 psi). Push-on fittings shall conform to AWWA C110 and AWWA C111, rated for 10.3 MPa (150 psi).

2.2.6 Cast Iron Soil Pipe

ASTM A 74 or KS D 4307.

2.2.7 Clay Pipe

ASTM C 700 Extra strength or Acid resistant.

2.3 JOINTS

Joints installation shall comply with the manufacturer's instructions. Fittings and gaskets utilized for waste drains or industrial waste lines shall be certified by the manufacturer as oil, industrial waste or acid resistant.

2.3.1 Concrete Pipe

Joints and gaskets shall conform to ASTM C 443 or KS M 6613.

2.3.2 Plastic Pipe

Flexible plastic pipe (PVC or high density polyethylene pipe) gasketed joints shall conform to ASTM D 3212 or KS M 3410.

2.3.2.1 ABS Pipe

ASTM D 2751 or KS M 3411, solvent weld or bell and spigot O-ring joint, size 300 mm (12 inches) or less in diameter, dimensions and tolerances in accordance with Table 2 therein.

2.3.2.2 High Density Polyethylene Pipe

Rubber gasket joints shall conform to ASTM C 443 or KS M 6613.

2.3.3 RPMP

Joints shall be bell and spigot type utilizing an elastomeric gasket in accordance with ASTM F 477.

2.3.4 RTRP

Joints shall be bell and spigot type utilizing an elastomeric gasket in accordance with ASTM F 477.

2.3.5 Ductile Iron Pipe

Push-on joints shall conform to AWWA C111 or KS D 4308. Mechanical joints shall conform to AWWA C111 as modified by AWWA C151 or KS D 4308. Flanged joints shall conform to AWWA C115 or KS D 4308.

2.3.6 Cast Iron Soil Pipe

Rubber gaskets for compression joints shall conform to ASTM C 564. Packing material for caulked joints shall be twisted jute or oakum, tarred type, or asphalt-saturated cellulose-fiber. Joints for acid resisting cast iron soil pipe shall be made with acid resistant non-asbestos packing. The packing shall contain no material which would affect adhesion of the joint sealing material to the pipe. Lead shall be suitable for caulking of joints.

2.3.7 Clay Pipe

Compression joints shall conform to ASTM C 425.

2.4 BRANCH CONNECTIONS

Branch connections shall be made by use of regular fittings or solvent cemented saddles as approved. Saddles for ABS and PVC composite pipe shall conform to Figure 2 of ASTM D 2680; saddles for ABS pipe shall comply with Table 3 of ASTM D 2751; and saddles for PVC pipe shall conform to Table 4 of ASTM D 3034.

2.5 FRAMES AND COVERS

Frames and covers shall be cast iron, ductile iron or reinforced concrete. Cast iron frames and covers shall be as indicated or shall be of type as suitable for the application, circular, without vent holes. The frames and covers shall have a combined weight of not less than 181.4 kg (400 pounds). Reinforced concrete frames and covers shall be as indicated or shall conform to ASTM C 478 or ASTM C 478M. The word "Sewer" or "S" shall be stamped or cast into covers so that it is plainly visible.

2.6 STEEL LADDER

A steel ladder shall be provided where the depth of a manhole exceeds 3.6 m (12 feet). The ladder shall not be less than 406.4 mm (16 inches) in width, with 19.1 mm (3/4 inch) diameter rungs spaced 304.8 mm (12 inches) apart. The two stringers shall be a minimum 9.5 mm (3/8 inch) thick and 50.8 mm (2 inch) wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A 123 or KS D 8308.

2.7 PLACE IN CONCRETE AND CEMENT MORTAR

2.7.1 Cement Mortar

Cement mortar shall conform to ASTM C 270, Type M with Type II cement.

2.7.2 Portland Cement

Portland cement shall conform to ASTM C 150, Type II or V for concrete used in concrete pipe, concrete pipe fittings, and manholes and type optional with the Contractor for cement used in concrete cradle, concrete encasement, and thrust blocking. Air-entraining admixture conforming to ASTM C 260 or KS F 2560 shall be used with Type V cement. Where aggregates are alkali reactive, as determined by Appendix XI of ASTM C 33, a cement containing less than 0.60 percent alkalies shall be used.

2.7.3 Portland Cement Concrete

Portland cement concrete shall conform to ASTM C 94, compressive strength of 27.5 MPa (4000 psi, 280 Kg/square centimeter) at 28 days, except for concrete cradle and encasement or concrete blocks for manholes. Concrete used for cradle and encasement shall have a compressive strength of 17 MPa (2500 psi, 175 Kg/square centimeter) minimum at 28 days. Concrete in place shall be protected from freezing and moisture loss for 7 days.

2.8 STRUCTURES

2.8.1 Precast Reinforced Concrete Manhole Sections

Precast reinforced concrete manhole sections shall conform to ASTM C 478, except that portland cement shall be as specified herein. Joints shall be cement mortar, an approved mastic, rubber gaskets, a combination of these types; or the use of external preformed rubber joint seals and extruded rolls of rubber with mastic adhesive on one side.

2.8.2 Glass-Fiber Reinforced Polyester Manholes

Glass-fiber-reinforced polyester manholes shall conform to ASTM D 3753.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Adjacent Facilities

3.1.1.1 Water Lines

Where the location of the sewer is not clearly defined by dimensions on the drawings, the sewer shall not be closer horizontally than 3 m (10 feet) to a water-supply main or service line, except that where the bottom of the water pipe will be at least 300 mm (12 inches) above the top of the sewer pipe, the horizontal spacing may be a minimum of 2 m (6 feet). Where gravity-flow sewers cross above water lines, the sewer pipe for a distance of 3 m (10 feet) on each side of the crossing shall be fully encased in concrete or shall be acceptable pressure pipe with no joint closer horizontally than 1 m

(3 feet) to the crossing. The thickness of the concrete encasement including that at the pipe joints shall be not less than 100 mm (4 inches).

3.1.1.2 Roads, Railroads, and Airfields

Sewer pipe shall be encased in a sleeve of rigid conduit for the lengths shown. Sleeves under railroads shall be in accordance with the Korean National Railroad company requirements. Where sleeves are required, the pipe sleeve shall be as specified for storm drains in Section 02720 STORM-DRAINAGE SYSTEM. A minimum clearance of at least 50 mm (2 inches) between the inner wall of the sleeve and the maximum outside diameter of the sleeved pipe and joints shall be provided. Sand bedding shall be provided for the sewer pipe through the sleeve. Sleeves of ferrous material shall be provided with the corrosion protection as required for the conditions encountered at the site of installation.

3.1.1.3 Structures

Where sewer pipe is to be installed within 1 m (3 feet) of an existing or proposed building or structural foundation such as a retaining wall, control tower footing, water tank footing, or any similar structure, the sewer pipe shall be sleeved as specified above. Care shall be exercised and proper precautions taken during installation of the sewer pipe and sleeve to assure that there will be no damage to such structures and no settlement or movement of foundations or footing.

3.1.2 Pipe Laying

a. Pipe shall be protected during handling against impact shocks and free fall and the pipe interior shall be free of extraneous material.

b. Pipe laying shall proceed upgrade with the spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow. Each pipe shall be laid accurately to the line and grade shown on the drawings. Pipe shall be laid and centered so that the sewer has a uniform invert. As the work progresses, the interior of the sewer shall be cleared of all superfluous materials.

c. Before making pipe joints all surfaces of the portions of the pipe to be joined shall be clean and dry. Lubricants, primers, and adhesives shall be used as recommended by the pipe manufacturer. The joints shall then be placed, fitted, joined, and adjusted to obtain the degree of water tightness required.

d. ABS composite pipe ends with exposed truss and filler material shall be coated with solvent weld material before making the joint to prevent water or air passage at the joint between the inner and outer wall of the pipe.

e. Installations of solvent weld joint pipe, using ABS or PVC pipe and fittings shall be in accordance with ASTM F 402. All required precautions shall be taken to assure adequate trench ventilation and protection for workers installing the pipe.

3.1.2.1 Caulked Joints

The packing material shall be well packed into the annular space to prevent the entrance of lead into the pipe. The remainder of the space shall be filled with molten lead that is hot enough to show a rapid change in color when stirred. Scum shall be removed before pouring. The lead shall be caulked to form a tight joint without overstraining the bell and shall have a minimum depth of 25 mm (1 inch) after caulking.

3.1.2.2 Trenches

Trenches shall be kept free of water and as dry as possible during bedding, laying, and jointing and for as long a period as required. When work is not in progress, open ends of pipe and fittings shall be satisfactorily closed so that no trench water or other material will enter the pipe or fittings.

3.1.2.3 Backfill

As soon as possible after the joint is made, sufficient backfill material shall be placed along the pipe to prevent pipe movement off line or grade. Plastic pipe shall be completely covered to prevent damage from ultraviolet light.

3.1.2.4 Width of Trench

If the maximum width of the trench at the top of the pipe, as specified in Section 02222: EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS, is exceeded for any reason other than by direction, the Contractor shall install at no additional cost to the Government such concrete cradling, pipe encasement, or other bedding required to support the added load of the backfill.

3.1.2.5 Joints

Joints between different pipe materials shall be made as specified, using approved jointing materials.

3.1.2.6 Handling and Storage

Pipe, fittings and joint material shall be handled and stored in accordance with the manufacturer's recommendations. Storage facilities for plastic pipe, fittings, joint materials and solvents shall be classified and marked in accordance with NFPA 704, with classification as indicated in NFPA 49 and NFPA 325M.

3.1.3 Leakage Tests

Lines shall be tested for leakage by low pressure air testing, infiltration tests or exfiltration tests, as appropriate. Low pressure air testing for vitrified clay pipes shall be as prescribed in ASTM C 828. Low pressure air testing for concrete pipes shall be as prescribed in ASTM C 828. Low pressure air testing for PVC pipe shall be as prescribed in UBPPA UNI-B-6. Low pressure air testing procedures for other pipe materials shall use the pressures and testing times prescribed in ASTM C 828 and ASTM C 924, after consultation with the pipe manufacturer. Prior to infiltration or exfiltration tests the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 600 mm (2 feet) or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the Contracting Officer. When the Contracting Officer determines that infiltration cannot be properly tested, an exfiltration test shall be made by filling the line to be tested with water so that a head of at least 600 mm (2 feet) is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be re-established. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by either the infiltration test or exfiltration test shall not exceed 50 mL per 5 mm diameter per 100 meters (0.2 gallons per inch diameter per 100 feet) of pipeline per hour. When leakage exceeds the maximum amount specified, satisfactory correction shall be made and re-testing accomplished. Testing, correction, and re-testing shall be made at no additional cost to the Government.

3.1.4 Test for Deflection

When flexible pipe is used, a deflection test shall be made on the entire length of the installed pipeline not less than 30 days after the completion of all work including the leakage test, backfill, and placement of any fill, grading, paving, concrete, or superimposed loads. Deflection shall be determined by use of a deflection device or by use of a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft. The ball, cylinder, or circular sections shall have a diameter, or minor diameter as applicable, of 92.5 percent of the inside diameter of the pipe, but 95 percent for RPMP and RTRP. A tolerance of plus 0.5 percent will be permitted. The ball, cylinder, or circular sections shall be of a homogeneous material throughout, shall have a density greater than 1.0 as related to water at 4.0 degrees C (39.2 degrees F), and shall have a surface brinell hardness of not less than 150. It shall be center bored and through bolted with a 6.4 mm (1/4 inch) minimum diameter steel shaft having a yield strength of 480 MPa (70,000 psi) or more, with eyes at each end for attaching pulling cables. The eye shall be suitably backed with flange or heavy washer such that a pull exerted on the opposite end of the shaft shall produce compression throughout the remote end of the ball, cylinder or circular section. Circular sections shall be so spaced that the distance from the external faces of the front and back sections shall equal or exceed the diameter of the circular section. Failure of the ball, cylinder, or circular section to pass freely through a pipe run, either by being pulled through or by being flushed through with water, shall be cause for rejection of that run. When a deflection device is used for the test in lieu of the ball, cylinder, or circular sections described, such device shall be approved prior to use. The device shall be sensitive to 1.0 percent of the diameter of the pipe being measured and shall be accurate to 1.0 percent of the indicated dimension. Installed pipe showing deflections greater than 7.5 percent of the normal diameter of the pipe, or 5 percent for RTRP and RPMP, shall be retested by a run from the opposite direction. If the re-test also fails, the suspect pipe shall be replaced at no cost to the Government.

3.2 CONCRETE CRADLE AND ENCASEMENT

The pipe shall be supported on a concrete cradle, or encased in concrete where indicated or directed.

3.3 WYE BRANCHES

Wye branches shall be installed where sewer connections are indicated or where directed. Cutting into piping for connections shall not be done except in special approved cases. When the connecting pipe cannot be adequately supported on undisturbed earth or tamped backfill, the pipe shall be encased in concrete backfill or supported on a concrete cradle as directed. Concrete required because of conditions resulting from faulty construction methods or negligence by the Contractor shall be installed at no additional cost to the Government. The installation of wye branches in an existing sewer shall be made by a method which does not damage the integrity of the existing sewer. One acceptable method consists of removing one pipe section, breaking off the upper half of the bell of the next lower section and half of the running bell of wye section. After placing the new section, it shall be rotated so that the broken half of the bell will be at the bottom. The two joints shall then be made with joint packing and cement mortar.

3.4 MANHOLES

3.4.1 General

Manholes shall be constructed of glass-fiber-reinforced polyester, prefabricated plastic, concrete, or precast concrete manhole sections. The invert channels shall be smooth and semicircular in shape conforming to the inside of the adjacent sewer section. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. Changes in size and grade of the channels shall be made gradually and evenly. The invert channels shall be formed directly in the concrete of the manhole base, or shall be built up with brick and mortar, or shall be half tile laid in concrete, or shall be constructed by laying full section sewer pipe through the manhole and breaking out the top half after the surrounding concrete has hardened. Pipe connections shall be made to manhole using water stops, standard O-ring joints, special manhole coupling, or shall be made in accordance with the manufacturer's recommendation. The Contractor's proposed method of connection, list of materials selected, and specials required, shall be approved prior to installation. The floor of the manhole outside the channels shall be smooth and shall slope toward the channels not less than 100 mm per meter (1 inch per foot) nor more than 200 mm per meter (2 inches per foot). Free drop inside the manholes shall not exceed 500 mm (1 foot 6 inches), measured from the invert of the inlet pipe to the top of the floor of the manhole outside the channels, and drop manholes shall be constructed whenever the free drop would otherwise be greater than 500 mm (1 foot 6 inches).

3.4.2 Steel Ladder

Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 1850 mm (6 feet) apart vertically, and shall be installed to provide at least 150 mm (6 inches) of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

3.4.3 Jointing, Plastering and Sealing

Mortar joints shall be completely filled and shall be smooth and free from surplus mortar on the inside of the manhole. Mortar and mastic joints between precast rings shall be full-bedded in jointing compound and shall be smoothed to a uniform surface on both the interior and exterior of the manhole. Installation of rubber gasket joints between precast rings shall be in accordance with the recommendations of the manufacturer. Precast rings may also be sealed by the use of extruded rolls of rubber with mastic adhesive on one side.

3.4.4 Frames and Covers

Unless otherwise indicated, tops of frames and covers shall be set flush with finished grade in paved areas or 50 mm (2 inches) higher than finished grade in unpaved areas. Frame and cover assemblies shall be sealed to manhole sections using external preformed rubber joint seals that meet the requirements of ASTM D 412 and ASTM D 624, or other methods specified in paragraph Jointing, Plastering and Sealing, unless otherwise specified.

3.4.5 External Preformed Rubber Joint Seals

External preformed rubber joint seals and extruded rolls of rubber with mastic adhesive shall meet the requirements of ASTM D 412 and ASTM C 972 to ensure conformance with paragraph Leakage Tests. The seal shall be multi-section with neoprene rubber top section and all lower sections made of Ethylene Propylene Di Monomer (EPDM) rubber with a minimum thickness of 1.5 mm (60 mils). Each unit shall consist of a top and a bottom section and shall have mastic on the bottom of the bottom section and mastic on the top and bottom of the top section. The mastic shall be non-hardening butyl rubber sealant and shall seal to the cone/top slab of the manhole/catch basin and over the lip of the casting. One unit shall seal a casting and up to six, 50 mm (2 inch) adjusting rings. The bottom section will be 305 mm (12 inches) in height. A 152 mm (6 inch) high top section will cover up to two, 50 mm (2 inch) adjusting rings. A 305 mm (12 inch) high bottom section will cover up to six, 50 mm (2 inch) adjusting rings. Extension sections shall cover up to two more adjusting rings. Each extension shall overlap the bottom section by 50 mm (2 inches) and shall be overlapped by the top section by 50 mm (2 inches).

3.5 CONNECTIONS TO EXISTING MANHOLES

Pipe connections to existing manholes shall be made in such manner that the finish work will conform as nearly as practicable to the essential applicable requirements specified for new manholes, including all necessary concrete work, cutting, and shaping. The connection shall be centered on the manhole. Holes for the new pipe shall be of sufficient diameter to allow packing cement mortar around the entire periphery of the pipe but no larger than 1-1/2 times the diameter of the pipe. Cutting the manhole shall be done in a manner that will cause the least damage to the walls.

3.6 BUILDING CONNECTIONS

Building connections shall include the lines to and connection with the building waste drainage piping at a point approximately 1.5 m (5 feet) outside the building, unless otherwise indicated. Where building drain piping is not installed, the Contractor shall terminate the building connections approximately 1.5 m (5 feet) from the site of the building at a point and in a manner designated.

3.7 CLEANOUTS AND OTHER APPURTENANCES

Cleanouts and other appurtenances shall be installed where shown on the drawings or as directed by the Contracting Officer, and shall conform to the detail of the drawings.

SECTION 02732

FORCE MAINS AND INVERTED SIPHONS; SEWER

TABLE OF CONTENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 6D	(1994; Supple 1 Jun 1996; Supple 2 Dec 1997) Pipleline Valves (Gate, Plug, Ball, and Check Valves)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53	(1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM C 478	(1997) Precast Reinforced Concrete Manhole Sections
ASTM 1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D 1785	(1993) Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2122	(1998) Determining Dimensions of Thermoplastic Pipe and Fittings

ASTM D 2241	(1993) Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D 2464	(1996b) Threaded Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D 2564	(1999) Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Piping Systems
ASTM D 2657	(1997) Heat-Joining Polyolefin Pipe and Fittings
ASTM D 2774	(1994) Underground Installation of Thermoplastic Pressure Piping
ASTM D 2996	(1995) Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D 3035	(1995) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter
ASTM D 3139	(1998) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D 3308	(1997) PTFE Resin Skived Tape
ASTM D 3350	(1998a) Polyethylene Plastics Pipe and Fittings Materials
ASTM D 3554	(1996) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe
ASTM D 4101	(1999a) Propylene Plastic Injection and Extrusion Materials
ASTM F 477	(1999) Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F 1483	(1998) Oriented Poly (Vinyl Chloride), PVCO, Pressure Pipe

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1	(1998) Cast Iron Pipe Flanges and Flanged Fittings
ASME B16.3	(1992) Malleable Iron Threaded Fittings, Classes 150 and 300

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C105	(1993) Polyethylene Encasement for Ductile-Iron Piping System
AWWA C110	(1993) Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (75 mm through 1200 mm), for Water and Other Liquids
AWWA C111	(1995) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

AWWA C115	(1996) Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151	(1996) Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids
AWWA C200	(1997) Steel Water Pipe 6 In. (150 mm) and Larger
AWWA C203	(1997) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C207	(1994) Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In. (100mm through 3,600 mm)
AWWA C208	(1996) Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C210	(1997) Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
AWWA C300	(1997) Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids
AWWA C301	(1992) Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids
AWWA C303	(1995) Reinforced Concrete Pressure Pipe, Steel Cylinder Type, Pretensioned, for Water and Other Liquids
AWWA C500	(1993; C500a) Seated Gate Valves for Water Supply Services
AWWA C508	(1993; C508a) Swing-Check Valves for Waterworks Service, 2In. (50 mm)Through 24 In. (600 mm) NPS
AWWA C600	(1993) Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA C900	(1997; C900a) Polyvinyl Chloride (PVC) Pressure Pipe, 4 In. Through 12 In., for Water Distribution
AWWA C909	(1998) Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 IN through 12 IN (100 mm through 300 mm), for Water Distribution

DUCTILE IRON PIPE RESEARCH ASSOCIATION (DIPRA)

DIPRA-TRD/9-92	(1992; Errata Mar 1993) Thrust Restraint Design for Ductile Iron Pipe

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-78	(1998) Cast Iron Plug Valves, Flanged and Threaded Ends

1.2 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-09 Reports

Hydrostatic Tests; GA.

Copies of test results.

1.3 DELIVERY AND STORAGE

All material delivered and stored shall be handled and stored in such a manner that pipe, fittings and accessories, and pipe coatings are not damaged.

PART 2 PRODUCTS

2.1 PIPE AND FITTINGS

Piping for force mains less than 100 mm (4 inches) in diameter shall be galvanized steel, polyvinyl chloride (PVC) plastic, polyethylene (PE) plastic or polypropylene plastic. Piping less than 100 mm (4 inches) in diameter inside pump stations shall be galvanized steel. Piping for force mains and inverted siphons 100 mm (4 inches) in diameter and larger shall be ductile iron, steel, concrete pressure pipe, polyvinyl chloride (PVC) plastic, polyethylene (PE) plastic, reinforced thermosetting resin pipe (RTRP). Piping 200 mm (8 inches) in diameter and larger may also be reinforced plastic mortar pressure (RPMP) pipe. Piping 100 mm (4 inches) in diameter and larger inside pump stations shall be ductile iron pipe with bolted flange joints. Pipe shall conform to the respective specifications and other requirements specified below.

2.1.1 Concrete Pressure Pipe

Concrete pressure pipe and fittings shall conform to AWWA C300, AWWA C301, or AWWA C303, as applicable for the service requirements, with rubber gasket joints of the type using steel bell and spigot joint rings.

2.1.2 Plastic Pipe

2.1.2.1 Polyethylene (PE) Pipe

ASTM D 3350 and ASTM D 3035, minimum pressure rating of 689 kPa (100 psi) at 23 degrees C (73.4 degrees F).

2.1.2.2 Polypropylene Pipe

ASTM D 2122 and ASTM D 4101.

2.1.2.3 Polyvinyl Chloride (PVC) Pipe

a. PVC Pipe and Fittings Less Than 100 mm (4-Inches) Diameter: KS M 3401 or ASTM D 1785, Schedule 80, or D2241, SDR 26, with screw joints, push-on joints, or solvent weld joints.

b. PVC Pipe and Fittings 100 mm (4-Inch) Diameter and Larger: KS M 3401 or ASTM D 2241, SDR 32.5, or AWWA C900, Class 200, with push-on joints.

2.1.3 Reinforced Plastic Mortar Pressure (RPMP) Pipe

ASTM D 3517. Fittings shall be compatible with the pipe supplied and shall be suitable for working and testing pressures specified for the pipe.

2.1.4 Reinforced Thermosetting Resin Pipe (RTRP)

ASTM D 2996, 2413 kPa (350 psi) rated, cast iron pipe dimensions only, with elastomeric gasket joints. Fittings: AWWA C110, rated 1034 kPa (150 psi). When mechanical joint fittings are used, inside sleeves provided by the manufacturer shall be used.

2.1.5 Ductile Iron Pipe

a. Ductile Iron Pipe: KS D 4311 or AWWA C151, working pressure not less than 1020 kPa (148 psi, 10 Kg/square centimeter), unless otherwise shown or specified.

b. River Crossing Pipe: AWWA C151, minimum thickness Class 54 with joints in compliance with applicable requirements of AWWA C110.

c. Fittings, Mechanical: KS D 4308 or AWWA C110, rated for 1020 kPa (148 psi).

d. Fittings, Push-On: KS D 4308 or AWWA C110 and AWWA C111, rated for 1020 kPa (148 psi).

2.1.6 Steel Pipe

a. Steel Pipe, 150 mm (6 Inches) Diameter and Larger: AWWA C200.

b. Steel Pipe Less Than 150 mm (6 Inches) Diameter: ASTM A 53, standard weight, threaded end, galvanized.

c. Fittings, 150 mm (6 Inches) Diameter and Larger: AWWA C200, fabricated in compliance with AWWA C208.

d. Fittings Less Than 150 mm (6 Inches) Diameter: ASME B16.3, galvanized.

2.2 JOINTS

2.2.1 PE Pipe

a. Heat Fusion Joints: ASTM D 2657.

b. Flanged Joints: ASME B16.1 or AWWA C207.

c. Mechanical Joints: ASME B16.1.

2.2.2 Polypropylene Pipe

Heat Fusion Joints: ASTM D 2657.

2.2.3 PVC Pipe

a. Screw Joint Fittings: ASTM D 2464, Schedule 80.

b. Push-On Joint Fittings: ASTM D 3139, with ASTM F 477 gaskets.

c. Solvent Cement: ASTM D 2564.

d. Couplings for use with plain end pipe shall have centering rings or stops to ensure the coupling is centered on the joint.

2.2.4 Ductile Iron Pipe

a. Push-on Joints: AWWA C111.

b. Mechanical Joints: AWWA C111 as modified by AWWA C151.

c. Flanged Joints: AWWA C115.

2.2.5 Steel Pipe

a. Push-on Joints: AWWA C200.

b. Mechanical Joints: AWWA C200.

c. Flanged Joints: AWWA C207.

2.3 VALVES

2.3.1 Gate Valves

Gate valves 80 mm (3 inches) and larger shall comply with AWWA C500. Valves for buried service shall be non-rising stem (NRS), 50 mm (2 inch) square nut operated with joints applicable to the pipe or installation. Buried valves shall be furnished with extension stems comprising socket, extension stem and operating nut, and shall be of an appropriate length to bring operating nut to within 150 mm (6 inches) of grade. One 1200 mm (4 foot) "T" handle valve wrench shall be furnished for each quantity of 6 buried valves. Gate valves that are exposed or installed inside shall be outside screw and yoke (OS&Y), hand-wheel operated with flange ends unless otherwise indicated. Gate valve operating nuts and hand-wheels shall have an arrow and the word "OPEN" cast in raised letters to indicate the direction of opening. Gate valves 350 mm (14 inches) and larger shall be equipped with gearing to reduce operating effort. Gate valves 350 mm (14 inches) and larger installed in horizontal lines in horizontal position with stems horizontal shall be equipped with bronze track, roller and scrapers to support the weight of the gate for its full length of travel. Gate valves 350 mm (14 inches) and larger installed in vertical pipelines with stems horizontal shall be fitted with slides to assist the travel of the gate assembly.

2.3.2 Check Valves

Check valves shall permit free flow of sewage forward and provide a positive check against backflow. Check valves shall be designed for a minimum working pressure of 1020 kPa (148 psi) or as indicated. The body shall be iron. The manufacturer's name, initials, or trademark and also the size of the valve, working pressure, and direction of flow shall be directly cast on the body.

a. Ball Check Valves shall be iron body, shall have flanged ends, and shall be the non-slam type. Flanges shall be the Class 125 (125 pound) type complying with ASME B16.1 or KS B 1502. Ball shall be stainless steel unless otherwise specified.

b. Swing Check Valves shall comply with AWWA C508 or KS B 2818 and shall be iron body, bronze mounted, and shall have flanged ends. Flanges shall be the Class 125 (125 pound) type complying with ASME B16.1 or KS B 1502.

2.3.3 Plug Valves

Cast iron valves shall comply with MSS SP-78. Steel plug valves shall comply with API Spec 6D.

2.3.4 Pinch Valves

Pinch valves shall be double acting, jam-proof type with unobstructed streamlined flows and built-in operator. The body shall be iron with a non-rising hand-wheel. The sleeve shall be of pure gum rubber, neoprene, Buna N or hypalon as required for service. The valve shall have flanged ends. Flanges shall be of the Class 125 (125 pound) type complying with ASME B16.1.

2.3.5 Air Release Valves

Air release valves shall be designed to permit release of air from an empty pipe during filling and shall be capable of discharging accumulated air in the line while the line is in operation and under pressure. Valves shall be attached by means of threaded pipe connections. Valves shall be vented to the atmosphere.

a. Manual Air Release Valves: Manual air release valves shall consist of a 80 mm (3 inch) gate valve and 80 mm (3 inch) ductile iron pipe and fittings. The valve shall be installed with its line of flow in the horizontal position.

b. Automatic Air Release Valve: Automatic air release valves shall be of the compound lever type capable of withstanding operating pressures of 1034 kPa (150 psi). The valves shall have a 13 mm (1/2 inch) outlet. The body and cover of the valve shall be of iron with a stainless steel float. All internal parts shall be stainless steel or bronze. The valve shall be specifically adapted for use with sewage. Each valve shall be complete with hose and blow-off valves to permit back-flushing without dismantling the valve.

2.4 VALVE BOXES

Valve boxes shall be cast iron or concrete, except that concrete boxes may be installed only in locations not subject to vehicular traffic. Cast iron boxes shall be the extension type with slide type adjustment and with flared base.

The minimum thickness of metal shall be 5 mm (3/16 inch). The box length shall be adaptable, without full extension, to the depth of cover over the pipe at the valve locations. Concrete boxes shall be the standard product of a manufacturer of precast concrete equipment. The word "SEWER" or “S” shall be cast in the cover.

2.5 VALVE VAULTS

Valve vaults shall be precast concrete units conforming to ASTM C 478.

2.6 MISCELLANEOUS MATERIALS

Miscellaneous materials shall comply with the following requirements:

2.6.1 Pipe Coatings and Linings

a. Steel, interior: AWWA C203 or AWWA C210.

b. Steel, exterior, buried: AWWA C203.

c. Steel, exterior, exposed: AWWA C210.

2.6.2 Joint Lubricants

Joint lubricants shall be as recommended by the pipe manufacturer.

2.6.3 Bolts, Nuts and Glands

AWWA C111.

2.6.4 Joint Compound

A stiff mixture of graphite and oil or inert filler and oil.

2.6.5 Joint Tape

ASTM D 3308.

2.6.6 Bond Wire

Bond wire type RHW or USE, Size 1/0 AWG, neoprene jacketed copper conductor shaped to stand clear of the joint.

PART 3 EXECUTION

3.1 INSTALLATION

Pipe, pipe fittings, and appurtenances shall be installed at the locations indicated. Excavation, trenching, and backfilling shall be as specified in Section 02222 EXCAVATION, TRENCHING AND BACKFILLING FOR UTILITIES SYSTEMS.

3.1.1 Adjacent Facilities

Installation of force mains and inverted siphons near adjacent facilities shall be as specified in Section 02730 SANITARY SEWERS.

3.1.2 Cutting

Pipe shall be cut in a neat manner with mechanical cutters. Wheel cutters shall be used where practicable. Sharp and rough edges shall be ground smooth and loose material removed from the pipe before laying.

3.1.3 Laying

Except where otherwise authorized, pipe shall be laid with bells facing the direction of laying. Before lowering and while suspended, the pipe shall be inspected for defects. Defective material shall be rejected. Pipe shall be laid in compliance with the following:

a. Ductile Iron: AWWA C600.

b. Steel: AWWA C600.

c. Concrete: Manufacturer's instructions.

d. Polyvinyl Chloride: Manufacturer's instructions.

e. Polyethylene: ASTM D 2774.

f. Polypropylene: ASTM D 2774.

g. Reinforced Thermosetting Resin: Manufacturer's instructions.

h. Reinforced Plastic Mortar: Manufacturer's Instructions.

3.1.4 Jointing

3.1.4.1 Concrete Pressure Pipe

The manufacturer's instructions shall be followed when lubricating and installing rubber gaskets. Joints shall comply with the manufacturer's instructions. The external annular space shall be filled with cement mortar or with a portland cement-filled polyurethane loop. For pipe 600 mm (24 inch) diameter and larger, the internal annular space shall be filled with cement mortar and struck off to ensure a smooth and continuous surface between pipe sections. Pipe less than 600 mm (24 inch) diameter shall have a rope or trowelable mastic affixed to the concrete face of the bell socket before joining the sections of pipe. The mastic shall not be detrimental to the rubber gasket and shall fill the interior annular space when the pipe sections are pushed together.

3.1.4.2 Polyethylene Pipe

Heat fusion joints shall comply with the manufacturer's instructions concerning equipment, temperature, melt time, heat coat, and joining time. Flanged and mechanical joints shall be made in compliance with the manufacturer's instructions.

3.1.4.3 Polypropylene Pipe

Heat fusion joints shall comply with the manufacturer's instructions concerning equipment, temperature, melt time, heat coat, and joining time.

3.1.4.4 Polyvinyl Chloride Pipe

a. Threaded joints shall be made by wrapping the male threads with joint tape or by applying an approved thread lubricant, then threading the joining members together. The joint shall be tightened with strap wrenches which will not damage the pipe and fittings. The joint shall be tightened no more than 2 threads past hand-tight.

b. Push-on joints: The ends of pipe for push-on joints shall be beveled to facilitate assembly. Pipe shall be marked to indicate when the pipe is fully seated. The gasket shall be lubricated to prevent displacement. Care shall be exercised to ensure that the gasket remains in proper position in the bell or coupling while making the joint.

c. Solvent-weld joints shall comply with the manufacturer's instructions.

3.1.4.5 Reinforced Plastic Mortar Pressure Pipe

Elastomeric gasket joints shall comply with the manufacturer's instructions.

3.1.4.6 Reinforced Thermosetting Resin Pipe

Elastomeric gasket joints shall comply with the manufacturer's instructions.

3.1.4.7 Ductile Iron Pipe

Installation of mechanical and push-on type joints shall comply with AWWA C600 and the manufacturer's instructions. Installation of flanged joints shall comply with manufacturer's instructions.

3.1.4.8 Steel Pipe

Screw joints shall be made tight with joint tape or joint compound applied with a brush to the male threads only. Installation of mechanical joints, push-on joints, and flanged joints shall comply with the manufacturer's instructions.

3.1.5 Coating and Lining

Field coating of non-galvanized steel pipe shall comply with AWWA C203. The applied materials shall be tested by means of a spark-type electrical device in compliance with AWWA C203. Flaws and holidays in the coating or lining of the pipe and the pipe joints shall be repaired such that the repaired areas will be at least equal in thickness to the minimum required for the pipe.

3.1.6 Polyethylene Encasement

Encasement shall be in accordance with AWWA C105.

3.1.7 Valves

Prior to installation, valves shall be cleaned of all foreign matter and inspected for damage. Valves shall be fully opened and closed to ensure that all parts are properly operating. Valves shall be installed with the stem in the vertical position. Valves shall be installed in valve vaults as indicated.

3.1.8 Valve Boxes

Valve boxes shall be installed over each outside gate valve, unless otherwise indicated. Valve boxes shall be centered over the valve. Fill shall be carefully tamped around each valve box to a distance of 1.2 m (4 feet) on all sides or to undisturbed trench face, if less than 1.2 m (4 feet).

3.1.9 Valve Vaults

Valve vaults shall be installed as indicated.

3.1.10 Drain Lines

Drain lines shall be installed where indicated. The drain line shall consist of a tee in the main line with a 100 mm (4 inch) diameter branch, a 100 mm (4 inch) diameter elbow, and a 100 mm (4 inch) gate valve.

3.1.11 Thrust Restraint

Plugs, caps, tees and bends deflecting 11-1/4 degrees or more, either vertically or horizontally, shall be provided with thrust restraint. Valves shall be securely anchored or shall be provided with thrust restraints to prevent movement. Thrust restraints shall be either thrust blocks or, for ductile-iron pipes, restrained joints.

3.1.11.1 Thrust Blocks

Thrust blocking shall be concrete of a mix not leaner than: 1 cement, 2-1/2 sand, 5 gravel; and having a compressive strength of not less than 14 MPa (2000 psi) after 28 days. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of thrust blocks shall be poured directly against undisturbed earth. The sides of thrust blocks not subject to thrust may be poured against forms. The area of bearing shall be as shown or as directed. Blocking shall be placed so that the fitting joints will be accessible for repair. Steel rods and clamps, protected by galvanizing or by coating with bituminous paint, shall be used to anchor vertical down bends into gravity thrust blocks.

3.1.11.2 Restrained Joints

For ductile-iron pipe, restrained joints shall be designed by the Contractor or the pipe manufacturer in accordance with DIPRA-TRD/9-92.

3.1.12 Grout

Grout for exterior joint protection on concrete pipes shall be a mix of 1 part portland cement, 2 parts sand, and of sufficient liquid consistency to flow into the joint recess beneath the diaper. Grout for interior joint protection shall be a mix of 1 part portland cement and 1 part sand. A polyurethane foam loop, impregnated with portland cement, may be substituted for grout for exterior joints.

3.1.13 Bonded Joints

Where indicated, a metallic bond shall be provided at each joint, including joints made with flexible couplings or rubber gaskets, of ferrous-metallic piping to effect continuous conductivity. The bond shall be of the thermal-weld type.

3.2 HYDROSTATIC TESTS

The pipeline shall be subjected to both a pressure test and a leakage test. The method proposed for disposal of waste water from hydrostatic tests shall be approved by the Contracting Officer. Testing shall be performed by an approved independent testing laboratory or by the Contractor subject to approval. The test may be witnessed by the Contracting Officer. The Contracting Officer shall be notified at least 7 days in advance of equipment tests. The final test report shall be delivered to the Contracting Officer within 30 days of the test.

3.2.1 Pressure Test

After the pipe has been installed, joints completed, thrust blocks have been in place for at least five days, and the trench has been partially backfilled, leaving the joints exposed for examination, the pipe shall be filled with water in a manner to expel all air. The pipeline shall be subjected to a test pressure of 700 kPa (100 psi) or 150 percent of the working pressure, whichever is greater, for a period of at least one hour. Each valve shall be opened and closed several times during the test. The exposed pipe, joints, fitting, and valves shall be examined for leaks. Visible leaks shall be stopped or the defective pipe, fitting, joints, or valve shall be replaced.

3.2.2 Leakage Test

The leakage test may be conducted subsequent to or concurrently with the pressure test. The amount of water permitted as leakage for the line shall be placed in a sealed container attached to the supply side of the test pump. No other source of supply will be permitted to be applied to the pump or line under test. The water shall be pumped into the line by the test pump as required to maintain the specified test pressure as described for pressure test for a 2-hour period. Exhaustion of the supply or the inability to maintain the required pressure will be considered test failure. Polyethylene pipe can experience diametric expansion and pressure elongation during initial testing. The manufacturer shall be consulted prior to testing for special testing considerations. Allowable leakage shall be determined by the following formula:

L = NDP/K Where:

L = Allowable leakage in gallons per hour.

N = Number of joints in length of pipeline tested.

D = Nominal diameter of the pipe in inches.

P = Square root of the test pressure in psig.

K = 7400 for pipe materials.

At the conclusion of the test, the amount of water remaining in the container shall be measured and the results recorded in the test report.

3.2.3 Retesting

If any deficiencies are revealed during any test, such deficiencies shall be corrected and the tests shall be re-conducted until the results of the tests are within specified allowances without additional cost to the Government.

SECTION 02811

UNDERGROUND SPRINKLER SYSTEMS

TABLE OF CONTENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53/A 53M	(1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 183	(1983; R 1998) Carbon Steel Track Bolts and Nuts
ASTM A 536	(1984; R 1999el) Ductile Iron Castings
ASTM B 32	(1996) Solder Metal
ASTM B 43	(1998) Seamless Red Brass Pipe, Standard Sizes
ASTM B 88	(1999) Seamless Copper Water Tube

ASTM D 1785	(1999) Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2241	(2000) Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D 2287	(1996a) Non-rigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds
ASTM D 2464	(1999) Threaded Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D 2466	(1999) Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2564	(1996a) Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Piping Systems
ASTM D 2774	(1994) Underground Installation of Thermoplastic Pressure Piping
ASTM D 2855	(1996) Making Solvent-Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings
ASTM D 3261	(1997) Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM F 441/F 441M	(1999) Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe, Schedules 40 and 80

AMERICAN SOCIETY OF MECHANICAL ENGINEERS INTERNATIONAL(ASME)

PDI WH 201	(1992) Water Hammer Arresters
ASME B1.2	(1983; R 1991; Errata May 1992) Gages and Gaging for Unified Inch Screw Threads
ASME B16.3	(1998) Malleable Iron Threaded Fittings,
ASME B16.15	(1985; R 1994) Cast Bronze Threaded Fittings Classes 125 and 250
ASME B16.18	(1984; R 1994) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(1995; B16.22a1998) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1012	(1995) Backflow Preventers with Intermediate Atmospheric Vent

ASSE 1013	(1999) Reduced Pressure Principle Backflow Preventers
ASSE 1020	(1998) Pressure Vacuum Breaker Assembly (Recommended for Outdoor Usage)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C509	(1994; Addendum 1995) Resilient-Seated Gate Valves for Water and Sewerage Systems
AWWA C606	(1997) Grooved and Shouldered Joints
AWWA C901	(1996) Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. Through 3 In., for Water Service

COMMERCIAL ITEM DESCRIPTIONS (CID)

CID A-A-51145	(Rev C) Flux, Soldering, Non-Electronic, Paste & Liquid

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCHR)

FCCHR-01	(1993) Manual of Cross-Connection Control

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(1997) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(1994) Cast Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(1993) Industrial Control and Systems, Controllers, Contactors, and Overload Relays Rated Not More Than 2,000 Volts AC or 750 DC
NEMA ICS 6	(1993) Enclosures for Industrial Control and Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

KOREAN INDUSTRIAL STANDARD (KS)

KS B2301	(1994) BRONZE GATE, GLOBE, ANGLE AND CHECK VALVES
KS M3411	(1996) POLYETHYLENE PIPE FITTINGS FOR WATER WORKS SERVICE

KOREAN WATER WORKS ASSOCIATION (AWWA)

KWWA M130	(1989) High Density Polyethylene Pipes for Water Works

1.2 PERFORMANCE REQUIREMENTS

System shall operate with a minimum water pressure as shown on drawings.

1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES.

SD-01 Data

Framed Instructions; GA.

Labels, signs, and templates of operating instructions that are required to be mounted or installed on or near the product for normal, safe operation.

Field Training Data; FIO.

Information describing training to be provided, training aids to be used, samples of training materials to be provided, and schedules and notification of training.

Design Analysis and Calculations; GA. Spare Parts; FIO.

Design analyses and pressure calculations verifying that system will provide the irrigation requirements. Spare parts data for each different item of material and equipment specified, after approval of the related submittals and not later than the start of the field tests. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

SD-04 Drawings

Sprinkler System; GA.

Detail drawings for valves, sprinkler heads, backflow preventers, automatic controllers, emitter heads, and water hammer arresters. Drawing shall include of a complete list of equipment and materials, and manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Drawings shall also contain complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will function as a unit. Drawings shall show proposed system layout, type and number of heads and emitters, zone valves, drain pockets, backflow devices, controllers, and mounting details of controllers. As-built Drawings which provide current factual information showing locations of mains, heads, valves, and controllers including deviations from and amendments to the drawings and changes in the work shall be included.

SD-06 Instructions

Sprinkler System; FIO.

Detailed procedures defining the Contractor's provisions for accident prevention, health protection, and other safety precautions for the work to be done.

SD-09 Reports

Field Tests; FIO.

Performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of control valves.

SD-13 Certificates

Sprinkler System; FIO.

The material supplier's or equipment manufacturer's statement that the supplied material or equipment meets specified requirements. Each certificate shall be signed by an official authorized to certify in behalf of material supplier or product manufacturer and shall identify quantity and date or dates of shipment or delivery to which the certificates apply.

SD-19 Operation and Maintenance Manuals

Sprinkler System; FIO.

Six copies of operation and six copies of maintenance manuals for the equipment furnished. One complete set prior to field testing and the remainder upon acceptance. Manuals shall be approved prior to the field training course. Operating manuals shall detail the step-by-step procedures required for system startup, operation, and shutdown. Operating manuals shall include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. Maintenance manuals shall list routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include piping and equipment layout, simplified wiring and control diagrams of the system as installed, and system programming schedule.

1.4 DELIVERY AND STORAGE

All equipment delivered and placed in storage shall be protected from the weather; excessive humidity and temperature variation; direct sunlight (in the case of plastic or rubber materials); and dirt, dust, or other contaminants.

1.5 FIELD MEASUREMENTS

The Contractor shall verify all dimensions in the field and shall advise the Contracting Officer of any discrepancy before performing the work.

PART 2 PRODUCTS

2.1 GENERAL MATERIALS AND EQUIPMENT REQUIREMENTS

2.1.1 Standard Products

Materials and equipment shall be the standard products of a manufacturer who has produced similar systems which have performed well for a minimum period of 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Nameplates

Each item of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.1.3 Extra Stock

The following extra stock shall be provided: Two sprinkler heads of each size and type, two valve keys for operating manual valves, two wrenches for removing and installing each type of head, two quick coupler keys and hose swivels, and four irrigation controller housing keys.

2.2 PIPING MATERIALS

2.2.1 Copper Tubing and Associated Fittings

2.2.1.1 Tubing

Tubing shall conform to requirements of ASTM B 88, Type K.

2.2.1.2 Fittings

Fittings shall conform to ASME B16.22 and ASME B16.18, solder joint. Solder shall conform to ASTM B 32 95-5 tin-antimony. Flux shall conform to CID A-A-51145, Type I.

2.2.2 Red Brass Pipe and Associated Fittings

2.2.2.1 Pipe

Pipe shall conform to requirements of ASTM B 43, regular.

2.2.2.2 Fittings

Fittings shall be Class 250, cast bronze threaded conforming to the requirements of ASME B16.15.

2.2.3 Galvanized Steel Pipe and Associated Fittings

2.2.3.1 Pipe

Pipe shall conform to requirements of ASTM A 53, Schedule 40.

2.2.3.2 Fittings

Fittings shall be Class 150 conforming to requirements of ASME B16.3.

2.2.4 Polyvinyl Chloride (PVC) Pipe, Fittings and Solvent Cement

2.2.4.1 Pipe

Pipe shall conform to the requirements of ASTM D 1785, PVC 1120 Schedule 40 or 80; or ASTM D 2241, PVC 1120 SDR 21, Class 200; or KS M3401, class 10K with back flow preventor and pressure regulating valve for the system's working pressure less than 10 Kg/square centimeter.

2.2.4.2 Fittings

Solvent welded socket type fittings shall conform to requirements of ASTM D 2466, Schedule 40. Threaded type fittings shall conform to requirements of ASTM D 2464, Schedule 80 or KS M3402 for the pipe conform to the KS M3401.

2.2.4.3 Solvent Cement

Solvent cement shall conform to the requirements of ASTM D 2564.

2.2.5 Polyethylene (PE) Plastic Piping

2.2.5.1 Pipe

Pipe shall conform to AWWA C901, outside diameter base with dimension ratio (DR) of 9.3 to provide 1034 kPa (150 psi) minimum pressure rating or KWWA M130, Class A with back flow preventor and pressure regulating valve for the system's working pressure less than 10 Kg/square centimeter.

2.2.5.2 Fittings

Fittings shall conform to ASTM D 3261, DR of 9.3 or KS M3411 for the pipe, KWWA M 130.

2.2.6 Dielectric Fittings

Fittings shall conform to ASTM F 441, Schedule 80, CPVC threaded pipe nipples, 100 mm (4 inch) minimum length.

2.2.7 Emitter Hose and Distribution Tubing

Emitter hose and distribution tubing shall conform to ASTM D 2287, maximum inside diameter of 13 mm (1/2 inch), minimum wall thickness of 2.286 mm (90 mils), vinyl plastic extruded from non-rigid chloride, integrally algae-resistant, homogeneous throughout, smooth inside and outside, free from foreign materials, cracks, serrations, blisters and other effects. Slip fittings shall be provided.

2.3 SPRINKLER AND EMITTER HEADS

2.3.1 Pop-Up Spray Heads

Pop-up spray heads lay flush with housing, then pop up when water pressure 138 kPa (20 psi) is activated in system. The rising member supporting the nozzle shall be identical on full, half, third or quarter pattern sprinklers so that nozzles will be interchangeable. The sprinkler head shall be designed to be adjustable for coverage and flow. The nozzle shall be removable so head does not have to be removed for flushing or cleaning. Nozzle rises a minimum of 100 mm (4 inches) above the body. The body shall be constructed with a 13 mm (1/2 inch) female thread for installation in a fixed underground pipe system.

2.3.1.1 Shrubbery Sprinkler Heads

Sprinkler heads shall be conical spray with adjustable or non-adjustable coverage and designed for permanent aboveground mounting on riser or pop-ups at a height compatible with ground covers. Provide brass nozzles.

2.3.2 Rotary Pop-Up Sprinklers

Sprinklers shall be capable of covering as shown. Construction shall be high impact molded plastic with filter screen, reducible watering radius, and choice of standard nozzles and have adjustable radius capabilities unless otherwise shown on the design drawing.

2.3.3 Bubbler Sprinkler Heads

Heads shall be multiple-spray bubbler with adjustable flow and designed for permanent aboveground mounting on risers.

2.3.4 Surface Connected Lawn Sprinkler Heads

Unless otherwise shown, heads shall be an impulse type with or without sled, ring, or wheel base; multiple T Type; a rotary type with sled, spike or wheel base; or oscillating type with wheel or sled base.

2.3.5 Emitter Heads

Emitter heads shall be self-cleaning, pressure compensating diaphragm with one or six self-piercing barbed outlets; each capable of emitting from 1 to 8 L/hour (1/4 to 2 gallons per hour) flow. Emitter body shall be ultraviolet stabilized, algae, and heat resistant plastic construction.

2.4 VALVES

2.4.1 Gate Valves, Less than 80 mm (3 Inches)

Gate valves shall conform to the requirements of MSS SP-80, Type 1, Class 150, threaded ends.

2.4.2 Gate Valves, 80 mm (3 Inches) and Larger

Gate valves shall conform to the requirements of AWWA C509 and have encapsulated resilient wedge, parallel seats, non-rising stems, and open by counterclockwise turning. End connections shall be flanged. Interior construction of valves shall be bronze including stem containing a maximum 2 percent aluminum and maximum 16 percent zinc.

2.4.3 Angle Valves, Less Than 65 mm (2-1/2 Inches)

Angle valves shall conform to the requirements of MSS SP-80, Type 3, Class 150 threaded ends.

2.4.4 Angle Valves, 65 mm (2-1/2 Inches) and Larger

Angle valves shall conform to the requirements of MSS SP-85, Type II, Class 250 flanged ends.

2.4.5 Quick Coupling Valves

Quick coupling valves shall have brass parts and shall be two-piece unit consisting of a coupler water seal valve assembly and a removable upper body to allow spring and key track to be serviced without shutdown of main. Lids shall be lockable vinyl with spring for positive closure on key removal.

2.4.6 Remote Control Valves, Electrical

Remote control valves shall be solenoid actuated globe valves of 20 to 80 mm (3/4 to 3 inch) size, suitable for 24 volts, 60 cycle, and designed to provide for shut-off in event of power failure. Valve shall be cast bronze or brass or plastic housing suitable for service at 1034 kPa (150 psi) operating pressure with external flow control adjustment for shut-off capability, external plug at diaphragm chamber to enable manual operation, filter in control chamber to prevent valve body clogging with debris, durable diaphragm, and accessibility to internal parts without removing valve from system.

2.4.7 Drain Valves

2.4.7.1 Manual Valves

Manual valves shall conform to requirements of MSS SP-80, Type 3, Class 150 threaded ends for sizes less than 65 mm (2-1/2 inches) and MSS SP-85, Type II, Class 250 flanged ends for sizes 65 mm (2-1/2 inches) and larger.

2.4.7.2 Automatic Valves

Automatic valves shall be brass or plastic, spring loaded ball drip type, Class 150 (150 pounds) and threaded ends, designed to close at 18 kPa (6 foot) pressure head with positive seal at 21 kPa (3 psi) pressure or greater and be open to drain at less than 21 kPa (3 psi) pressure.

2.4.8 Pressure Regulating Master Valve

Pressure regulating master valve shall be automatic mechanical self-cleaning, self-purging control system having an adjustable pressure setting operated by a solenoid on alternating current with 0.70 amperes at 24 volts. Valve shall close slowly and be free of chatter in each diaphragm position, have manual flow stem to adjust closing speed and internal flushing, and one or two inlet tappings capable of being installed as a straight pattern valve. Body shall be cast bronze or brass with removable brass seat serviceable from top without removing valve body from system. Valve shall operate at 1034 kPa (150 psi) working pressure and pilot range from 70 to 875 kPa (10 to 125 psi).

2.4.9 Backflow Preventers

Reduced pressure principle assemblies, double check valve assemblies, atmospheric (nonpressure) type vacuum breakers, and pressure type vacuum breakers shall be tested, approved, and listed in accordance with FCCHR-01. Backflow preventers with intermediate atmospheric vent shall be in accordance with ASSE 1012. Reduced pressure principle backflow preventers shall be in accordance with ASSE 1013.

2.4.9.1 Pressure Type Vacuum Breaker

Vacuum breaker shall conform to the requirements of ASSE 1020 and shall be bronze or brass construction, with one or two check valves, vacuum relief, inlet and discharge shut-offs valves, field test cocks, and vacuum relief opening of greater diameter than unit.

2.4.9.2 Reduced Pressure Type Backflow Preventers

Backflow preventers shall be Class 150 flanged cast iron, bronze or brass mounted gate valve and strainer, 304 stainless steel or bronze, internal parts. Total pressure drop through complete assembly shall be a maximum of 70 kPa (10 psi) at rated flow. Piping shall be galvanized steel pipe and fittings. Strainers shall be bronze or brass construction with gasket caps. Units shall have 200-mesh stainless steel screen elements.

2.5 ACCESSORIES AND APPURTENANCES

2.5.1 Valve Keys for Manually Operated Valves

Valve keys shall be 15 mm (1/2 inch) diameter by 1000 mm (3 feet) long, tee handles and keyed to fit valves.

2.5.2 Valve Boxes and Concrete Pads

2.5.2.1 Valve Boxes

Valve boxes shall be cast iron, plastic lockable, or precast concrete for each gate valve, manual control valve and remote control valve. Box sizes shall be adjustable for valve used. Word "IRRIGATION" shall be cast on cover. Shaft diameter of box shall be minimum 130 mm (5-1/4 inches). Cast iron box shall have bituminous coating.

2.5.2.2 Concrete Pads

Concrete pads shall be precast or cast-in-place reinforced concrete construction for reduced pressure type backflow preventers.

2.5.3 Pressure Gauges

Pressure gauges shall conform to requirements of ASME B40.1, single style pressure gauge for water with 115 mm (4-1/2 inch) dial brass or aluminum case, bronze tube, gauge cock, pressure snubber, and siphon. Scale range shall be suitable for irrigation sprinkler systems.

2.5.4 Service Clamps

Service clamps shall be bronze flat, double strap, with neoprene gasket or "O"-ring seal.

2.5.5 Water Hammer Arresters

Water hammer arrester shall conform to the requirements of PDI WH 201; stainless steel construction with an encased and sealed bellows compression chamber.

2.5.6 Emitter Head Accessories

2.5.6.1 Strainer

Strainer shall be provided at inlet to each drip line. Strainer shall have stainless steel screen having equivalent of 140-mesh filtration capacity and incorporate flush valves within strainer to clean screen without disassembling unit.

2.5.6.2 Pressure Regulator

Pressure regulator shall be provided at each drip system if supply pressure exceeds 350 kPa (50 psi).

2.5.6.3 Riser Adapters

Riser adapters shall be provided with a rigid piping system.

2.5.6.4 Tubing Stakes

Tubing stakes shall be plastic coated steel, or other non-corrosive strong material to secure tubing.

2.5.6.5 Emitter Outlet Check Valve (Bug Cap)

Check valves shall be provided at end of each emitter outlet distribution line. Valves shall permit free flow of water with minimum restriction; prevent back siphoning, entry of insects, and contamination into outlet ports.

2.5.6.6 Access Sleeve

Access sleeve shall be provided at buried emitters placed in covered boxes. Lids of access sleeve shall be secured with removable lugs. Drip hose in both vertical and horizontal axis shall be secured.

2.5.6.7 Closure Caps

Closure caps shall be in accordance with manufacturer's recommendations.

2.6 AUTOMATIC CONTROLLERS, ELECTRICAL

Controller shall conform to the requirements of NEMA ICS 2 with 120-volt single phase service, operating with indicated stations, and grounded chassis. Enclosure shall conform to NEMA ICS 6 Type 3R, with locking hinged cover, pedestal-mounted or wall-mounted. Controller shall be programmed for various schedules by setting switches and dials equipped with the following features: A switch for each day of week for two or three schedules, allowing each station to be scheduled individually as to days of watering; a minute switch for each station with a positive increment range of 3 to 60 minutes for sprinkler heads and 0 to 3 hours for emitter heads, set time within one percent; a switch allowing selected schedules to be repeated after each completion of initial watering schedule and allowing each operation to be scheduled throughout a 24-hour day; a circuit breaker for surge protection; and circuit for a 9-volt rechargeable NiCad battery.

2.7 ELECTRICAL WORK

Wiring and rigid conduit for electrical power shall be in accordance with NFPA 70, and Section 16375: ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

2.8 CONCRETE MATERIALS

Concrete shall have a compressive strength of 17 MPa (2500 psi) at 28 days as specified in Section 03300: CAST-IN-PLACE STRUCTURAL CONCRETE.

2.9 WATER SUPPLY MAIN MATERIALS

Tapping sleeves, service cut off valves, and connections to water supply mains shall be in accordance with Section 02660: WATER LINES.

2.10 INSULATING JOINTS

Insulating joints and dielectric fittings shall be in accordance with Section 02660: WATER LINES.

PART 3 EXECUTION

3.1 INSTALLATION

Sprinkler system shall be installed after site grading has been completed. Excavation, trenching, and backfilling for sprinkler system shall be in accordance with the applicable provisions of Section 02222: EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS, except as modified herein.

3.1.1 Trenching

Trench around roots shall be hand excavated to pipe grade when roots of 50 mm (2 inches) diameter or greater are encountered. Trench width shall be 100 mm (4 inches) minimum or 1-1/2 times diameter of pipe, whichever is wider. Backfill shall be hand tamped over excavation. When rock is encountered, trench shall be excavated 100 mm (4 inches) deeper and backfilled with silty sand (SM) or well-graded sand (SW) to pipe grade. Trenches shall be kept free of obstructions and debris that would damage pipe. Subsoil shall not be mixed with topsoil. Existing concrete walks, drives and other obstacles shall be bored at a depth conforming to bottom of adjacent trenches. Pipe sleeves for bored pipe shall be two pipe diameters larger than sprinkler pipe.

3.1.2 Piping System

3.1.2.1 Cover

Underground piping shall be installed as to meet the minimum depth of backfill cover specified.

3.1.2.2 Clearances

Minimum horizontal clearances between lines shall be 100 mm (4 inches) for pipe 50 mm (2 inches) and less; 300 mm (12 inches) for 65 mm (2-1/2 inches) and larger. Minimum vertical clearances between lines shall be 25 mm (1 inch).

3.1.2.3 Minimum Slope

Minimum slope shall be 50 mm (6 inches) per 10 m (100 feet) in direction of drain valves.

3.1.3 Piping Installation

3.1.3.1 Polyvinyl Chloride (PVC) Pipe

a. Solvent-cemented joints shall conform to the requirements of ASTM D 2855.

b. Threaded joints shall be full cut with a maximum of three threads remaining exposed on pipe and nipples. Threaded joints shall be made tight without recourse to wicks or fillers, other than polytetrafluoroethylene thread tape.

c. Piping shall be joined to conform with requirements of ASTM D 2774 or ASTM D 2855, and pipe manufacturer's instructions. Pipe shall be installed in a serpentine (snaked) manner to allow for expansion and contraction in trench before backfilling. Pipes shall be installed at temperatures over 5 degrees C (40 degrees F).

3.1.3.2 Soldered Copper Tubing

Pipe shall be reamed and burrs removed. Contact surfaces of joint shall be cleaned and polished. Flux shall be applied to male and female ends. End of tube shall be inserted into fittings full depth of socket. After soldering, a solder bead shall show continuously around entire joint circumference. Excess acid flux shall be removed from tubings and fittings.

3.1.3.3 Threaded Brass or Galvanized Steel Pipe

Prior to installation, pipe shall be reamed. Threads shall be cut in conformance with ASME B1.2. Pipe joint compound shall be applied to male end only.

3.1.3.4 Insulating Joints

Insulating and dielectric fittings shall be provided where pipes of dissimilar metal are joined and at connections to water supply mains as shown. Installation shall be in accordance with Section 02660: WATER LINES.

3.1.4 Valves

3.1.4.1 Manual Valves

Valves shall be installed in a valve box extending from grade to below valve body, with a minimum of 100 mm (4 inches) cover measured from finish grade to top of valve stem.

3.1.4.2 Automatic Valves

Valve shall be set plumb in a valve box extending from grade to below valve body, with minimum of 100 mm (4 inch) cover measured from grade to top of valve. Install automatic valves beside sprinkler heads with a valve box.

3.1.4.3 Drain Valves

Entire system shall be manually or automatically drainable. Low points of system shall be equipped with drain valve draining into an excavation containing 0.03 cubic meter (1 cubic foot) gravel. Gravel shall be covered with building paper then backfilled with excavated material and 150 mm (6 inches) of topsoil.

3.1.5 Sprinklers and Quick Coupling Valves

Sprinklers and valves shall be installed plumb and level with terrain.

3.1.6 Installation of Drip Irrigation System

3.1.6.1 Emitter Hose

Emitter laterals shall be buried 150 mm (6 inches) deep. Connections shall be solvent welded in accordance with manufacturer's recommendation to standard weight Schedule 40 PVC fittings and bushings. Hose shall be installed in a serpentine manner. When cutting hose, shearing tool such as a pipe cutter, knife, or shears shall be used. Manufacturer's recommended tool and procedures when punching hose for emitters shall be followed.

3.1.6.2 Emitter Heads

Emitters shall be installed in a plastic emitter box. Emitter on a rigid PVC nipple shall be connected to PVC drip lateral with a tee or elbow. Tubing shall be attached to barbed fitting and daylight distribution tubing at root ball secured with stake, with bug cap at end of secured distribution tubing. After installing emitters and before operating system, end of drip lateral shall be opened and flushed clean. The number of emitters on a line shall not exceed manufacturer's recommendations for that hose or distribution tubing size and length.

3.1.6.3 Tubing Stakes

Main irrigation line shall be secured with stakes where line is aboveground. Stakes shall be spaced to ensure that hose does not shift location in presence of foot traffic, operations, gravity on slope installations, or environmental effects. Discharge of the emitter distribution tubing shall be staked to ensure that discharge point of emitter will be maintained at specified position in relation to plant material to be irrigated.

3.1.7 Backflow Preventers

Backflow preventer shall be installed in new connection to existing water distribution system, between connection and control valves. Backflow preventer shall be installed with concrete pads.

3.1.7.1 Pressure Type Vacuum Breaker

Pressure type vacuum breaker shall be installed 300 mm (12 inches) above highest head.

3.1.7.2 Reduced Pressure Type

Reduced pressure type shall be installed as follows: Flush pipe lines prior to installing device and protect device by a strainer located upstream. Device shall not be installed in pits or where any part of device could become submerged in standing water.

3.1.8 Control Wire and Conduit

3.1.8.1 Wires

Low voltage wires may be buried beside pipe in same trench. Rigid conduit shall be provided where wires run under paving. Wires shall be number tagged at key locations along main to facilitate service. One control circuit shall be provided for each zone and a circuit to control sprinkler system.

3.1.8.2 Loops

A 300 mm (12 inch) loop of wire shall be provided at each valve where controls are connected.

3.1.8.3 Expansion and Contraction

Multiple tubes or wires shall be bundled and taped together at 6 m (20 foot) intervals with 300 mm (12 inch) loop for expansion and contraction.

3.1.8.4 Splices

Electrical splices shall be waterproof.

3.1.9 Automatic Controller

Exact field location of controllers shall be determined before installation. Coordinate the electrical service to these locations. Install in accordance with manufacturer's recommendations and NFPA 70.

3.1.10 Thrust Blocks

Concrete shall be placed so that sides subject to thrust or load are against undisturbed earth, and valves and fittings are serviceable after concrete has set. Thrust blocks shall be as specified in Section 02660: WATER LINES.

3.1.11 Backfill

3.1.11.1 Minimum Cover

Depth of cover shall be 300 mm (12 inches) for 32 mm (1-1/4 inch) pipe or smaller; 450 mm (18 inches) for 40 to 50 mm (1-1/2 to 2 inch) pipe; 600 mm (24 inches) for 65 mm (2-1/2 inch) pipe or larger; 1000 mm (36 inches) for pipes under traffic loads, farm operations, and freezing temperatures; and 450 mm (18 inches) for low-voltage wires. Remainder of trench or pipe cover shall be filled to within 80 mm (3 inches) of top with excavated soil, and compact soil with plate hand-held compactors to same density as undisturbed adjacent soil.

3.1.11.2 Restoration

Top 80 mm (3 inches) shall be filled with topsoil and compacted with same density as surrounding soil. Lawns and plants shall be restored in accordance with Section 02935: TURF, and Section 02950: TREES, SHRUBS, GROUND COVERS AND VINES. Pavements shall be restored in accordance with Section 02515: CONCRETE PAVEMENT for ROADS AND AIRFIELD, and Section 02551: BITUMINOUS PAVING FOR ROADS, STREETS AND OPEN STORAGE AREAS.

3.1.12 Adjustment

After grading, seeding, and rolling of planted areas, sprinkler heads shall be adjusted flush with finished grade. Adjustments shall be made by providing new nipples of proper length or by use of heads having an approved device, integral with head, which will permit adjustment in height of head without changing piping.

3.1.13 Disinfection

Sprinkler system fed from a potable water system shall be disinfected upstream of backflow preventer in accordance with Section 02660: WATER LINES.

3.1.14 Cleaning of Piping

Prior to the hydrostatic and operation tests, the interior of the pipe shall be flushed with clean water until pipe is free of all foreign materials. Flushing and cleaning out of system pipe, valves, and components shall not be considered completed until witnessed and accepted by Contracting Officer.

3.2 FIELD TESTS

All instruments, equipment, facilities, and labor required to conduct the tests shall be provided by Contractor.

3.2.1 Hydrostatic Pressure Test

Piping shall be tested hydrostatically before backfilling and proved tight at a hydrostatic pressure of 1034 kPa (150 psi) without pumping for a period of one hour with an allowable pressure drop of 35 kPa (5 psi). If hydrostatic pressure cannot be held for a minimum of 4 hours, Contractor shall make adjustments or replacements and the tests repeated until satisfactory results are achieved and accepted by the Contracting Officer.

3.2.2 Leakage Tests

Leakage tests for service main shall be in accordance with Section 02660: WATER LINES.

3.2.3 Operation Test

At conclusion of pressure test, sprinkler heads or emitter heads, quick coupling assemblies, and hose valves shall be installed and entire system tested for operation under normal operating pressure. Operation test consists of the system operating through at least one complete programmed cycle for all areas to be sprinkled.

3.3 POSTING FRAMED INSTRUCTIONS

Framed instructions containing wiring and control diagrams under glass or in laminated plastic shall be posted where directed. Condensed operating instructions, prepared in typed form, shall be framed as specified above and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the system. After as-built drawings are approved by Contracting Officer, controller charts and programming schedule shall be prepared. One chart for each controller shall be supplied. Chart shall be a reduced drawing of actual as-built system that will fit the maximum dimensions inside controller housing. Black line print for chart and a different pastel or transparent color shall indicate each station area of coverage. After chart is completed and approved for final acceptance, chart shall be sealed between two 0.505 mm (20 mil) pieces of clear plastic.

3.4 FIELD TRAINING

A field training course shall be provided for designated operating and maintenance staff members. Training shall be provided for a total period of 16 hours of normal working time and shall start after the system is functionally complete but prior to final acceptance tests. Field training shall cover all of the items contained in the operating and maintenance manuals.

3.5 CLEANUP

Upon completion of installation of system, all debris and surplus materials resulting from the work shall be removed.

SECTION 02831

CHAIN LINK FENCE

TABLE OF CONTENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 116 (2000) Zinc-Coated (Galvanized) Steel Woven Wire Fence Fabric

ASTM A 121 (1999) Zinc-Coated (Galvanized) Steel Barbed Wire

ASTM A 153/A 153M (2000) Zinc-Coated (Hot Dip) on Iron and Steel Hardware

ASTM A 176	(1999) Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip
ASTM A 392	(1996) Zinc-Coated Steel Chain-Link Fence Fabric
ASTM A 478	(1997) Chromium-Nickel Stainless and Heat-Resisting Steel Weaving and Knitting Wire
ASTM A 491	(1996) Aluminum-Coated Steel Chain-Link Fence Fabric
ASTM A 585	(1997) Aluminum-Coated Steel Barbed Wire
ASTM A 666	(2000) Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
ASTM A 702	(1989; R 1994el) Steel Fence Posts and Assemblies, Hot Wrought
ASTM A 780	(2000) Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings
ASTM A 824	(1995) Metallic-Coated Steel Marcelled Tension Wire for Use With Chain Link Fence
ASTM C 94/C 94M	(2000) Ready-Mixed Concrete
ASTM D 4541	(1995e1) Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM F 626	(1996a) Fence Fittings
ASTM F 668	(1999a) Poly(Vinyl Chloride) (PVC)-Coated Steel Chain-Link Fence Fabric
ASTM F 883	(1997) Padlocks
ASTM F 900	(1994) Industrial and Commercial Swing Gates
ASTM F 1043	(2000) Strength and Protective Coatings on Metal Industrial Chain-Link Fence Framework
ASTM F 1083	(1997) Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
ASTM F 1184	(1994) Industrial and Commercial Horizontal Slide Gates
ASTM G 23	(1996) Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Non-metallic Materials
ASTM G 26	(1995) Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Non-metallic

Materials

ASTM G 53	(1996) Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Non-metallic Materials

1.2 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES.

SD-07 Certificates

Chain Link Fence; FIO.

Statement signed by an official authorized to certify on behalf of the manufacturer attesting that the chain link fence and component materials meet the specified requirements.

SD-10 Operation and Maintenance Manuals

Electro-Mechanical Locks and Gate Operators; FIO.

Six copies of operating and maintenance instructions, a minimum of 2 weeks prior to field training. Operating instructions shall outline the step-by-step procedures required for system startup, operation, and shutdown. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Maintenance instructions shall include routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The instructions shall include the general gate layout, equipment layout and simplified wiring and control diagrams of the system as installed.

1.3 APPROVAL OF POLYVINYL CHLORIDE-COATED FENCE MATERIALS

Polyvinyl chloride-coated fence materials shall be thoroughly inspected for cracking, peeling, and conformance with the specifications by the Contracting Officer's Representative prior to installation. Any fence materials rejected by the Contracting Officer's Representative shall be replaced by the contractor with approved materials at no additional cost to the Government.

PART 2 PRODUCTS

2.1 FENCE FABRIC

Fence fabric shall conform to the following:

2.1.1 Chain Link Fence Fabric

ASTM A 392, Class, zinc-coated steel wire with minimum coating weight of 370 grams (1.2 ounces) of zinc per square meter (foot) of coated surface, or ASTM A 491, Type I, aluminum-coated steel wire. Fabric shall be fabricated of 9 gauge wire woven in 50.8 mm (2 inch) mesh. Fabric height shall be as shown on the drawing. Fabric shall be twisted and barbed on the top selvage and knuckled on the bottom selvage.

2.2 Gates

ASTM F 900 and/or ASTM F 1184. Gate shall be the type and swing shown. Gate frames shall conform to strength and coating requirements of ASTM F 1083 for Group IA, steel pipe, with external coating Type A, nominal pipe size (NPS) 1-1/2. Gate frames shall conform to strength and coating requirements of ASTM F 1043, for Group IC, steel pipe with external coating Type A or Type B, nominal pipe size (NPS) 1-1/2. Gate fabric shall be as specified for chain-link fabric. Each end member of gate frames shall be extended sufficiently above the top member to carry three strands of barbed wire in horizontal alignment with barbed wire strands on the fence. Gate leaves more than 2.44 m (8 feet) wide shall have either intermediate members and diagonal truss rods or shall have tubular members as necessary to provide rigid construction, free from sag or twist. Gate leaves less than 2.44 m (8 feet) wide shall have truss rods or intermediate braces. Intermediate braces shall be provided on all gate frames with an electro-mechanical lock. Gate fabric shall be attached to the gate frame by method standard with the manufacturer except that welding will not be permitted. Latches, hinges, stops, keepers, rollers, and other hardware items shall be furnished as required for the operation of the gate. Latches shall be arranged for padlocking so that the padlock will be accessible from both sides of the gate. Stops shall be provided for holding the gates in the open position.

2.3 Posts

ASTM F 1083, zinc-coated. Group IA, with external coating Type A steel pipe. Group IC steel pipe, zinc-coated with external coating Type A or Type B and Group II, formed steel sections, shall meet the strength and coating requirements of ASTM F 1043. Group III, ASTM F 1043 steel H-section may be used for line posts in lieu of line post shapes specified for the other classes. Sizes shall be as shown on the drawings. Line posts and terminal (corner, gate, and pull) posts selected shall be of the same designation throughout the fence. Gate post shall be for the gate type specified subject to the limitation specified in ASTM F 900 and/or ASTM F 1184.

2.3.1 Composite Polyester Resin Reinforced Line Posts

Polyester resin reinforced line posts shall be produced from unsaturated polyster resin reinforced with E-glass. Posts shall be filled with an appropriate filler material to form a rigid structural support member. The post shall meet the strength requirements of ASTM F 1043 for heavy industrial fencing. Posts shall be protected from UV and moisture degradation by a protective veil impregnated with resin (8-12 mil minimum) and an acrylic based (2 mil minimum) coating system. Posts shall exhibit corrosion and ultraviolet resistance as demonstrated when exposed to accelerated environmental test chamber for not less than 3,600 hours. The post will show no structural failure (i.e., less than 10% loss of strength) as a result of exposure to moisture and lamps required in ASTM G 23, ASTM G 26 and ASTM G 53. Post coating system strength shall be tested in accordance with ASTM D 4541 for 90% adhesion strength. Posts shall be colored as directed by the COR. Provide outside diameter as specified in ASTM F 1043 for round steel pipe.

2.4 Braces and Rails

ASTM F 1083, zinc-coated, Group IA, steel pipe, size NPS 1-1/4. Group IC steel pipe, zinc-coated, shall meet the strength and coating requirements of ASTM F 1043. Group II, formed steel sections, size 42.16 mm (1.66 inch), 1.66 inch, conforming to ASTM F 1043, may be used as braces and rails if Group II line posts are furnished.

2.5 Tension Wire

Tension wire shall be Type I or Type II, Class 2 coating, in accordance with ASTM A 824.

2.1.6 Barbed Wire for Farm Style Fence Barbed wire shall conform to ASTM A 121 zinc-coated class 1, 13 gauge wire with 13-1/2 gauge 4-point barbs spaced no more than 150 mm 6 inches apart.

2.7 Accessories

ASTM F 626. Ferrous accessories shall be zinc or aluminum coated. Truss rods shall be furnished for each terminal post. Truss rods shall be provided with turnbuckles or other equivalent provisions for adjustment. Barbed wire shall be 2 strand, 12-1/2 gauge wire, zinc-coated, Class 3 in accordance with ASTM A 121 or aluminum coated Type I in accordance with ASTM A 585. Barbed wire shall be four-point barbed type steel wire. Barbed wire support arms shall be the single or V arm type and of the design required for the post furnished. Tie wire for attaching fabric to rails, braces, and posts shall be 9 gauge steel wire and match the coating of the fence fabric. Miscellaneous hardware coatings shall conform to ASTM A 153 unless modified herein.

2.8 Concrete

ASTM C 94, using 19 mm (3/4 inch) maximum size aggregate, and having minimum compressive strength of 21 MPa (3000 psi) at 28 days. Grout shall consist of one part portland cement to three parts clean, well-graded sand and the minimum amount of water to produce a workable mix.

2.9 Padlocks

ASTM F 883, Type PO1, Grade 2, Size 44.4 mm (1-3/4 inch). Padlocks shall be keyed alike and each lock shall be furnished with two keys.

2.10 Gate Operator

Electric gate operators for sliding gates shall be as follows: Electrical gate operators shall have a right angle gearhead instantly reversing motor with magnetic drum-type brake, friction disc clutch, reversing starter with thermal overload protection, and a chain-driven geared rotary-type automatic limit switch. Gears shall consist of a hardened steel machine cut worm and mating bronze gear. All gears and bearings shall operate in a bath of oil. Gate operators with V-belt pulleys will not be allowed. Gate operators shall be equipped with an emergency release to allow the gate to be operated manually. The emergency release mechanism shall be capable of being locked in the engaged or disengaged position. Positive stops shall be provided on the gate tracks as a backup to the limit switches.

2.11 Electro-Mechanical Locks

Electro-mechanical locking devices for sliding gates and personnel gates shall be solenoid actuated such that the deadbolt retracts when the solenoid is energized and remains electrically retracted until the gate is closed. The solenoid shall be the continuous duty type, rated for 120V ac, 60Hz operation. The locking device shall be unlockable by key and shall be keyed on both sides. Status of the electro-mechanical lock shall be monitored by two limit switches (integral to the locking device) wired in series. One switch shall monitor the deadlock lever and the other switch shall monitor the locking tongue.

PART 3 EXECUTION

3.1 GENERAL

Fence shall be installed to the lines and grades indicated. The area on either side of the fence line shall be cleared to the extent indicated. Line posts shall be spaced equidistant at intervals not exceeding 3.05 m (10 feet). Terminal (corner, gate, and pull) posts shall be set at abrupt changes in vertical and horizontal alignment. Fabric shall be continuous between terminal posts; however, runs between terminal posts shall not exceed 152.4 m (500 feet). Any damage to galvanized surfaces, including welding, shall be repaired with paint containing zinc dust in accordance with ASTM A 780.

3.2 EXCAVATION

Post holes shall be cleared of loose material. Waste material shall be spread where directed. The ground surface irregularities along the fence line shall be eliminated to the extent necessary to maintain a 50.8 mm (2 inch) clearance between the bottom of the fabric and finish grade.

3.3 POSTS

Posts shall be set plumb and in alignment. Except where solid rock is encountered, posts shall be set in concrete to the depth indicated on the drawings. Where solid rock is encountered with no overburden, posts shall be set to a minimum depth of 457 mm (18 inches) in rock. Where solid rock is covered with an overburden of soil or loose rock, posts shall be set to the minimum depth indicated on the drawing unless a penetration of 457 mm (18 inches) in solid rock is achieved before reaching the indicated depth, in which case depth of penetration shall terminate. All portions of posts set in rock shall be grouted. Portions of posts not set in rock shall be set in concrete from the rock to ground level. Posts set in concrete shall be set in holes not less than the diameter shown on the drawings. Diameters of holes in solid rock shall be at least 25.4 mm (1 inch) greater than the largest cross section of the post. Concrete and grout shall be thoroughly consolidated around each post, shall be free of voids and finished to form a dome. Concrete and grout shall be allowed to cure for 72 hours prior to attachment of any item to the posts. Group II line posts may be mechanically driven, for temporary fence construction only, if rock is not encountered. Driven posts shall be set to a minimum depth of 914 mm (3 feet) and shall be protected with drive caps when being set. Fence post rigidity shall be tested by applying a 222.4 Newtons (50 pound) force on the post, perpendicular to the fabric, at 1.52 m (5 feet) above ground. Post movement measured at the point where the force is applied shall be less than or equal to 19 mm (3/4 inch) from the relaxed position. Every tenth post shall be tested for rigidity. When a post fails this test, further tests on the next four posts on either side of the failed post shall be made. All failed posts shall be removed, replaced, and re-tested at the Contractor's expense.

3.4 RAILS

3.4.1 Top Rail

Top rail shall be supported at each post to form a continuous brace between terminal posts. Where required, sections of top rail shall be joined using sleeves or couplings that will allow expansion or contraction of the rail. Bottom rail, if required for high security fence, shall be installed as indicated on the drawings.

3.4.2 Bottom Rail

The bottom rail shall be bolted to double rail ends and double rail ends shall be securely fastened to the posts. Bolts shall be peened to prevent easy removal. Bottom rail shall be installed before chain link fabric.

3.5 BRACES AND TRUSS RODS

Braces and truss rods shall be installed as indicated and in conformance with the standard practice for the fence furnished. Horizontal (compression) braces and diagonal truss (tension) rods shall be installed on fences over 1.83 m (6 feet) in height. A center brace or 2 diagonal truss rods shall be installed on 3.66 m (12 foot) fences. Braces and truss rods shall extend from terminal posts to line posts. Diagonal braces shall form an angle of approximately 40 to 50 degrees with the horizontal. No bracing is required on fences 1.83 m (6 feet) high or less if a top rail is installed.

3.6 TENSION WIRES

Tension wires shall be installed along the top and bottom of the fence line and attached to the terminal posts of each stretch of the fence. Top tension wires shall be installed within the top 305 mm (1 foot) and 102 mm (4 inches) of the installed fabric for high security fence. Bottom tension wire shall be installed within the bottom 152 mm (6 inches) of the installed fabric. Tension wire shall be pulled taut and shall be free of sag.

3.7 CHAIN LINK FABRIC

Chain link fabric shall be installed on the side of the post indicated. Fabric shall be attached to terminal posts with stretcher bars and tension bands. Bands shall be spaced at approximately 381 mm (15 inch) intervals. The fabric shall be installed and pulled taut to provide a smooth and uniform appearance free from sag, without permanently distorting the fabric diamond or reducing the fabric height. Fabric shall be fastened to line posts at approximately 381 mm (15 inch) intervals and fastened to all rails and tension wires at approximately 610 mm (24 inch) intervals. Fabric shall be cut by untwisting and removing pickets. Splicing shall be accomplished by weaving a single picket into the ends of the rolls to be joined. The bottom of the installed fabric shall be 50.8 mm (2 inches) plus or minus 12.7 mm (1/2 inch) above the ground. After the fabric installation is complete, the fabric shall be exercised by applying a 222 newtons (50 pound) push-pull force at the center of the fabric between posts. The use of a 133 newtons (30 pound) pull at the center of the panel shall cause fabric deflection of not more than 63.5 mm (2.5 inches) when pulling fabric from the post side of the fence. Every second fence panel shall meet this requirement. All failed panels shall be re-secured and re-tested at the Contractor's expense.

3.8 BARBED WIRE SUPPORTING ARMS AND BARBED WIRE

Barbed wire supporting arms and barbed wire shall be installed as indicated and as recommended by the manufacturer. Supporting arms shall be anchored to the posts in a manner to prevent easy removal with hand tools. Supporting arms shall be anchored with 9.5 mm (3/8 inch) diameter plain pin rivets or, at the Contractor's option, with studs driven by low-velocity explosive-actuated tools for steel, wrought iron, ductile iron, or malleable iron. Studs driven by an explosive-actuated tool shall not be used with gray iron or other material that can be fractured. A minimum of two studs per support arm shall be used.] Barbed wire shall be pulled taut and attached to the arms with clips or other means that will prevent easy removal.

3.9 GATES

Gates shall be installed at the locations shown. Hinged gates shall be mounted to swing as indicated. Latches, stops, and keepers shall be installed as required. Padlocks shall be attached to gates or gate posts with chains. Hinge pins, and hardware shall be welded or otherwise secured to prevent removal.

3.10 BARBED TAPE INSTALLATION

Stainless steel reinforced barbed tape shall be installed as detailed on the drawings. Barbed tape shall be stretched out to its manufacturer's recommended length, set on top of the barbed wire and "V" shaped support arms, and then secured to the barbed wire. The barbed tape shall be secured to the barbed wire at the two points and at every spiral turn of both coils as shown on the drawings. Stainless steel reinforced or non-reinforced barbed tape for ground applications shall be installed per manufacturer's recommendations unless otherwise shown on the drawings.

3.11 GROUNDING

Fences crossed by overhead powerlines in excess of 600 volts shall be grounded as specified in Section 16670: LIGHTNING PROTECTION SYSTEM. Electrical equipment attached to the fence shall be grounded as specified in Section 16370: ELECTRICAL DISTRIBUTION SYSTEM, AERIAL or Section 16375: ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Fences shall be grounded on each side of all gates, at each corner, at the closest approach to each building located within 15m (50 feet) of the fence, and where the fence alignment changes more than 15 degrees. Grounding locations shall not exceed 198m (650 feet). Each gate panel shall be bonded with a flexible bond strap to its gate post. Fences crossed by powerlines of 600 volts or more shall be grounded at or near the point of crossing and at distances not exceeding 45 m (150 feet) on each side of crossing. Ground conductor shall consist of No. 8 AWG solid copper wire. Grounding electrodes shall be 19 mm (3/4 inch) by 3.05 m (10 foot) long copper-clad steel rod. Electrodes shall be driven into the earth so that the top of the electrode is at least 152 mm (6 inches) below the grade. Where driving is impracticable, electrodes shall be buried a minimum of 305 mm (12 inches) deep and radially from the fence. The top of the electrode shall be not less than 0.6 m (2 feet) or more than 2.4 m (8 feet) from the fence. Ground conductor shall be clamped to the fence and electrodes with bronze grounding clamps to create electrical continuity between fence posts, fence fabric, and ground rods. After installation the total resistance of fence to ground shall not be greater than 25 ohms.

SECTION 02915

TRANSPLANTING EXTERIOR PLANT MATERIAL

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NURSERY AND LANDSCAPE ASSOCIATION (ANLA)

ANLA Z60.1 (1996) Nursery Stock

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A300 (1995) Tree Care Operations - Trees,

Shrubs and other Woody Plant Maintenance

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 602 (1995a) Agricultural Liming Materials

ASTM D 3776 (1996) Mass per Unit Area (Weight) of Fabric

ASTM D 4491 (1999) Water Permeability of Geotextiles by Permittivity

ASTM D 4533 (1991; R 1996) Trapezoid Tearing Strength of Geotextiles

ASTM D 4632 (1991; R 1997) Grab Breaking Load and Elongation of Geotextiles

ASTM D 4751 (1999) Determining Apparent Opening Size of a Geotextile

ASTM D 4833 (2000) Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products

ASTM D 4873 (1997) Identification, Storage, and Handling of Geosynthetic Rolls

ASTM D 4972 (1995a) pH of Soils

ASTM D 5034 (1995) Breaking Strength and Elongation of Textile Fabrics (Grab Test)

ASTM D 5035 (1995) Breaking Force and Elongation of Textile Fabrics (Strip Method)

ASTM D 5268 (1992; R 1996) Topsoil Used for Landscaping Purposes

ASTM D 5883 (1996el) Use of Rotary Kiln Produced Expanded Shale, Clay or Slate (ESCS) as a Mineral Amendment in Topsoil Used for Landscaping and Related Purposes

1.2 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having a "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Finished Grade and Topsoil; GA

Underground Utilities; GA

Delivered Topsoil; GA

Obstructions Below Ground; GA

Finished grade status; location of underground utilities and facilities; and availability of topsoil from the stripping and stock piling operation.

SD-03 Product Data

Super Absorbent Polymers; GA

Geosynthetics; GA

Root Barriers; GA

Manufacturer's literature including physical characteristics, application and installation instructions.

Equipment; FIO

A listing of equipment to be used for the transplanting operation, including size model, year and type of mechanical tree transplanting equipment.

Transplanting Plan; GA

Methods to be used for each plant species to be transplanted ensuring survivability.

Application of Pesticide; GA

Pesticide treatment plan with sequence of treatment work, plus dates and times. The plan shall state the applicator's years of previous experience in applying pesticides of this type or under these conditions, if requested by the Contracting Officer. The pesticide trade name, EPA registration number, chemical composition, formulation, concentration of original and diluted material, application rate of active ingredients, method of application, area treated, amount applied shall be included.

Plant Establishment Period; FIO

Calendar time period for the plant establishment period. When there is more than one establishment period, the boundaries of the planted areas covered for each period shall be described.

Maintenance Record; FIO

Maintenance work performed, quantity of plant losses, and replacements; and diagnosis of unhealthy plant material.

SD-06 Test Reports

Soil Test; FIO

Percolation Test; FIO

Recycled Compost; FIO

Certified reports of inspections and laboratory tests, prepared by an independent testing agency, including analysis and interpretation of test results. Each report shall be properly identified. Test methods used and compliance with recognized test standards shall be described.

SD-07 Certificates

Topsoil; FIO

Fertilizer; GA

Soil Conditioner; GA

pH Adjuster; GA

Pesticide; GA

Prior to delivery of materials, certificates of compliance attesting that materials meet the specified requirements. Certified copies of the material certificates shall include the following.

For items listed in this section:

1) Certification of recycled content or,

2) Statement of recycled content.

3) Certification of origin including the name, addresses and telephone number of manufacturer.

a. Topsoil. Particle size, pH, organic matter content, textural class, soluble salts, chemical and mechanical analyses.

b. Fertilizer. Chemical analysis and composition percent.

c. Soil Conditioner. Composition and source.

d. pH Adjuster. Calcium carbonate equivalent and sieve analysis.

e. Pesticide. EPA registration number and registered uses.

SD-10 Operation and Maintenance Data

Maintenance Instructions; FIO

Instruction for care of installed plant material during initial establishment period and long term care.

1.3 TRANSPLANTING PLAN

A transplanting plan shall be submitted and shall delineate methods and times for root pruning, digging, balling, removing, storing, transporting, planting, watering, and maintenance to ensure survivability. The plan shall also include equipment, anti-desiccant and pesticides to be used. A listing of the plant material to be transplanted shall be provided by common name and botanical name as listed under "Nomenclature" in ANLA Z60.1; classification; caliper; and height.

1.4 PLANT MATERIAL SURVIVABILITY

Plant material survivability shall be determined by growing condition; root pruning and transplanting method to maintain a healthy root system; and recovery of leaves or needles with the crown in good balance with the trunk free from disfigurement or abrasion.

1.5 DECIDUOUS TREES

A "P1" height to caliper relationship shall be maintained in accordance with ANLA Z60.1. Height of branching shall bear a relationship to the size and species of tree and with the crown in good balance with the trunk. The trees shall not be "poled" or the leader removed.

1.5.1 Single stem

The trunk shall be reasonably straight and symmetrical with crown and have a persistent main leader. The form of growth desired shall be as indicated.

1.5.1.1 Multi-stem

All countable stems, in aggregate, shall be maintained. To be considered a stem, there shall be no division of the trunk which branches a minimum 150mm 6 inches from the ground surface. The form of growth desired shall be as indicated.

1.5.1.2 Specimen

The tree shall be well branched and pruned naturally according to the species. The form of growth desired, which may not be in accordance with natural growth habit, shall be as indicated.

1.5.2 Palms

Palms shall have the height measured from the base of the trunk to the base of the fronds or foliage in accordance with ANLA Z60.1. The palm shall have a straight trunk and healthy fronds or foliage. Palms trimmed or pruned shall retain a minimum 150 mm 6 inches of foliage at the crown as a means of determining plant health.

1.5.3 Deciduous Shrubs

Deciduous shrubs shall have the height and number of primary stems recommended by ANLA Z60.1. Plant material shall bear a relationship to the size and species of plant with the crown in good balance with the trunk, well shaped, and with sufficient well-spaced side branches. The form of growth desired shall be as indicated.

1.5.4 Coniferous Evergreen Plant Material

Coniferous evergreen plant material shall have the height-to-spread ratio recommended by ANLA Z60.1. The coniferous evergreen trees shall not be "poled" or the leader removed. Plant material shall be well shaped and trimmed to form a symmetrical and tightly knit plant. The form of growth desired shall be as indicated.

1.5.5 Broadleaf Evergreen Plant Material

Broadleaf evergreen plant material shall have the height-to-spread ratio recommended by ANLA Z60.1. Plant material shall bear a relationship to the size and species of plant with the crown in good balance with the trunk, well shaped, and with sufficient well-spaced side branches. The form of growth desired shall be as indicated.

1.5.6 Ground Cover and Vines

Ground cover and vine plant material shall have the minimum number of runners and length of runner recommended by ANLA Z60.1. Plant material shall have heavy, well developed and balanced crown with vigorous, well developed root system. The form of growth desired shall be as indicated.

1.5.7 Protection During Transplanting

Plant material shall be protected during transplanting to prevent desiccation and damage to the branches, trunk, and root system. Branches shall be protected by tying-in. Exposed branches shall be covered during transport. The root area shall be treated with gels containing mycorrhizal fungi inoculum. Plant material shall be undamaged, well shaped, vigorous and healthy with a well-branched root system, free from disease, harmful insects and insect eggs, sun-scald injury, disfigurement or abrasion after transplanting. Plant material showing desiccation, abrasion, sun scald injury or structural branching damage shall be replaced at no cost to the government.

1.6 DELIVERY OF MATERIALS

1.6.1 Delivered Topsoil

Prior to the delivery of any topsoil, the availability of topsoil shall be verified in paragraph TOPSOIL. A soil test shall be provided for delivered topsoil.

1.6.2 Soil Amendments

Soil amendments shall be delivered to the site in the original, unopened containers bearing the manufacturer's chemical analysis. In lieu of containers, soil amendments may be furnished in bulk. A chemical analysis shall be provided for bulk deliveries.

1.6.3 Pesticide Material

Pesticide material shall be delivered to the site in the original, unopened containers bearing legible labels indicating the Environmental Protection Agency (EPA) registration number and the manufacturer's registered uses.

1.7 PLANT MATERIAL IDENTIFICATION

Plant material to be transplanted shall be tagged and/or shown on drawings. Transplanted plant material shall be delivered with attached, durable, waterproof labels and weather-resistant ink or imprinted tags, stating the correct botanical plant name and size.

1.8 INSPECTION OF MATERIALS

Materials shall be inspected for compliance with paragraph PRODUCTS, paragraph PLANT MATERIAL SURVIVABILITY and paragraph PLANT MATERIAL IDENTIFICATION. Open soil amendment containers or wet soil amendments shall be rejected. Topsoil that contains slag, cinders, stones, lumps of soil, sticks, roots, trash or other material larger than 40 mm 1-1/2 inch diameter shall be rejected. Topsoil that contains viable plant material and plant parts shall be rejected. Unacceptable material shall be removed from the job site.

1.9 STORAGE OF MATERIALS

Storage of material shall be in designated areas. Soil amendments shall be stored in dry locations and away from contaminants. Chemical treatment material shall be stored according to manufacturer's instructions and not with planting operation material.

1.10 HANDLING OF MATERIALS

Materials shall not be dropped from vehicles. Plant material shall be transported without scarring trunks or deforming crown branching. Materials found to be in unacceptable condition shall be replaced at no additional cost to the Government.

1.11 TIME LIMITATION

The time limitation from digging, removing, transporting, to installing transplanted plant material shall be the same day. The time limitation between installing the plant material and placing the mulch shall be a maximum 48 hours.

1.12 WARRANTY

Transplanted plant material shall have a warranty for survivability as defined in paragraph PLANT MATERIAL SURVIVABILITY, and plant growth to be in a vigorous growing condition for a minimum 6 month period for plants other than specimen trees and a minimum 12 month calendar time period for specimen trees. The warranty of plant growth shall be provided regardless of the contract time period. When the transplanted plant material is determined to be unhealthy in accordance with paragraph PLANT ESTABLISHMENT PERIOD, it shall be replaced once under this warranty.

PART 2 PRODUCTS

2.1 TOPSOIL

Topsoil shall be as defined in ASTM D 5268. When available, the topsoil shall be the existing surface soil stripped and stockpiled onsite in accordance with Section 02300 EARTHWORK. When additional topsoil is required beyond the available topsoil from the stripping operation, topsoil shall be delivered and amended as recommended by the soil test for the plant material specified. Topsoil shall be free from slag, cinders, stones, lumps of soil, sticks, roots, trash or other material over a minimum 40 mm 1-1/2 inch diameter. Topsoil shall be free from viable plants and plant parts.

2.2 SOIL AMENDMENTS

Soil amendments shall consist of pH adjuster, fertilizer, organic material and soil conditioners meeting the following requirements. Vermiculite is not permitted.

2.2.1 pH Adjuster

The pH adjuster shall be an agricultural liming material in accordance with ASTM C 602. These materials may be burnt lime, hydrated lime, ground limestone, or shells. The pH adjuster shall be used to create a favorable soil pH for the plant material specified.

2.2.2 Limestone

Limestone material shall contain a minimum calcium carbonate equivalent of 80 percent. Gradation: A minimum 95 percent shall pass through a 2.36 mm No. 8 sieve and a minimum 55 percent shall pass through a 0.25 mm No. 60 sieve. To raise soil pH, ground limestone shall be used.

2.2.3 Hydrated Lime

Hydrated lime shall contain a minimum calcium carbonate equivalent of 110 percent. Gradation: A minimum 100 percent shall pass through a 2.36 mm No. 8 sieve and a minimum 97 percent shall pass through a 0.25 mm No. 60 sieve.

2.2.4 Burnt Lime

Burnt lime shall contain a minimum calcium carbonate equivalent of 140 percent. Gradation: A minimum 95 percent shall pass through a 2.36 mm No.8 sieve and a minimum 35 percent shall pass through a 0.25 mm No. 60 sieve.

2.2.5 Fertilizer

The nutrients ratio shall be 5 percent nitrogen, 3 percent phosphorus, and 2 percent potassium or 1 percent nitrogen, 2 percent phosphorus, and 1 percent potassium. Fertilizer shall be controlled release, commercial grade, suitable for use on newly transplanted plant material; free flowing, pellet or tablet form; uniform in composition; and consistent with a prescribed nitrogen-phosphorus-potassium ratio. Amount shall be as recommended by the soil test.

2.2.6 Organic Material

Organic material shall consist of either bonemeal, peat, rotted manure, decomposed wood derivatives, recycled compost, or worm castings.

2.2.6.1 Bonemeal

Bonemeal shall be a finely ground, steamed bone product containing from a minimum 2 to a maximum 4 percent nitrogen and a minimum 16 to a maximum 40 percent phosphoric acid.

2.2.6.2 Rotted Manure

Rotted manure shall be unleached horse, chicken, or cattle manure containing a maximum 25 percent by volume of straw, sawdust, or other bedding materials. Manure shall contain no chemicals or ingredients harmful to plants. The manure shall be heat treated to kill weed seeds and shall be free of stones, sticks, and soil.

2.2.6.3 Decomposed Wood Derivatives

Decomposed wood derivatives shall be ground bark, sawdust, or other wood waste material free of stones, sticks, and toxic substances harmful to plants, and stabilized with nitrogen.

2.2.6.4 Recycled Compost

Compost shall be a well-decomposed, stable, weed free organic matter source. It shall be derived from food, agricultural, or industrial residuals; biosolids (treated sewage sludge); yard trimmings; or source-separated or mixed solid waste. The compost shall possess no objectionable odors and shall not resemble the raw material from which it was derived. The material shall not contain substances toxic to plants.

Gradation: The compost material shall pass through a 10 mm 3/8 inch screen, possess between a minimum 5.5 to a maximum 8.0 pH, and have a moisture content between a minimum 35 and a maximum 55 percent by weight. The material shall not contain more than a maximum 1 percent by weight of man-made foreign matter. Compost shall be cleaned of plastic materials a minimum 50 mm 2 inches in length. Compost shall conform to EPA requirements in accordance with Section 01670 RECYCLED / RECOVERED MATERIALS.

2.2.6.5 Worm Castings

Worm castings shall be screened from worms and food source and shall be commercially packaged.

2.2.7 Soil Conditioner

Soil conditioner shall be sand, super absorbent polymers, calcined clay, or gypsum for single use or in combination to meet topsoil requirements for the plant material specified.

2.2.7.1 Sand

Sand shall be clean and free of toxic materials. Gradation: A minimum 95 percent by weight shall pass a 2 mm No. 10 sieve and a minimum 10 percent by weight shall pass a 1.18 mm No. 16 sieve. Greensand shall be balanced with the inclusion of trace minerals and nutrients.

2.2.7.2 Super Absorbent Polymers

To improve water retention in soils, super absorbent polymers shall be sized at a maximum 1000 microns. Polymers shall be added as a soil amendment and be cross-linked polyacrylamide with an absorption capacity of a minimum 250 to a maximum 400 times its weight.

2.2.7.3 Calcined Clay

Granular particles shall be produced from montmorillonite clay calcined to a minimum temperature of 650 degrees C 1200 degrees F. Gradation: A minimum 90 percent passing 2.36 mm No. 8 sieve; a minimum 99 percent shall be retained on 0.25 mm No. 60 sieve; and a maximum 2 percent shall pass a 0.15 mm No. 100 sieve. Bulk density: A maximum 640-kilogram per cubic meter 40 pounds per cubic foot.

2.2.7.4 Gypsum

Gypsum shall be commercially packaged, free flowing, and a minimum 95 percent calcium sulfate by volume.

2.2.7.5 Expanded Shale, Clay, or Slate (ESCS)

Rotary kiln produced ESCS material shall be in conformance with ASTM D 5883.

2.3 MULCH

Mulch shall be free from weeds, mold, and other deleterious materials. Mulch materials shall be native to the region. Rotted manure is not recommended to be used as a mulch because it would encourage surface rooting of the plant material and weeds.

2.3.1 Inorganic Mulch

When inorganic mulch is required for decorative purposes, it shall be provided in areas designated, and consist of:

Riverbank stone ranging in size from [_____] to [_____] mm inches.

Crusher run rock ranging in size from [_____] to [_____] mm inches.

Granite chips ranging in size from [_____] to [_____] mm inches.

Marble chips ranging in size from [_____] to [_____] mm inches.

Crushed bricks ranging in size from [_____] to [_____] mm inches.

Volcanic rock ranging in size from [_____] to [_____] mm inches.

Crushed shells ranging in size from [_____] to [_____] mm inches.

Recycled rubber chips or pellets ranging in size from [____] to [____] mm inches.

The size and kind of the material shall be determined by the designer or COR and should be considered to prevent wash out.

2.3.2 Organic Mulch

Organic mulch materials shall be native to the project site and consist of recycled mulch, shredded bark, wood chips, or ground bark.

2.3.2.1 Recycled Mulch

Recycled mulch may include compost, tree trimmings, or pine needles with a gradation that passes through a 65 x 65 mm 2-1/2 x 2-1/2 inch screen. It shall be cleaned of all sticks a minimum 25 mm 1 inch in diameter and plastic materials a minimum 75 mm 3 inch length. The material shall be treated to retard the growth of mold and fungi. Other recycled mulch may include peanut shells, pecan shells or cocoa bean shells.

2.3.2.2 Shredded Bark

Locally shredded material shall be treated to retard the growth of mold and fungi.

2.3.2.3 Wood Chips and Ground Bark

Locally chipped or ground material shall be treated to retard the growth of mold and fungi. Gradation: A maximum 50 mm 2 inch wide by 100 mm 4 inch long. The material may be a by-product of "sustainable practices" such as tree farm trimming.

2.4 GEOSYNTHETICS

Geosynthetics shall be defined as a product manufactured in accordance with ASTM D 3776, ASTM D 4491, ASTM D 4533, ASTM D 4632, ASTM D 4751, ASTM D 4833 and ASTM D 4873, ASTM D 5034 or ASTM D 5035. It shall be referred to as products manufactured for use as weed barriers, drainage matting, root barriers, or soil enhancement systems.

2.5 WOOD STAKING MATERIAL

Wood stakes shall be hardwood or fir; a minimum No. 2 grade, rough sawn; free from knots, rot, cross grain, or other defects that would impair their strength.

2.5.1 Bracing Stake

Wood bracing stakes shall be a minimum 50 x 50 mm 2 x 2 inch square and a minimum 2400 mm 8 feet long with a point at one end. Stake shall be set without damaging rootball.

2.5.2 Wood Ground Stakes

Wood ground stakes shall be a minimum of 50 x 50 mm 2 x 2 inch square and a minimum 900 mm 3 feet long with a point at one end.

2.5.3 Deadmen

Wood deadmen shall be a minimum 100 x 100 x 900 mm 4 x 4 x 36 inches long.

2.6 METAL STAKING AND GUYING MATERIAL

Metal shall be aluminum or steel consisting of recycled content made for holding plant material in place.

2.6.1 Bracing Stakes

Metal bracing stakes may be hollow or solid and shall be a minimum 25 mm 1 inch diameter and a minimum 2400 mm 8 feet long. Stake shall be set without damaging rootball and be capable of supporting the tree adequately.

2.6.2 Metal Ground Stakes

Metal ground stakes shall be a minimum 13 mm 1/2 inch diameter and a minimum 900 mm 3 feet long.

2.6.3 Earth Anchor

Metal earth anchors shall be a minimum 13 mm 1/2 inch diameter and a minimum 600 mm 2 feet long.

2.6.4 Guying Material

Metal guying material shall be a minimum 12 gauge wire. Multi-strand cable shall be woven wire. Guying material tensile strength shall conform to the size of tree to be held firmly in place.

2.6.5 Turnbuckle

Metal turnbuckles shall be galvanized or cadmium-plated steel, and shall be a minimum 75 mm 3 inches long with closed screw eyes on each end. Screw thread tensile strength shall conform to the size of tree to be held firmly in place.

2.7 PLASTIC STAKING AND GUYING MATERIAL

Plastic shall consist of recycled plastic product made for holding plant material firmly in place. Plastic shall not be used for deadmen.

2.7.1 Plastic Bracing Stake

Plastic bracing stakes shall be a minimum 50 mm 2 inch diameter and a minimum 2400 mm 8 feet long. Stake shall be set without damaging rootball.

2.7.2 Plastic Ground Stakes

Plastic ground stakes shall be a minimum 50 mm 2 inch diameter and a minimum 900 mm 3 feet long.

2.7.3 Plastic Guying Material

Plastic guying material shall be designed with a maximum 13.1 kN per meter 900 pound force per foot elastic limit for the purpose of firmly holding plant material in high wind velocities.

2.7.4 Chafing Guard

Plastic chafing guards shall be used to protect tree trunks and branches when metal is used as guying material. The material shall be the same color throughout the project site. Length shall be a minimum 1.5 times the circumference of the plant trunk at its base.

2.8 RUBBER GUYING MATERIAL

Rubber chafing guards, consisting of recycled material, shall be used to protect tree trunks and branches when metal guying material is applied. The material shall be the same color throughout the project. Length shall be a minimum 1.5 times the circumference of the plant trunk at its base.

2.9 FLAG

Plastic flag material shall be used on guying material. It shall be a minimum 150 mm 6 inches long. Tape color shall be consistent and visually complimentary to the entire project area. The tape color shall meet pedestrian visual safety requirements for day and night. Tree root barriers shall be metal or plastic consisting of recycled content. Barriers shall utilize vertical stabilizing members to encourage downward tree root growth. Barriers shall limit, by a minimum 90 percent, the occurrence of surface roots. Tree root barriers which are designed to be used as plant pit liners will be rejected.

2.10 MYCORRHIZAL FUNGI INOCULUM

Mycorrhizal fungi inoculum shall be composed of multiple-fungus inoculum as recommended by the manufacturer for the plant material specified.

2.11 WATER

Unless otherwise directed, water shall be the responsibility of the Contractor. Water shall be potable or supplied by an existing irrigation system.

2.12 PESTICIDE

Pesticide shall be insecticide, herbicide, fungicide, nematocide, rodenticide or miticide. For the purpose of this specification a soil fumigant shall have the same requirements as a pesticide. The pesticide material shall be EPA registered and approved.

PART 3 EXECUTION

3.1 TRANSPLANTED PLANT MATERIAL TIME AND CONDITIONS

3.1.1 Deciduous Plant Material Time

Deciduous plant material shall be transplanted from April to May.

3.1.2 Evergreen Plant Material Time

Evergreen plant material shall be transplanted from April to May.

3.1.3 Transplanting Conditions

All transplanting operations shall be performed only during periods when beneficial results can be obtained. When drought, excessive moisture, frozen ground or other unsatisfactory conditions prevail, the work shall be stopped when directed. When special conditions warrant a variance to all transplanting operations, proposed transplanting times shall be submitted for approval. The installing site for the plant material shall be prepared and excavated in accordance with paragraph INSTALLING SITE PREPARATION and paragraph INSTALLING SITE EXCAVATION, prior to removing the plant material.

3.1.4 Underground Utilities

The location of underground utilities and facilities at both the removal and installing sites shall be verified and marked. Damage to underground utilities and facilities shall be repaired at the Contractor's expense.

3.1.5 Protecting Existing Vegetation

When there are established lawns at both the removal and installing sites, the turf shall be covered and/or protected during the operation. Existing trees, shrubs, and plant beds at both the removal and installing site that are to be preserved shall be barricaded along the dripline. The area shall be barricaded and protected from damage by a tree barricade or other measure. Damage to existing plant material shall be mitigated by the Contractor at no additional cost to the Government. Damage shall be accessed by a state certified arborist or other approved professional using the National Arborist Association's tree valuation guideline.

3.1.6 Installing Site Tests

3.1.6.1 Percolation Test

Test for percolation shall be done to determine positive drainage of plant pits and beds at the installing site. A positive percolation shall consist of a minimum 25 mm 1 inch per 3 hours; when a negative percolation test occurs, a shop drawing shall be submitted indicating the corrective measures.

3.1.6.2 Soil Test

Delivered topsoil, excavated plant pit soil, and stockpiled topsoil shall be tested in accordance with ASTM D 5268 and ASTM D 4972 for determining the particle size, pH, organic matter content, textural class, chemical analysis, soluble salts analysis, and mechanical analysis. Sample collection onsite shall be random over the entire installing site. Sample collection for stockpiled topsoil shall be at different levels in the stockpile. The soil shall be free from debris, noxious weeds, toxic substances, or other materials harmful to plant growth. The test shall determine the quantities and type of soil amendments required to meet local growing conditions for the plant material to be transplanted.

3.1.7 Plant Material Preparation and Handling

3.1.7.1 Root Pruning

Large canopy and specimen plant material shall be root pruned a minimum of one year before transplanting. Minimum root ball sizes shall be in accordance with ANLA Z60.1. Medium sized plant material shall be spaded or hand dug prior to removal. A sharp spade shall be used to cut straight down a minimum of 450 mm 18 inches deep.

3.1.7.2 Plant Material Preparation

Plant material designated for transplanting shall be watered thoroughly several days before root pruning, digging or moving. Broken or interfering growth shall be pruned. Large canopy and specimen plant material shall be wire balled and burlapped. Trees shall be lifted by the use of tree straps. Canopy and evergreen trees up to a maximum 300 mm 12 inches caliper shall be transplanted by the largest available tree spade in order to reduce shock. The installing site for the plant material shall be prepared and excavated in accordance with paragraphs: Transplanting Plant Material Time and Conditions, Installing Site Preparation, and Installing Site Excavation, prior to moving the plant material.

3.1.7.3 Tree Spading

The following minimum size spades shall be used for trees sized as measured at caliper; 150 mm 6 inches above the ground for trees 100 mm 4 inches in diameter or smaller, 300 mm 12 inches above the ground for trees with a larger diameter.

Tree Spade Deciduous Tree Evergreen Tree Size

Minimum Minimum 50 mm to Minimum 1.5 m to 1100 mm Maximum 75 mm caliper Maximum 2.1 m height

Minimum Minimum 75 mm to Minimum 2.1 m to 1650 mm Maximum 125 caliper Maximum 3 m height

Minimum Minimum 150 mm to Minimum 2.6 m to 2125 mm Maximum 200 mm caliper Maximum 3.6 m height

Tree Spade Deciduous Tree Evergreen Tree Size

Minimum Minimum 2 inch to Minimum 5 feet to 44 inch Maximum 3 inch caliper Maximum 7 feet height

Minimum Minimum 3 inch to Minimum 7 feet to 66 inch Maximum 5 inch caliper Maximum 10 feet height

Minimum Minimum 6 inch to Minimum 12 feet to 85 inch Maximum 8 inch caliper Maximum 15 feet height

3.1.7.4 Caliper

The caliper shall be measured at a minimum 150 mm 6 inch height above the ground surface for trees up to a maximum 100 mm 4 inch caliper. The caliper shall be measured at a minimum 300 mm 12 inch height above the ground surface for trees with a larger caliper.

3.2 INSTALLING SITE PREPARATION

3.2.1 Finished Grade and Topsoil

The Contractor shall verify that finished grades are as indicated on drawings, and that the placing of topsoil, the smooth grading, and the compaction requirements have been completed in accordance with Section 02120 GRADING, prior to the commencement of the transplanting operation.

3.2.2 Layout

Plant material installing sites and bed outlines shall be staked on the project site before any excavation is made. Plant material locations may be adjusted to meet field conditions.

3.3 INSTALLING SITE EXCAVATION

3.3.1 Obstructions Below Ground

When obstructions below ground affect the work, shop drawings showing proposed adjustments to plant material location, and planting method shall be submitted for approval.

3.3.2 Turf Removal and Replacement

Where the installation operation occurs in an existing lawn area, the turf shall be removed from the excavation area to a depth that will ensure the removal of the entire root system.

3.3.3 Plant Pits

Plant pits shall be dug to a depth equal to the height of the root ball as measured from the base of the ball to the base of the plant trunk. Plant pits shall be dug a minimum of 3 to a maximum 5 times the diameter of the root system to allow for root expansion. The pit shall be constructed with sides sloping towards the base as a cone, to encourage well-aerated soil to be available to the root system for favorable root growth. Cylindrical pits with vertical sides shall not be used. Pits shall be dug immediately before plants are placed in the pit.

3.4 INSTALLATION

3.4.1 Setting Plant Material

Plant material shall be set plumb and held in position until sufficient soil has been firmly placed around root system or ball. In relation to the surrounding grade, the plant material shall be set even with the grade at which it was grown. The root system shall be spread out and arranged in its natural position. Damaged or girdled roots shall be removed with a clean cut. The beginning of the root flare shall be visible at soil level when the tree is planted, since it is critical not to plant the tree too deep. The following shall be performed:

a. Plumb tree and backfill half of the hole.

b. Water the hole to collapse air pockets and form a soupy mixture.

c. Backfill and gently firm soil.

d. Clear soil mounded against trunk.

3.4.2 Root Barriers

Tree root barriers shall be installed as indicated in the contract documents and as recommended by the manufacturer. Tree root barriers shall be used for trees located up to a maximum 1800 mm 6 feet from paved surfaces or structures.

3.4.3 Backfill Soil Mixture

The backfill soil mixture may be a mix of topsoil and soil amendments suitable for the plant material specified. When practical, the excavated soil from the plant pit that is not amended provides the best backfill and shall be used. Fertilizer shall not be used in the backfill soil mixture.

3.4.4 Adding Mycorrhizal Fungi Inoculum

Mycorrhizal fungi inoculum shall be added as recommended by the manufacturer for the plant material specified.

3.4.5 Backfill Procedure

Prior to backfilling, all metal, wood, synthetic products, or treated burlap devices shall be removed from the ball or root system avoiding damage to the root system. The backfill procedure shall remove air pockets from around the root system. Biodegradable burlap and tying material shall be carefully opened and folded back from the top a minimum 1/3 depth from the top of the root ball. For plant material in biodegradable containers the container shall be split prior to setting the plant with container. The plant material shall be carefully removed from containers that are not biodegradable.

3.4.5.1 Earth Berm

An earth berm, consisting of backfill soil mixture, shall be formed with a minimum 100 mm 4 inch height around the edge of the plant pit to aid in water retention and to provide soil for settling adjustments.

3.4.6 Plant Bed

Plant material shall be set in plant beds according to the drawings. Backfill soil mixture shall be placed on previously scarified subsoil to completely surround the root balls, and shall be brought to a smooth and even surface, blending to existing areas. Earth berms shall be provided. Polymers shall be spread uniformly over the plant bed and in the planting pit as recommended by the manufacturer and thoroughly incorporated into the soil to a maximum 100 mm 4 inch depth.

A regular watering schedule shall be established. Slow deep watering shall be used. Plant pits and plant beds shall be watered immediately after backfilling, until completely saturated. Run-off and puddling shall be prevented. Watering of other plant material or adjacent areas shall be prevented.

3.4.8 Staking and Guying

Staking will be required when trees are unstable or will not remain set due to their size, shape, or exposure to high wind velocity.

3.4.8.1 One Bracing Stake

Trees 1200 to 1800 mm 4 to 6 feet high shall be firmly anchored in place with one bracing stake. The bracing stake shall be placed on the side of the tree facing the prevailing wind. The bracing stake shall be driven vertically into firm ground and shall not injure the ball or root system. The tree shall be held firmly to the stake with a double strand of guying material. The guying material shall be firmly anchored at a minimum 1/2 tree height and shall prevent girdling. A chafing guard shall be used when metal is the guying material.

3.4.8.2 Two Bracing Stakes

Trees from 1800 to 2400 mm 6 to 8 feet height shall be firmly anchored in place with 2 bracing stakes placed on opposite sides. Bracing stakes shall be driven vertically into firm ground and shall not injure the ball or root system. The tree shall be held firmly between the stakes with a double strand of guying material. The guying material shall be firmly anchored at a minimum 1/2 tree height and shall prevent girdling. Chafing guards shall be used when metal is the guying material.

3.4.8.3 Three Ground Stakes

Trees over a minimum 2400 mm 8 feet height and less than a maximum 150 mm 6 inch caliper shall be held firmly in place with 3 bracing or ground stakes spaced at equal intervals around the tree. Ground stakes shall be avoided in areas to be mowed. Stakes shall be driven into firm ground outside the earth berm. The guying material shall be firmly anchored at a minimum 1/2 tree height and shall prevent girdling. For trees over a minimum 75 mm 3 inch diameter at breast height, turnbuckles shall be used on the guying material for tree straightening purposes. One turnbuckle shall be centered on each guy line. Chafing guards shall be used when metal is the guying material.

3.4.9 Deadmen or Earth Anchors

Trees over a minimum 150 mm 6 inch caliper shall be held firmly in place with wood deadmen buried a minimum 900 mm 3 feet in the ground or metal earth anchors. Multi-strand cable guying material shall be firmly anchored at a minimum 1/2 tree height and shall prevent girdling. Turnbuckles shall be used on the guying material for tree straightening purposes. One turnbuckle shall be centered on each guy line. Chafing guards shall be used.

3.4.10 Flags

A flag shall be securely fastened to each guy line between the tree, stake, deadmen, or earth anchor. The flag shall be visible to pedestrians.

3.5 FINISHING

3.5.1 Plant Material

Prior to placing mulch, the installed area shall be uniformly edged to provide a clear division line between the planted area and the adjacent turf area, shaped as indicated. The installed area shall be raked and smoothed while maintaining the earth berms.

3.5.2 Placing Geosynthetics

Prior to placing mulch, geosynthetics shall be placed as indicated in the construction documents and in accordance with the manufacturer's recommendations.

3.5.3 Placing Mulch

The placement of mulch shall occur a maximum of 48 hours after planting. Mulch, used to reduce soil water loss, regulate soil temperature and prevent weed growth, shall be spread to cover the installed area with a minimum 100 mm 4 inch uniform thickness. Mulch shall be kept out of the crowns of shrubs, ground cover, and vines and shall be kept off buildings, sidewalks and other facilities.

3.5.4 Pruning

Pruning shall be accomplished by trained and experienced personnel. The pruning of trees and palms shall be in accordance with ANSI A300. Only dead or broken material shall be pruned from installed plants. The typical growth habit of individual plant material shall be retained. Clean cuts shall be made flush with the parent trunk. Improper cuts, stubs, dead and broken branches shall be removed. "Headback" cuts at right angles to the line of growth will not be permitted. Trees shall not be poled or the leader removed, nor shall the leader be pruned or "topped off".

3.6 MAINTENANCE DURING TRANSPLANTING OPERATION

Installed plant material shall be maintained in a healthy growing condition. Maintenance operations shall begin immediately after each plant is installed to prevent desiccation and shall continue until the plant establishment period commences. Installed areas shall be kept free of weeds, grass, and other undesired vegetation. The maintenance includes maintaining the mulch, watering, and adjusting settling.

3.7 APPLICATION OF PESTICIDE

When application of a pesticide becomes necessary to remove a pest or disease, a pesticide treatment plan shall be submitted and coordinated with the installation pest management program.

3.7.1 Technical Representative

The certified, installation pest management coordinator shall be the technical representative, shall be present at all meetings concerning treatment measures for pest or disease control,and may be present during treatment application.

3.7.2 Application

A state certified applicator shall apply required pesticides in accordance with EPA label restrictions and recommendations. Clothing and personal protective equipment shall be used as specified on the pesticide label. A closed system is recommended as it prevents the pesticide from coming into contact with the applicator or other persons. Water for formulating shall only come from designated locations. Filling hoses shall be fitted with a backflow preventer meeting local plumbing codes or standards. Overflow shall be prevented during the filling operation. Prior to each day of use, the equipment used for applying pesticide shall be inspected for leaks, clogging, wear, or damage. Any repairs are to be performed immediately.

3.8 RESTORATION AND CLEAN UP

3.8.1 Restoration

Turf areas containing ruts or dead turf, as a result of work under this contract, shall be graded smooth and sodded with the same species. All pavements and facilities that have been damaged from the transplanting operation shall be restored to original condition at the Contractor's expense.

3.8.2 Backfill Removal Site Plant Pits

The Contractor shall ensure that all remaining holes from the removal site have been backfilled, tamped and finished to meet existing grade after settling. Turf shall be installed in accordance with [Section 02935 TURF.

3.8.3 Clean Up

Excess and waste material shall be removed from both removal site and the installed site and shall be disposed offsite at an approved landfill or recycling center. Adjacent paved areas shall be cleared.

3.9 PLANT ESTABLISHMENT PERIOD

3.9.1 Commencement

Upon completion of the last day of the installing operation, the plant establishment period for maintaining installed plant material in a healthy growing condition shall commence and shall be in effect for the remaining contract time period, not to exceed 12 months. Written calendar time period shall be furnished for the plant establishment period. When there is more than one plant establishment period, the boundaries of the planted area covered for each period shall be described. The plant establishment period shall be coordinated with Sections 02921 SEEDING; 02922 SODDING; 02923 SPRIGGING and 02930 EXTERIOR PLANTING. The plant establishment period shall be modified for separate completion dates for areas.

3.9.2 Maintenance During Establishment Period

Maintenance of plant material shall include straightening plant material, straightening stakes; tightening guying material; correcting girdling; supplementing mulch; pruning dead or broken branch tips; maintaining plant material labels; watering; eradicating weeds, insects and disease; post-fertilization; and removing and replacing unhealthy plants.The plant material shall be watered as necessary to prevent desiccation and to maintain an adequate supply of moisture within the root zone. An adequate supply of moisture is estimated to be the equivalent of 25 mm 1 inch absorbed water per week, delivered in the form of rain or augmented by watering. Run-off, puddling and wilting shall be prevented. Unless otherwise directed, watering trucks shall not be driven over turf areas. Watering of other adjacent areas or existing plant material shall be prevented.

3.9.2.1 Weeding

Grass and weeds in the installed areas shall not be allowed to reach a maximum 75 mm 3 inches height before being completely removed, including the root system.

3.9.2.2 Pesticide Treatment

Treatment for disease or pest shall be in accordance with paragraph APPLICATION OF PESTICIDE.

3.9.2.3 Post-Fertilization

The plant material shall be top dressed at least once during the period of establishment with controlled release fertilizer (paragraph SOIL AMENDMENTS) applied at the rate of 1 kilogram per 10 square meters 2 pounds per 100 square feet of plant pit or bed area. Dry fertilizer adhering to plants shall be flushed off. The application shall be timed prior to the advent of winter dormancy.

3.9.2.4 Plant Pit Settling

When settling occurs to the backfill soil mixture, additional backfill soil shall be added to the plant pit or plant bed until the backfill level is equal to the surrounding grade. Serious settling that affects the setting of the plant in relation to the maximum depth at which it was grown requires replanting in accordance with paragraph INSTALLATION. The earth berm shall be maintained.

3.9.2.5 Removal Site Settlement

All plant pits at the removal site shall meet existing grade after settling. Correction shall be provided as required and in accordance with paragraph BACKFILL REMOVAL SITE PLANT PITS.

3.9.2.6 Maintenance Record

A record shall be furnished describing the maintenance work performed, the quantity of plant losses, diagnosis of the plant loss, and the quantity of replacements made on each site visit.

3.9.3 Acceptable Plant Material

Plant material shall be undamaged, well shaped, vigorous and healthy with a well branched root system, free from disease, harmful insects and insect eggs, sun-scald injury, disfigurement or abrasion after transplanting and in accordance with paragraph PLANT MATERIAL SURVIVABILITY. Plant material showing desiccation, abrasion, sun-scald injury or structural branching damage shall be replaced at no cost to the Government.

3.9.4 Unhealthy Or Dead Plant Material

3.9.4.1 Transplant Shock

Deciduous plants showing symptoms of leaf scorch, a yellowing or bronzing of the tissue between the veins or along the margins of leaves or wilting; leaf rolling or curling may be need to be replaced, if required by the Contracting Officer. Evergreen plant stress is exhibited by overall grey-green color followed by light tan. The Contractor shall evaluate the severity of the symptom and shall provide recommendations.

3.9.4.2 Dead Plant Material

A tree shall be considered dead when the main leader has died back, or up to a maximum 25 percent of the crown has died. A shrub shall be considered unhealthy or dead when up to a maximum 25 percent of the plant has died. This condition shall be determined by scraping on a branch an area 2 mm 1/16 inch square, maximum, to determine if there is a green cambium layer below the bark. The Contractor shall determine the cause for dead plant material and shall provide recommendations for replacement. Dead plant material shall be removed immediately and shall be replaced as soon as seasonal conditions permit.

3.9.4.3 Replacement Plant Material

Replacement plant material shall be installed in accordance with paragraph INSTALLATION. Plant material shall be replaced in accordance with paragraph WARRANTY. An extended plant establishment period shall not be required for replacement plant material.

3.9.5 Maintenance Instructions

Written instructions shall be furnished containing drawings and other necessary information for year-round care of the installed plant material; including, when and where maintenance should occur, and the procedures for plant material replacement.

3.9.6 End of Establishment Period Clean Up

The Contractor shall remove all guying, bracing and staking at the end the establishment period with the approval of the Contracting Officer. All materials removed as a result of this operation shall be disposed offsite at an approved landfill. Any damage resulting from this operation shall be restored to its original condition at the Contractor's expense.

SECTION 02935

TURF

TABLE OF CONTENT

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AGRICULTURAL MARKETING SERVICE (AMS)

AMS-01 (Amended thru: Aug 1988) Federal Seed Act Regulations (Part 201-202)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 602 (1995; Rev. A) Agricultural Liming Materials

ASTM D 4427 (1992; R 1996) Peat Samples by Laboratory Testing

ASTM E 11 (1995) Wire-Cloth Sieves for Testing

ASTM D 977 (1991) Emulsified Asphalt

ASTM D 2028 (1976; R 1992) Cutback Asphalt (Rapid-Curing Type)

ASTM D 2607 (1969) Peats, Mosses, Humus, and Related Products

COMMERCIAL ITEM DESCRIPTIONS (CID)

CID A-A-1909 (Basic; Notice 1) Fertilizer

1.2 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330: SUBMITTAL PROCEDURES.

SD-01 Data

Manufacturer's Literature; FIO.

Manufacturer's literature discussing physical characteristics, application and installation instructions for erosion control material, and for chemical treatment material.

SD-07 Schedules

Equipment List; FIO.

A list of proposed pesticide application, seeding and mulching equipment to be used in performance of turfing operation, including descriptive data and calibration tests.

SD-08 Statements

Delivery; FIO.

Delivery schedule, at least 10 days prior to the intended date of the first delivery.

Application of Pesticide; GA.

Pesticide treatment plan with proposed sequence of pesticide treatment work. The pesticide trade name, chemical composition, formulation, concentration, application rate of active ingredients and method of application for all materials; and the name and state license number of the state certified applicator shall be included.

Maintenance Report; FIO.

Written record of maintenance work performed.

Turf Establishment Period; GA.

Written calendar time period for the turf establishment period. When there is more than one turf establishment period, the boundaries of the turfed area covered for each period shall be described.

SD-13 Certificates

Certificates of compliance certifying that materials meet the requirements specified, prior to the delivery of materials. Certified copies of the reports for the following materials shall be included:

Seed; FIO.

For mixture, percent pure live seed, minimum percent germination and hard seed, maximum percent weed seed content, date tested and state certification.

Sod; FIO.

For species, mixture percentage, percent purity, field location.

Sprigs; FIO.

For cultivar, genetic purity, field location.

Fertilizer; FIO.

For chemical analysis, composition percent.

Agricultural Limestone; FIO.

For calcium carbonate equivalent and sieve analysis.

Peat; FIO.

For compliance with ASTM D 2607.

Asphalt Adhesive; FIO.

For compliance with ASTM D 977 and ASTM D 2028.

Pesticide Material; FIO.

For EPA registration number and registered uses.

Topsoil; FIO.

For pH, particle size, chemical analysis and mechanical analysis.

1.3 SOURCE INSPECTIONS

Sod and sprigging material will be subject to inspection by the Contracting Officer at the growing site.

1.4 DELIVERY, INSPECTION, STORAGE, AND HANDLING

1.4.1 Delivery

1.4.1.1 Protection

Sod and/or sprigs shall be protected from drying out and contamination during delivery.

1.4.1.2 Topsoil

A soil test shall be provided for topsoil delivered to the site.

1.4.1.3 Soil Amendments

Soil amendments shall be delivered to the site in the original, unopened containers bearing the manufacturer's chemical analysis. In lieu of containers, soil amendments may be furnished in bulk. A chemical analysis shall be provided for bulk deliveries.

1.4.1.4 Pesticide

Pesticide material shall be delivered to the site in the original, unopened containers bearing legible labels indicating the Environmental Protection Agency (EPA) registration number and the manufacturer's registered uses.

1.4.2 Inspection

Seed, sod and/or sprigs shall be inspected upon arrival at the job site by the Contracting Officer for conformity to type and quality in accordance with paragraph MATERIALS. Other materials shall be inspected for meeting specified requirements and unacceptable materials shall be removed from the job site.

1.4.3 Storage

Materials shall be stored in areas designated by the Contracting Officer. Sod or sprigs shall be lightly sprinkled with water, covered with moist burlap, straw, or other covering and protected from exposure to wind and direct sunlight until planted. Covering for sod or sprigs shall allow air to circulate and prevent internal heat from building up. Seed, lime and fertilizer shall be stored in cool, dry locations away from contaminants. Chemical treatment materials shall not be stored with other landscape materials.

1.4.4 Handling

1.4.4.1 Materials

Care shall be taken to avoid injury to sod and/or sprigs. Except for bulk deliveries, materials shall not be dropped or dumped from vehicles.

1.4.4.2 Time Limitation

a. Sod: Limitation of the time between harvesting and placing of sod shall be 36 hours.

b. Sprigs: Limitation of time between harvesting and placing of sprigs shall be 24 hours.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Seed

2.1.1.1 Seed Classification

Seed of the latest season's crop shall be provided in original sealed packages bearing the producer's guaranteed analysis for percentages of mixture, purity, germination, hard seed, weed seed content, and inert material. Labels shall be in conformance with AMS-01 and applicable state seed laws.

2.1.1.2 Seed Mixtures

Seed mixtures shall be proportioned by weight as shown on the soil test result or based on the past local experience.

2.1.1.3 Quality

Weed seed shall not exceed 1 percent by weight of the total mixture. Wet, moldy, or otherwise damaged seed shall be rejected.

2.1.1.4 Overseed for Sprigs:

Overseed for sprigs shall be in accordance with manufacturer’s recommendation.

2.1.1.5 Temporary Seed

The temporary seed for erosion control shall be in accordance with manufacturer’s recommendation.

2.1.1.6 Seed Mixing

The field mixing of seed shall be performed on site in the presence of the Contracting Officer.

2.1.2 Sod

2.1.2.1 Sod Classification

Sod shall be provided as classified by applicable state laws. Each individual sod section shall be of a size to permit rolling and lifting without breaking.

2.1.2.2 Grass Species

Grass species shall be proportioned in accordance with manufacturer’s recommendation.

2.1.2.3 Quality

The sod shall be relatively free of thatch, diseases, nematodes, soil-borne insects, weeds or undesirable plants, stones larger than 50 mm (2 inches) in any dimension, woody plant roots and other material detrimental to a healthy stand of turf. Sod that has become dry, moldy, or yellow from heating, or has irregularly shaped pieces of sod and torn or uneven ends shall be rejected.

2.1.2.4 Thickness

Sod shall be machine cut to a uniform thickness of 30 mm (1-1/4 inches) within a tolerance of 5 mm (1/4 inch), excluding top growth and thatch. Measurement for thickness shall exclude top growth and thatch.

2.1.2.5 Anchors

Sod anchors shall be as recommended by the sod supplier.

2.1.3 Sprigs

2.1.3.1 Plantings

The cultivar of sod shall be provided as healthy living stems, stolons, or rhizomes with attached roots, including two to three nodes, and shall be from 100 to 150 mm (4 to 6 inches) long, without adhering soil.

2.1.3.2 Quality

Sprigs shall be provided which have been grown under climatic conditions similar to those in the locality of the project. Sprigs shall be obtained from heavy and dense sod, free from weeds or other material detrimental to a healthy stand of turf. Sprigs that have been exposed to heat or excessive drying shall be rejected.

2.1.4 Soil Amendments

Soil amendments shall consist of lime, fertilizer, organic soil amendments and soil conditioners meeting the following requirements.

2.1.4.1 Lime

Lime shall be agricultural limestone and shall have a minimum calcium carbonate equivalent of 90 percent and shall be ground to such a fineness that at least 90 percent will pass a 10-mesh sieve and at least 50 percent will pass a 60-mesh sieve.

2.1.4.2 Fertilizer

Fertilizer shall be commercial grade, free flowing, and uniform in composition. Granular Fertilizer: As recommended by the soil test.

2.1.4.3 Organic Soil Amendments

a. Topsoil: The existing surface soil shall be stripped and stockpiled on the site in accordance with Section 02210: GRADING. When required beyond that available from stripping, the topsoil shall be delivered. Delivered topsoil shall conform to topsoil requirements specified in Section 02210: GRADING, and shall be amended as recommended by soil test.

b. Peat: Peat moss, Hypnum moss peat, Reed-sedge peat, or Peat humus derived from a bog, swampland or marsh shall conform to ASTM D 4427.

c. Sand: Clean, free of toxic materials; 95 percent by weight shall pass a No. 10 sieve and 10 percent by weight shall pass a No. 16 sieve.

d. Rotted Manure: Well-rotted, horse or cattle manure containing a maximum 25 percent by volume of straw, sawdust, or other bedding materials, free of stones, sticks, soil and containing no chemicals or ingredients harmful to plants.

e. Decomposed Wood Derivatives: Ground bark, sawdust, or other wood waste material free of stones, sticks, soil, and toxic substances harmful to plants, stabilized with nitrogen and having the following properties:

Particle Size: Minimum percent by weight passing:

Sieve Size	Percent
No. 4.75mm	95
No. 2.36mm	80

Nitrogen Content: Minimum percent based on dry weight:

Material	Percent
Redwood Sawdust	0.5
Fir Sawdust	0.7
Fir or Pine Bark	1.0

f. Calcined Clay: Granular particles produced from montmorillonite clay calcined to minimum temperature of 650 degrees C (1200 degrees F) to the following gradation: minimum 90 percent passing No. 8, 99 percent retained on No. 60 sieve and maximum 2 percent passing No. 100 sieve. Bulk density: maximum 640 kg per cubic m (40 pounds per cubic foot).

2.1.4.4 Soil Conditioner

Soil conditioner shall be for single use or in combination to meet requirements for topsoil. Gypsum shall be commercially packaged, free flowing, minimum 95 percent calcium sulfate by volume.

2.1.5 Mulch

Mulch shall be free from weeds, mold, and other deleterious materials.

2.1.5.1 Straw

Straw shall be stalks from oats, wheat, rye, barley, or rice furnished in air-dry condition and with a consistency for placing with commercial mulch-blowing equipment.

2.1.5.2 Hay

Hay shall be native hay, sudan-grass hay, broomsedge hay, or other herbaceous mowings furnished in an air-dry condition suitable for placing with commercial mulch-blowing equipment.

2.1.5.3 Wood Cellulose Fiber

Wood cellulose fiber shall not contain any growth or germination-inhibiting factors and shall be dyed an appropriate color to facilitate visual metering during application. Composition on air-dry weight basis: 9 to 15 percent moisture, pH range from 4.5 to 6.0.

2.1.5.4 Wood Chips

Wood chips shall be chips or shredded bark with maximum particle size of 5 mm (3/16 inch).

2.1.5.5 Paper Fiber Mulch

Paper fiber mulch shall be recycled news print that is shredded for the purpose of mulching seed.

2.1.6 Asphalt Adhesive

Asphalt adhesive shall conform to the following:

2.1.6.1 Emulsified Asphalt

Conforming to ASTM D 977, Grade SS-1.

2.1.6.2 Cutback Asphalt

Conforming to ASTM D 2028, designation RC-70.

2.1.7 Water

Water shall not contain elements toxic to plant life.

2.1.8 Pesticide

Pesticide shall be insecticide, herbicide, fungicide, nematocide, rodenticide and miticide. For the purpose of this specification, soil fumigant shall have the same requirements as a pesticide. The pesticide material shall be EPA registered and approved insecticide, herbicide, fungicide, nematocide, rodenticide, miticide, and soil fumigant.

2.1.9 Erosion Control Material

Soil erosion control shall conform to the following:

2.1.9.1 Soil Erosion Control Blanket

Machine produced mat of wood excelsior formed from a web of interlocking wood fibers, covered on one side with either knitted straw blanket-like mat construction, covered with biodegradable plastic mesh, or interwoven biodegradable thread, plastic netting or twisted kraft paper cord netting.

2.1.9.2 Soil Erosion Control Fabric

Knitted construction of polypropylene yarn with uniform mesh openings 20 t0 25 mm (3/4 to 1 inch square) with strips of biodegradable paper. Filler paper strips shall last 6 to 8 months.

2.1.9.3 Soil Erosion Control Net

Heavy, twisted jute mesh weighing approximately 605 grams per meter (1.22 pounds per yard) and 1200 mm (4 feet) wide with mesh openings of approximately 25 mm (1 inch square).

2.1.9.4 Soil Erosion Control Chemicals

High-polymer synthetic resin or cold-water emulsion of selected petroleum resins.

2.1.9.5 Hydrophilic Colloids

Hydrophilic colloids shall be physiologically harmless to plant and animal life, without phytotoxic agents. Colloids shall be naturally occurring, silicate powder based, and shall form a water insoluble membrane after curing. Colloids must resist mold growth.

2.1.9.6 Anchors

Erosion control anchor material shall be as recommended by the manufacturer.

PART 3 EXECUTION

3.1 SEEDING, SODDING AND SPRIGGING TIMES AND CONDITIONS

3.1.1 Seeding Time

Seed shall be sown from April 1 to June 15 for spring planting and from August 1 to September 30 for fall planting.

3.1.2 Sodding Time

Sod shall be placed from April 1 to May 31 for spring planting and from August 1 to September 30 for fall planting.

3.1.3 Sprigging Time

Sprigs shall be planted from April 1 to May 31 for spring planting and from August 1 to September 30 for fall planting.

3.1.4 Turfing Conditions

Turf operations shall be performed only during periods when beneficial results can be obtained. When drought, excessive moisture or other unsatisfactory conditions prevail, the work shall be stopped when directed. When special conditions warrant a variance to the turf operations, proposed times shall be submitted to and approved by the Contracting Officer.

3.2 SITE PREPARATION

3.2.1 Grading

The Contracting Officer shall verify that finished grades are as indicated on drawings, and the placing of topsoil and the smooth grading has been completed in accordance with Section: 02210 GRADING.

3.2.2 Application of Soil Amendments

3.2.2.1 Soil Test

A soil test shall be performed for pH, chemical analysis and mechanical analysis to establish the quantities and type of soil amendments required to meet local growing conditions for the type and variety of turf specified.

3.2.2.2 Lime

Lime shall be applied at the rate recommended by the soil test. Lime shall be incorporated into the soil to a minimum depth of 100 mm (4 inches) or may be incorporated as part of the tillage operation.

3.2.2.3 Fertilizer

Fertilizer shall be applied at the rate recommended by the soil test. Fertilizer shall be incorporated into the soil to a minimum depth of 100 mm (4 inches) and may be incorporated as part of the tillage or hydroseeding operation.

3.2.2.4 Soil Conditioner

Soil Conditioner shall be spread uniformly over the soil to a minimum depth of 75 millimeters (3 inches) and thoroughly incorporated by tillage into the soil to a minimum depth of 100 mm (4 inches).

3.2.3 Tillage

3.2.3.1 Minimum Depth

Soil on slopes gentler than 3-horizontal-to-1-vertical shall be tilled to a minimum depth of 100 mm (4 inches). On slopes between 3-horizontal-to-1-vertical and 1-horizontal-to-1 vertical, the soil shall be tilled to a minimum depth of 50 mm (2 inches) by scarifying with heavy rakes, or other method. Rototillers shall be used where soil conditions and length of slope permit. On slopes 1-horizontal-to-1 vertical and steeper, no tillage is required.

3.2.4 Finished Grading

3.2.4.1 Preparation

Turf areas shall be filled as needed or have surplus soil removed to attain the finished grade. Drainage patterns shall be maintained as indicated on drawings. Turf areas compacted by construction operations shall be completely pulverized by tillage. Soil used for repair of erosion or grade deficiencies shall conform to topsoil requirements specified in Section 02210 GRADING. Finished grade shall be 25 mm (1 inch) below the adjoining grade of any surfaced area. New surfaces shall be blended to existing areas.

3.2.4.2 Lawn Area Debris

Lawn areas shall have debris and stones larger than 25 mm (1 inch) in any dimension removed from the surface.

3.2.4.3 Field Area Debris

Field areas shall have debris and stones larger than 75 mm (3 inches) in any dimension removed from the surface.

3.2.4.4 Protection

Finished graded areas shall be protected from damage by vehicular or pedestrian traffic and erosion.

3.3 SEEDING

3.3.1 General

Prior to seeding, any previously prepared seedbed areas compacted or damaged by interim rain, traffic or other cause, shall be reworked to restore the ground condition previously specified. Seeding operations shall not take place when the wind velocity will prevent uniform seed distribution.

3.3.2 Equipment Calibration

The equipment to be used and the methods of turfing shall be subject to the inspection and approval of the Contracting Officer prior to commencement of turfing operations. Immediately prior to the commencement of turfing operations, the Contractor shall conduct turfing equipment calibration tests in the presence of the Contracting Officer.

3.3.3 Applying Seed

3.3.3.1 Broadcast Seeding

Seed shall be uniformly broadcast at the rate of 2.5 kilograms per hectare (5 pounds per 1000 square feet) using broadcast seeders. Half of seed shall be broadcast in one direction, and the remainder at right angles to the first direction. Seed shall be covered to an average depth of 5 mm (1/4 inch) by disk harrow, steel mat drag, cultipacker, or other approved device.

3.3.3.2 Drill Seeding

Seed shall be uniformly drilled to an average depth of 15 mm (1/2 inch) and at the rate of 2 kilograms per hectare (4 pounds per 1000 square feet) using equipment having drills not more than 160 mm (6-1/2 inches) apart. Row markers shall be used with the drill seeder.

3.3.3.3 Rolling

Immediately after seeding, except for slopes 3-horizontal-to-1 vertical and greater, the entire area shall be firmed with a roller not exceeding 130 kg (90 pounds) for each meter (foot) of roller width. Areas seeded with seed drills equipped with rollers shall not be rolled.

3.3.4 Hydroseeding

Seed and fertilizer shall be added to water and thoroughly mixed at the rates specified. Wood cellulose fiber mulch shall be added at the rates recommended by the manufacturer after the seed, fertilizer and water have been thoroughly mixed, to produce a homogeneous slurry. Slurry shall be uniformly applied under pressure over the entire area. The hydroseeded area shall not be rolled.

3.3.5 Mulch

3.3.5.1 Straw or Hay Mulch

Straw or hay mulch shall be spread uniformly at the rate of 4.5 metric tons per hectare (2 tons per acre). Mulch shall be spread by hand, blower-type mulch spreader or other approved method. Mulching shall be started on the windward side of relatively flat areas or on the upper part of a steep slope and continued uniformly until the area is covered. The mulch shall not be bunched. All seeded areas shall be mulched on the same day as the seeding.

3.3.5.2 Mechanically Anchoring

Immediately following spreading, the mulch shall be anchored to the soil by a V-type-wheel land packer, a scalloped-disk land packer designed to force mulch into the soil surface, or other suitable equipment.

3.3.5.3 Asphalt Adhesive Tackifier

When asphalt adhesive is applied to the in-place mulch, spraying shall be at the rate of between 400 to 500 liters per hectare (10 to 13 gallons per 1000 square feet).

3.3.5.4 Non-Asphaltic Tackifier

Hydrophilic colloid shall be applied at rate recommended by manufacturer. Apply with hydraulic equipment suitable for mixing and applying uniform mixture of tackifier.

3.3.5.5 Spreading Asphalt Adhesive Coated Mulch

Straw or hay mulch shall be spread simultaneously with asphalt adhesive at the rate of 2 tons per acre by using power mulch equipment which shall be equipped with suitable asphalt pump and nozzle. The adhesive-coated mulch shall be applied evenly over the surface. Sunlight shall not be completely excluded from penetration to the ground surface.

3.3.5.6 Wood Cellulose Fiber

Wood cellulose fiber mulch for use with the hydraulic application of seed and fertilizer shall be applied as part of the hydroseeding operation.

3.3.6 Water

Watering shall be started within 7 days after completing the seeded area. Water shall be applied at a rate sufficient to ensure moist soil conditions to a minimum depth of 25 mm (1 inch). Run-off and puddling shall be prevented.

3.4 SODDING

3.4.1 General

Areas shall be sodded as indicated. Adequate soil moisture shall be ensured prior to sodding by spraying water on the area to be sodded and wetting the soil to a minimum depth of 25 mm (1 inch).

3.4.2 Placing Sod

Rows of sod shall be placed parallel to and tightly against each other. Joints shall be staggered laterally. The sod strips shall not be stretched or overlapped. All joints shall be butted tight. Voids and air drying of roots shall be prevented. On long slopes, sod shall be laid at right angles to slopes. In ditches, sod shall be laid at right angles to the flow of water. When required, the sod shall be anchored by placing anchors a minimum distance of 600 mm (2 feet) on center with a minimum of 2 anchors per sod section.

3.4.3 Finishing

Air pockets shall be eliminated and a true and even surface shall be provided by tamping or rolling the sod in place. Displacement of the sod shall be assured by knitting of sod to the soil. Frayed edges shall be trimmed and holes or missing corners shall be patched in the sod.

3.4.4 Watering Sod

Watering shall be started immediately after completing each day of sodding. Water shall be applied at a rate sufficient to ensure moist soil conditions to a minimum depth of 25 mm (1 inch). Run-off and puddling shall be prevented.

3.5 SPRIGGING

3.5.1 General

Areas shall be sprigged as indicated.

3.5.2 Broadcast Sprigging

Sprigs shall be broadcast uniformly by hand, with mechanical equipment or other approved method. Sprigs shall be planted to provide a minimum number of 30 (25) viable sprigs per square meter (yard). The maximum space between sprigs shall be 300 mm (12 inches). Sprigs shall be forced into the soil to a minimum depth of 25 mm (1 inch) by disk-rolling, pressing with steel matting, or other approved method.

3.5.3 Hydroplanting

Sprigs shall be mixed with water and uniformly applied under pressure over the entire area. Sprigs shall be covered by distributing a topdressing uniformly and evenly to a minimum depth of 25 mm (1 inch). Topdressing shall conform to the topsoil requirements specified in the Section 02210: GRADING.

3.5.4 Row Sprigging

Sprigs shall be planted in rows spaced a maximum of 300 mm (12 inches) apart and to a minimum depth of 25 mm (1 inch) with mechanical sprig planter or other methods. Sprigs shall be placed a maximum of 150 mm (6 inches) apart in the rows.

3.5.5 Overseeding

When required, seed shall be uniformly broadcast and applied at the rate of 0.2 kilograms per square meter (18 pounds per 1000 square feet).

3.5.6 Rolling

Immediately after completion of the sprigging operation, except on slopes 3-horizontal-to-1-vertical or steeper, the entire area shall be firmed with a roller not exceeding 135 kg for each meter (90 pounds for each foot) of roller width.

3.5.7 Finishing

The finished surface shall be flush with the finished grade. Approximately 25 percent of the planted sprigs should extend above the soil upon completion of the sprigging operation.

3.5.8 Watering Sprigs

Watering shall be started immediately after completing each day of sprigging. Water shall be applied at a rate sufficient to ensure moist soil conditions to a minimum depth of 25 mm (1 inch). Run-off and puddling shall be prevented.

3.6 EROSION CONTROL

3.6.1 Erosion Control Material

Erosion control material, where indicated or required, shall be installed in accordance with manufacturer's instructions. Placement of the erosion control material shall be accomplished without damage to installed material or without deviation to finished grade.

3.6.2 Temporary Turf Cover

3.6.2.1 General

When there are contract delays in the turfing operation or a quick cover is required to prevent erosion, the areas designated for turf shall be seeded with a temporary seed as directed by the Contracting Officer.

3.6.2.2 Application

When no other turfing materials have been applied, the quantity of one half of the required soil amendments shall be applied and the area tilled in accordance with paragraph SITE PREPARATION. Seed shall be uniformly broadcast and applied at the rate of 1.5 Kg per 100 square meter but this quantity can be adjusted by the field experience and soil conditions. The area shall be watered as required.

3.7 APPLICATION OF PESTICIDE

When pesticide becomes necessary to remove a pest or disease, a state-certified applicator shall apply required pesticides in accordance with EPA label restrictions and recommendations. Hydraulic equipment shall be provided for the liquid application of pesticides with a leak-proof tank, positive agitation methods, controlled application pressure and metering gauges. A pesticide plan shall be provided to the Contracting Officer as stated in paragraph SUBMITTALS.

3.8 RESTORATION AND CLEAN UP

3.8.1 Restoration

Existing turf areas, pavements and facilities that have been damaged from the turfing operation shall be restored to original condition at Contractor's expense.

3.8.2 Clean Up

Excess and waste material shall be removed from the planting operation and shall be disposed of off the site. Adjacent paved areas shall be cleaned.

3.9 PROTECTION OF TURFED AREAS

Immediately after turfing, the area shall be protected against traffic or other use by erecting barricades and providing signage as required, or as directed by the Contracting Officer.

3.10 TURF ESTABLISHMENT PERIOD

3.10.1 Commencement

The Turf Establishment Period for establishing a healthy stand of turf shall begin on the first day of work under this contract and shall end three (3) months after the last day of turfing operations required by this contract. Written calendar time period shall be furnished to the Contracting Officer for the Turf Establishment Period. When there is more than one turf establishment period, describe the boundaries of the turfed area covered for each period.

3.10.2 Satisfactory Stand of Turf

3.10.2.1 Seeded Area

a. Lawn Area: A satisfactory stand of turf from the seeding operation for a lawn area is defined as a minimum of 160 grass plants per square meter (15 grass plants per square foot). Bare spots shall be no larger than 150 mm (6 inches) square. The total bare spots shall not exceed 2 percent of the total seeded area.

b. Field Area: A satisfactory stand of turf from the seeding operation for a field area is defined as a minimum of 100 grass plants per square meter (10 grass plants per square foot). The total bare spots shall not exceed 2 percent of the total seeded area.

3.10.2.2 Sodded Area

A satisfactory stand of turf from the sodding operation is defined as living sod uniform in color and leaf texture. Bare spots shall be no larger than 50 mm (2 inches) square.

3.10.2.3 Sprigged Area

A satisfactory stand of turf from the sprigging operation is defined as a minimum of 20 turf plants per square meter(two turf plants per square foot). Bare spots shall be no larger than 230 mm (9 inches) square. The total bare spots shall not exceed 2 percent of the total sprigged area.

3.10.3 Maintenance During Establishment Period

3.10.3.1 General

Maintenance of the turfed areas shall include eradicating weeds, eradicating insects and diseases, protecting embankments and ditches from erosion, maintaining erosion control materials and mulch, protecting turfed areas from traffic, mowing, watering, and post-fertilization.

3.10.3.2 Mowing

a. Lawn Areas: Lawn areas shall be mowed to a minimum height of 50 milimeters (2 inches) when the average height of the turf becomes 100 millimeters (4 inches). Clippings shall be removed when the amount of cut turf is heavy enough to damage the turfed areas.

b. Field Areas: Field areas shall be mowed once during the season to a minimum height of 450 millimeters (18 inches).

3.10.3.3 Watering

Watering shall be at intervals to obtain a moist soil condition to a minimum depth of 25 mm (1 inch). Frequency of watering and quantity of water shall be adjusted in accordance with the growth of the turf. Run-off, puddling and wilting shall be prevented.

3.10.3.4 Post-Fertilization

Composite fertilizer shall be applied at the rate of 300 kilograms per hectare before seeding. After the fertilizer applied scratch the ground about 5 cm thick, make the surface smooth and compacted with 100 to 150 kilogram per square meter power.

3.10.3.5 Pesticide

Treatment for disease or pest shall be in accordance with paragraph APPLICATION OF PESTICIDE.

3.10.3.6 Repair

The Contractor shall re-establish as specified herein, eroded, damaged or barren areas. Mulch shall also be repaired or replaced as required.

3.10.3.7 Maintenance Report

A written record shall be furnished to the Contracting Officer of the maintenance work performed.

3.11 FINAL ACCEPTANCE

3.11.1 Preliminary Inspection

Prior to the completion of the Turf Establishment Period, a preliminary inspection shall be held by the Contracting Officer. Time for the inspection shall be established in writing. The acceptability of the turf in accordance with the Turf Establishment Period shall be determined. An unacceptable stand of turf shall be repaired as soon as turfing conditions permit.

3.11.2 Final Inspection

A final inspection shall be held by the Contracting Officer to determine that deficiencies noted in the preliminary inspection have been corrected. Time for the inspection shall be established in writing.

DIVISION 03 CONCRETE

SECTION 03100

STRUCTURAL CONCRETE FORMWORK

TABLE OF CONTENTS

PART 1 GENERAL

This specification covers the requirements for formwork for cast-in-place concrete and will be used with Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 347R (1994) Guide to Formwork for Concrete

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.4 (1995) Basic Hardboard

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 578 (1995) Rigid, Cellular Polystyrene Thermal Insulation

U.S. DEPARTMENT OF COMMERCE (DOC)

PS 1 (1996) Voluntary Product Standard - Construction and Industrial Plywood

KOREA INDUSTRIAL STANDARD (KS)

KS F 3110 (1997) Plywood for Concrete Form

1.2 SUBMITTALS

Government approval is required for submittals with a “G” designation; submittals not having a “G” designation are for information only. When used, a designation following the “G” designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Formwork; G.

Drawings showing details of formwork, including dimensions of fiber voids, joints, supports, studding and shoring, and sequence of form and shoring removal.

SD-03 Product Data

Design; G.

Design analysis and calculations for form design and methodology used in the design.

Form Materials; G.

Manufacturer's data including literature describing form materials, accessories, and form releasing agents.

Form Releasing Agents; G.

Manufacturer's recommendation on method and rate of application of form releasing agents.

SD-04 Samples

Fiber Voids; G.

One sample unit of fiber voids prior to installation of the voids.

SD-07 Certificates

Fiber Voids; G.

Certificates attesting that fiber voids conform to the specified requirements.

1.3 DESIGN

Formwork shall be designed in accordance with methodology of ACI 347R for anticipated loads, lateral pressures, and stresses. Forms shall be capable of producing a surface which meets the requirements of the class of finish specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Forms shall be capable of withstanding the pressures resulting from placement and vibration of concrete.

1.4 STORAGE AND HANDLING

Fiber voids shall be stored above ground level in a dry location. Fiber voids shall be kept dry until installed and overlaid with concrete.

PART 2 PRODUCTS

2.1 FORM MATERIALS

2.1.1 Forms For Class A and Class B Finish

Forms for Class A and Class B finished surfaces shall be plywood panels conforming to DOC PS 1, Grade B-B concrete form panels, Class I or II, or KS F 3110. Other form materials or liners may be used provided the smoothness and appearance of concrete produced will be equivalent to that produced by the plywood concrete form panels. Forms for round columns shall be the prefabricated seamless type.

2.1.2 Forms For Class C Finish

Forms for Class C finished surfaces shall be shiplap lumber; plywood conforming to DOC PS 1, Grade B-B concrete form panels or KS F 3110, Class I or II; tempered concrete form hardboard conforming to AHA A135.4; other approved concrete form material; or steel, except that steel lining on wood sheathing shall not be used. Forms for round columns may have one vertical seam.

2.1.3 Forms For Class D Finish

Forms for Class D finished surfaces, except where concrete is placed against earth, shall be wood or steel or other approved concrete form material.

2.1.4 Retain-In-Place Metal Forms

Retain-in-place metal forms for concrete slabs and roofs shall be as specified in Section 05300 STEEL DECKING.

2.1.5 Pan-Form Units

Pan-form units for one-way or two-way concrete joist and slab construction shall be factory-fabricated units of the approximate section indicated. Units shall consist of steel or molded fiberglass concrete form pans. Closure units shall be furnished as required.

2.1.6 Form Ties

Form ties shall be factory-fabricated metal ties, shall be of the removable or internal disconnecting or snap-off type, and shall be of a design that will not permit form deflection and will not spall concrete upon removal. Solid backing shall be provided for each tie. Except where removable tie rods are used, ties shall not leave holes in the concrete surface less than 6 mm (1/4 inch) nor more than 25 mm (1 inch) deep and not more than 25 mm (1 inch) in diameter. Removable tie rods shall be not more than 38 mm (1-1/2 inches) in diameter.

2.1.7 Form Releasing Agents

Form releasing agents shall be commercial formulations that will not bond with, stain or adversely affect concrete surfaces. Agents shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds.

2.1.8 Fiber Voids

Fiber voids shall be the product of a reputable manufacturer regularly engaged in the commercial production of fiber voids. The voids shall be constructed of double faced, corrugated fiberboard. The corrugated fiberboard shall be fabricated of wet strength paper, impregnated with paraffin, and laminated with moisture resistant adhesive, and shall have a board strength of 20 kg per square centimeter (275 psi). Voids which are impregnated with paraffin after construction, in lieu of being constructed with paraffin impregnated fiberboard, are acceptable. Voids shall be designed to support not less than 4900 kg per square meter (1000 psf). To prevent separation during concrete placement fiber voids shall be assembled with steel or plastic banding at 1.22 meters (4 feet) on center maximum, or by adequate stapling or gluing as recommended by the manufacturer. Fiber voids placed under concrete slabs and that are 200 mm (8 inches) in depth may be heavy duty “waffle box” type, constructed of paraffin impregnated corrugated fiberboard.

2.2 FIBER VOID RETAINERS

2.2.1 Polystyrene Rigid Insulation

Polystyrene rigid insulation shall conform to ASTM C 578, Type V, VI, or VII, square edged. Size shall be 38 mm (1-1/2 inches) thick by 400 mm (16 inches) in height by 1 meter (3 feet) in length, unless otherwise indicated.

2.2.2 Precast Concrete

Precast concrete units shall have a compressive strength of not less than 17 MPa (2500 psi). reinforced with 150 mm by 150 mm by W1.4 WWF (6 inch by 6 inch by W1.4 WWF) wire mesh, and 300 mm (height) by 1 m (length) by 40 mm (thickness) (12 inches (height) by 3 feet (length) by 1-5/8 inches (thickness)) in size unless indicated.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Formwork

Forms shall be mortar tight, properly aligned and adequately supported to produce concrete surfaces meeting the surface requirements specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE and conforming to construction tolerance given in TABLE 1. Where concrete surfaces are to have a Class A or Class B finish, joints in form panels shall be arranged as approved. Where forms for continuous surfaces are placed in successive units, the forms shall fit over the completed surface to obtain accurate alignment of the surface and to prevent leakage of mortar. Forms shall not be reused if there is any evidence of surface wear and tear or defects which would impair the quality of the surface. Surfaces of forms to be reused shall be cleaned of mortar from previous concreting and of all other foreign material before reuse. Form ties that are to be completely withdrawn shall be coated with a nonstaining bond breaker.

3.1.2 Fiber Voids

Voids shall be placed on a smooth firm dry bed of suitable material, to avoid being displaced vertically, and shall be set tight, with no buckled cartons, in order that horizontal displacement cannot take place. Each section of void shall have its ends sealed by dipping in paraffin, with any additional cutting of voids at the jobsite to be field dipped in the same type of sealer, unless liners and flutes are completely impregnated with paraffin. Prior to placing reinforcement, the entire formed area for slabs shall be covered with a 1.22 m x 2.44 m (4 feet x 8 feet) minimum flat sheets of fiber void corrugated fiberboard. Joints shall be sealed with a moisture resistant tape having a minimum width of 75 mm (3 inch). If voids are destroyed or damaged for any reason and are not capable of supporting the design load, they shall be replaced prior to placing of concrete.

3.1.3 Fiber Void Retainers

Fiber void retainers shall be installed, continuously, on both sides of fiber voids placed under grade beams in order to retain the cavity after the fiber voids biodegrade.

3.2 CHAMFERING

Except as otherwise shown, external corners that will be exposed shall be chamfered, beveled, or rounded by moldings placed in the forms.

3.3 COATING

Forms for Class A and Class B finished surfaces shall be coated with a form releasing agent before the form or reinforcement is placed in final position. The coating shall be used as recommended in the manufacturer's printed or written instructions. Forms for Class C and D finished surfaces may be wet with water in lieu of coating immediately before placing concrete, except that in cold weather with probable freezing temperatures coating shall be mandatory. Surplus coating on form surfaces and coating on reinforcing steel and construction joints shall be removed before placing concrete.

3.4 REMOVAL OF FORMS

Forms shall be removed preventing injury to the concrete and ensuring the complete safety of the structure. Formwork for columns, walls, side of beams and other parts not supporting the weight of concrete may be removed when the concrete has attained sufficient strength to resist damage from the removal operation but not before at least 24 hours has elapsed since concrete placement. Supporting forms and shores shall not be removed from beams, floors and walls until the structural units are strong enough to carry their own weight and any other construction or natural loads. Supporting forms or shores shall not be removed before the concrete strength has reached 70 percent of design strength, as determined by field cured cylinders or other approved methods. This strength shall be demonstrated by job-cured test specimens, and by a structural analysis considering the proposed loads in relation to these test strengths and the strength of forming and shoring system. The job-cured test specimens for form removal purposes shall be provided in numbers as directed and shall be in addition to those required for concrete quality control. The specimens shall be removed from molds at the age of 24 hours and shall receive, insofar as possible, the same curing and protection as the structures they represent.

TABLE 1

TOLERANCES FOR FORMED SURFACES (mm)

1. Variations from the plumb:	In any 3 m (10’) of length -- 6 mm (1/4”)
a. In the lines and surfaces of columns, piers, walls and in arises	Maximum for entire length -- 25 mm (1”)
b. For exposed corner columns, control-joint grooves, and other conspicuous lines	In any 6 m (20’) of length -- 6 mm (1/4”) Maximum for entire length -- 13 mm (1/2”)
2. Variation from the level or from the grades indicated on	In any 3 m (10’) of length -- 6 mm (1/4”) In any bay or in any

the drawings:	6 m (20’)of length --------- 10 mm (3/8”)
a. In slab soffits, ceilings, beam soffits, and in arises, measured before removal of supporting shores	Maximum for entire length -- 20 mm (3/4”)
b. In exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines	In any bay or in any 6 m (20’)of length ---------- 6 mm (1/4””) Maximum for entire length -- 13 mm (1/2”)
3. Variation of the linear building lines from established position in plan	In any 6 m (20’)------------ 13 mm (1/2”) Maximum -------------------- 25 mm (1”)
4. Variation of distance between walls, columns, partitions	6 mm per 3 m (1/4”per 10’) of distance, but not more than 13 mm (1/2”) in any one bay, and not more than 25 mm (1”) total variation
5. Variation in the sizes and locations of sleeves, floor openings, and wall opening	Minus ----------------------- 6 mm (1/4”) Plus ----------------------- 13 mm (1/2”)
6. Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls	Minus ----------------- ----- 6 mm (1/4”) Plus ------------------ ---- 13 mm (1/2”)
7. Footings:	
a. Variation of dimensions in plan	Minus ---------------------- 13 mm (1/2”) Plus ----------------------- 50 mm (2”) when formed or plus 75 mm (3”) when placed against unformed excavation
b. Misplacement of eccentricity	2 percent of the footing width in the direction of misplacement but not more than ------------------ 50 mm (2”)
c. Reduction in thickness	Minus ----------------------- 5 percent of specified thickness
8. Variation in steps:	
a. In a flight of stairs	Riser ----------------------- 3 mm (1/8”) Tread ----------------------- 6 mm (1/4”)
b. In consecutive steps	Riser ----------------------- 2 mm (1/16”) Tread ----------------------- 3 mm (1/8”)

SECTION 03150

EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 111	(1983; R 1996) Inorganic Matter or Ash in Bituminous Materials

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.4	(1995) Basic Hardboard

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 109/A 109M	(1998a) Steel, Strip, Carbon, Cold-Rolled
ASTM A 167	(1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 480/A 480M	(1999b) General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A 570/A 570M	(1998) Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality
ASTM B 152	(1997a) Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B 152M	(1997a) Copper Sheet, Strip, Plate, and Rolled Bar (Metric)
ASTM B 370	(1998) Copper Sheet and Strip for Building Construction

ASTM C 919	(1984; R 1998) Use of Sealants in Acoustical Applications
ASTM C 920	(1998) Elastomeric Joint Sealants
ASTM D 4	(1986; R 1998) Bitumen Content
ASTM D 6	(1995) Loss on Heating of Oil and Asphaltic Compounds
ASTM D 412	(1998a) Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension
ASTM D 471	(1998el) Rubber Property - Effect of Liquids
ASTM D 1190	(1997) Concrete Joint Sealer, Hot-Applied Elastic Type
ASTM D 1191	(1984; R 1994el) Concrete Joint Sealers
ASTM D 1751	(1999) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R 1996el) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 1854	(1996) Jet-Fuel-Resistant Concrete Joint Sealer, Hot-Poured Elastic Type
ASTM D 2628	(1991; R 1998) Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D 2835	(1989; R 1998) Lubricant for Installation of Preformed Compression Seals in Concrete Pavements
ASTM D 5249	(1995) Backer Material for Use With Cold and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints
ASTM D 5329	(1996) Standard Test Method for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements

CORPS OF ENGINEERS (COE)

COE CRD-C 513	(1974) Corps of Engineers Specifications for Rubber Waterstops
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Waterstops; G.

Shop drawings and fabrication drawings provided by the manufacturer or prepared by the Contractor.

SD-03 Product Data

Preformed Expansion Joint Filler; G. Sealant; G. Waterstops; G.

Manufacturer's literature, including safety data sheets, for preformed fillers and the lubricants used in their installation; field-molded sealants and primers (when required by sealant manufacturer); preformed compression seals; and waterstops. Manufacturer's recommended instructions for installing preformed fillers, field-molded sealants; preformed compression seals; and waterstops; and for splicing non-metallic waterstops.

SD-04 Samples

Lubricant for Preformed Compression Seals; G.

Specimens identified to indicate the manufacturer, type of material, size and quantity of material, and shipment or lot represented. Each sample shall be a piece not less than 3 m (9 ft) of 25 mm (1 inch) nominal width or wider seal or a piece not less than 4 m (12 ft) of compression seal less than 25 mm (1 inch) nominal width. One L quart of lubricant shall be provided.

Field-Molded Type; G.

Four liters One gallon of field-molded sealant and one L quart of primer (when primer is recommended by the sealant manufacturer) identified to indicate manufacturer, type of material, quantity, and shipment or lot represented.

Non-metallic Materials; G.

Specimens identified to indicate manufacturer, type of material, size, quantity of material, and shipment or lot represented. Each sample shall be a piece not less than 300 mm (12 inch) long cut from each 61 m (200 ft) of finished waterstop furnished, but not less than a total of 1 m (4 ft) of each type, size, and lot furnished. One splice sample of each size and type for every 50 splices made in the factory and every 10 splices made at the job site. The splice samples shall be made using straight run pieces with the splice located at the mid-length of the sample and finished as required for the installed waterstop. The total length of each splice shall be not less than 300 mm (12 inches) long.

SD-07 Certificates

Preformed Expansion Joint Filler; G. Sealant; G. Waterstops; G.

Certificates of compliance stating that the joint filler and sealant materials and waterstops conform to the requirements specified.

1.3 DELIVERY AND STORAGE

Material delivered and placed in storage shall be stored off the ground and protected from moisture, dirt, and other contaminants. Sealants shall be delivered in the manufacturer's original unopened containers. Sealants whose shelf life has expired shall be removed from the site.

PART 2 PRODUCTS

2.1 CONTRACTION JOINT STRIPS

Contraction-joint strips shall be 3 mm (1/8-inch) thick tempered hardboard conforming to AHA A135.4, Class 1. In lieu of hardboard strips, rigid polyvinylchloride (PVC) or high impact polystyrene (HIPS) insert strips specifically designed to induce controlled cracking in slabs on grade may be used. Such insert strips shall have removable top section.

2.2 PREFORMED EXPANSION JOINT FILLER

Expansion-joint filler shall be preformed material conforming to ASTM D 1751 or ASTM D 1752. Unless otherwise indicated, filler material shall be 10 mm (3/8 inch) thick and of a width applicable for the joint formed. Backer material, when required, shall conform to ASTM D 5249.

2.3 SEALANT

Elastomeric joint seals conforming to ASTM D 2628 shall be used in compression type joints. For slabs receiving considerable fuel spillage, the hot-applied jet-fuel resistant type shall be used when a thermoplastic elastomeric rubber (TPE-R) waterstop is not specified. Joint sealant shall conform to the following:

2.3.1 Preformed Polychloroprene Elastomeric Type

ASTM D 2628.

2.3.2 Lubricant for Preformed Compression Seals

ASTM D 2835.

2.3.3 Hot-Poured Type

ASTM D 1190 tested in accordance with ASTM D 1191.

2.3.4 Field Molded Type

ASTM C 920, Type M for horizontal joints or Type NS for vertical joints, Class 25, and Use NT. Bond breaker material shall be polyethylene tape, coated paper, metal foil or similar type materials. The back-up material shall be compressible, non-shrink, nonreactive with sealant, and non-absorptive material type such as extruded butyl or polychloroprene rubber.

2.3.5 Hot-Applied Jet-Fuel Resistant Type

ASTM D 1854 tested in accordance with ASTM D 5329.

2.4 WATERSTOPS

Intersection and change of direction waterstops shall be shop fabricated.

2.4.1 Flexible Metal

Copper waterstops shall conform to ASTM B 152M or ASTM B 152 and ASTM B 370, O60 soft anneal temper and 0.686 mm (20 oz mass per sq ft) sheet thickness. Stainless steel waterstops shall conform to ASTM A 167 and ASTM A 480/A 480M, UNS S30453 (Type 304L), and 0.9525 mm (20 gauge) thick strip.

2.4.2 Rigid Metal

Flat steel waterstops shall conform to ASTM A 109/A 109M, No. 2 (half hard) temper, No. 2 edge, No. 1 (matte or dull) finish or ASTM A 570/A 570M, Grade 40.

2.4.3 Non-Metallic Materials

Non-metallic waterstops shall be manufactured from a prime virgin resin; reclaimed material is not acceptable. The compound shall contain plasticizers, stabilizers, and other additives to meet specified requirements. Rubber waterstops shall conform to COE CRD-C 513. Polyvinylchloride waterstops shall conform to COE CRD-C 572. Thermoplastic elastomeric rubber waterstops shall conform to ASTM D 471.

2.4.4 Non-Metallic Hydrophilic

Swellable strip type compound of polymer modified chloroprene rubber that swells upon contact with water shall conform to ASTM D 412 as follows: Tensile strength 2.9 MPa (420 psi) minimum; ultimate elongation 600 percent minimum. Hardness shall be 50 minimum on the type A durometer and the volumetric expansion ratio in distilled water at 20 degrees C (70 degrees F) shall be 3 to 1 minimum.

2.4.5 Preformed Elastic Adhesive

Preformed plastic adhesive waterstops shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler, and shall contain no solvents, asbestos, irritating fumes or obnoxious odors. The compound shall not depend on oxidizing, evaporating, or chemical action for its adhesive or cohesive strength.

2.4.5.1 Chemical Composition

The chemical composition of the sealing compound shall meet the requirements shown below.

PERCENT BY WEIGHT

COMPONENT	MIN.	MAX.	TEST
Bitumen (Hydrocarbon plastic)	50	70	ASTM D 4
Inert Mineral Filler	30	50	AASHTO T 111
Volatile Matter	--	2	ASTM D 6

2.4.5.2 Adhesion Under Hydrostatic Pressure

The sealing compound shall not leak at the joints for a period of 24 hours under a vertical 2 m (6 foot) head pressure. In a separate test, the sealing compound shall not leak under a horizontal pressure of 65 kPa (10 psi) which is reached by slowly applying increments of 13 kPa (2 psi) every minute.

2.4.5.3 Sag of Flow Resistance

Sagging shall not be detected when tested as follows: Fill a wooden form 25 mm (1 inch) wide and 150 mm (6 inches) long flush with sealing compound and place in an oven at 58 degrees C (135 degrees F) in a vertical position for 5 days.

2.4.5.4 Chemical Resistance

The sealing compound when immersed separately in a 5% solution of caustic potash, a 5% solution of hydrochloric acid, 5% solution of sulfuric acid and a saturated hydrogen sulfide solution for 30 days at ambient room temperature shall show no visible deterioration.

PART 3 EXECUTION

3.1 JOINTS

Joints shall be installed at locations indicated and as authorized.

3.1.1 Contraction Joints

Contraction joints may be constructed by inserting tempered hardboard strips or rigid PVC or HIPS insert strips into the plastic concrete using a steel parting bar, when necessary, or by cutting the concrete with a saw after concrete has set. Joints shall be approximately 3 mm (1/8 inch) wide and shall extend into the slab one-fourth the slab thickness, minimum, but not less than 25 mm (1 inch).

3.1.1.1 Joint Strips

Since contraction joint strips are difficult to align and maintain in alignment, joint strips shall not be used where appearance is important or where concrete slabs will not be covered with subsequent toppings that will hide the joint. Strips shall be of the required dimensions and as long as practicable. After the first floating, the concrete shall be grooved with a tool at the joint locations. The strips shall be inserted in the groove and depressed until the top edge of the vertical surface is flush with the surface of the slab. The slab shall be floated and finished as specified. Working of the concrete adjacent to the joint shall be the minimum necessary to fill voids and consolidate the concrete. Where indicated, the top portion of the strip shall be sawed out after the curing period to form a recess for sealer. The removable section of PVC strips shall be discarded and the insert left in place. Means shall be provided to insure true alignment of the strips is maintained during insertion.

3.1.1.2 Sawed Joints

Joint sawing shall be early enough to prevent uncontrolled cracking in the slab, but late enough that this can be accomplished without appreciable spalling. Concrete-sawing machines shall be adequate in number and power, and with sufficient replacement blades to complete the sawing at the required rate. Joints shall be cut to true alignment and shall be cut in sequence of concrete placement. Sludge and cutting debris shall be removed.

3.1.2 Expansion Joints

Preformed expansion joint filler shall be used in expansion and isolation joints in slabs around columns and between slabs on grade and vertical surfaces where indicated. The filler shall extend the full slab depth, unless otherwise indicated. The edges of the joint shall be neatly finished with an edging tool of 3 mm (1/8 inch) radius, except where a resilient floor surface will be applied. Where the joint is to receive a sealant, the filler strips shall be installed at the proper level below the finished floor with a slightly tapered, dressed and oiled wood strip temporarily secured to the top to form a recess to the size shown on the drawings. The wood strip shall be removed after the concrete has set. Contractor may opt to use a removable expansion filler cap designed and fabricated for this purpose in lieu of the wood strip. The groove shall be thoroughly cleaned of laitance, curing compound, foreign materials, protrusions of hardened concrete, and any dust which shall be blown out of the groove with oil-free compressed air.

3.1.3 Joint Sealant

Sawed contraction joints and expansion joints in slabs shall be filled with joint sealant, unless otherwise shown. Joint surfaces shall be clean, dry, and free of oil or other foreign material which would adversely affect the bond between sealant and concrete. Joint sealant shall be applied as recommended by the manufacturer of the sealant.

3.1.3.1 Joints With Preformed Compression Seals

Compression seals shall be installed with equipment capable of installing joint seals to the prescribed depth without cutting, nicking, twisting, or otherwise distorting or damaging the seal or concrete and with no more than 5 percent stretching of the seal. The sides of the joint and, if necessary, the sides of the compression seal shall be covered with a coating of lubricant. Butt joints shall be coated with liberal applications of lubricant.

3.1.3.2 Joints With Field-Molded Sealant

Joints shall not be sealed when the sealant material, ambient air, or concrete temperature is less than 4 degrees C. (40 degrees F.) When the sealants are meant to reduce the sound transmission characteristics of interior walls, ceilings, and floors the guidance provided in ASTM C 919 shall be followed. Joints requiring a bond breaker shall be coated with curing compound or with bituminous paint. Bond breaker and back-up material shall be installed where required. Joints shall be primed and filled flush with joint sealant in accordance with the manufacturer's recommendations.

3.2 WATERSTOPS, INSTALLATION AND SPLICES

Waterstops shall be installed at the locations shown to form a continuous water-tight diaphragm. Adequate provision shall be made to support and completely protect the waterstops during the progress of the work. Any waterstop punctured or damaged shall be repaired or replaced. Exposed waterstops shall be protected during application of form release agents to avoid being coated. Suitable guards shall be provided to protect exposed projecting edges and ends of partially embedded waterstops from damage when concrete placement has been discontinued. Splices shall be made by certified trained personnel using approved equipment and procedures.

3.2.1 Copper And Stainless Steel

Splices in copper waterstops shall be lap joints made by brazing. Splices in stainless steel waterstops shall be welded using a TIG or MIG process utilizing a weld rod to match the stainless. All welds shall be annealed to maintain physical properties. Carbon flame shall not be used in the annealing process. Damaged waterstops shall be repaired by removing damaged portions and patching. Patches shall overlap a minimum of 25 mm (1 inch) onto undamaged portion of the waterstop.

3.2.2 Flat Steel

Splices in flat steel waterstops shall be properly aligned, butt welded, and cleaned of excessive material.

3.2.3 Non-Metallic

Fittings shall be shop made using a machine specifically designed to mechanically weld the waterstop. A miter guide, proper fixturing (profile dependant), and portable power saw shall be used to miter cut the ends to be joined to ensure good alignment and contact between joined surfaces. The splicing of straight lengths shall be done by squaring the ends to be joined.

Continuity of the characteristic features of the cross section of the waterstop (ribs, tabular center axis, protrusions, etc.) shall be maintained across the splice.

3.2.3.1 Rubber Waterstop

Splices shall be vulcanized or shall be made using cold bond adhesive as recommended by the manufacturer. Splices for TPE-R shall be as specified for PVC.

3.2.3.2 Polyvinyl Chloride Waterstop

Splices shall be made by heat sealing the adjacent waterstop edges together using a thermoplastic splicing iron utilizing a non-stick surface specifically designed for waterstop welding. The correct temperature shall be used to sufficiently melt without charring the plastic. The spliced area, when cooled, shall show no signs of separation, holes, or other imperfections when bent by hand in as sharp an angle as possible.

3.2.3.3 Quality Assurance

Edge welding will not be permitted. Centerbulbs shall be compressed or closed when welding to non-centerbulb type. Waterstop splicing defects which are unacceptable include, but are not limited to the following: 1) Tensile strength less than 80 percent of parent section. 2) Free lap joints. 3) Misalignment of centerbulb, ribs, and end bulbs greater than 2 mm (1/16 inch.) 4) Misalignment which reduces waterstop cross section more than 15 percent. 5) Bond failure at joint deeper than 2 mm (1/16 inch) or 15 percent of material thickness. 6) Misalignment of waterstop splice resulting in misalignment of waterstop in excess of 13 mm (1/2 inch) in 3 m (10 feet.) 7) Visible porosity in the weld area, including pin holes. 8) Charred or burnt material. 9) Bubbles or inadequate bonding. 10) Visible signs of splice separation when cooled splice is bent by hand at a sharp angle.

3.2.4 Non-Metallic Hydrophilic Waterstop Installation

Ends to be joined shall be miter cut with sharp knife or shears. The ends shall be adhered with cyanacryiate (super glue) adhesive. When joining hydrophilic type waterstop to PVC waterstop, the hydrophilic waterstop shall be positioned as shown on the drawings. A liberal amount of a single component hydrophilic sealant shall be applied to the junction to complete the transition.

3.2.5 Preformed Plastic Adhesive Installation

The installation of preformed plastic adhesive waterstops shall be a prime, peel, place and pour procedure. Joint surfaces shall be clean and dry before priming and just prior to placing the sealing strips. The end of each strip shall be spliced to the next strip with a 25 mm (1 inch) overlap; the overlap shall be pressed firmly to release trapped air. During damp or cold conditions the joint surface shall be flashed with a safe, direct flame to warm and dry the surface adequately; the sealing strips shall be dipped in warm water to soften the material to achieve maximum bond to the concrete surface.

3.3 CONSTRUCTION JOINTS

Construction joints are specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE except that construction joints coinciding with expansion and contraction joints shall be treated as expansion or contraction joints as applicable.

SECTION 03200

CONCRETE REINFORCEMENT

TABLE OF CONTENTS

PART 1 GENERAL

This specification covers the requirements for concrete reinforcement, including welded wire fabric, for building construction in conjunction with Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 318/318R (1995) Building Code Requirements for Structural Concrete and Commentary

ACI 318M/318RM (1999) Building Code Requirements for Structural Concrete and Commentary (Metric)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53 (1999) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A 82 (1997a) Steel Wire, Plain, for Concrete Reinforcement

ASTM A 184/A 184M (1996) Fabricated Deformed Steel Bar Mats for Concrete Reinforcement

ASTM A 185 (1997) Steel Welded Wire Fabric, Plain, for Concrete Reinforcement

ASTM A 496	(1997) Steel Wire, Deformed, for Concrete Reinforcement
ASTM A 497	(1997) Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement
ASTM A 615/A 615M	(1996a) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 675/A 675M	(1990a; R 1995e1) Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
ASTM A 706/A 706M	(1998) Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 767/A 767M	(1997) Zinc-Coated (Galvanized) Steel Bars in Concrete Reinforcement
ASTM A 775/A 775M	(1997e1) Epoxy-Coated Reinforcement Steel Bars
ASTM A 884/A 884M	(1996ae1) Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement
ASTM C 1116	(1995) Fiber-Reinforced Concrete and Shotcrete

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4	(1998) Structural Welding Code - Reinforcing Steel

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI MSP-1	(1996) Manual of Standard Practice

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3504	(1988) Steel Bar for Concrete Reinforcement
KS D 7017	(1999) Welded Steel Wire Fabrics

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Reinforcement; G.

Detail drawings showing reinforcing steel placement, schedules, sizes, grades, and splicing and bending details. Drawings shall show support details including types, sizes and spacing.

SD-03 Product Data

Welding; G.

A list of qualified welders names.

SD-07 Certificates

Reinforcing Steel; G.

Certified copies of mill reports attesting that the reinforcing steel furnished contains no less than 25 percent recycled scrap steel and meets the requirements specified herein, prior to the installation of reinforcing steel.

1.3 WELDING

Welders shall be qualified in accordance with AWS D1.4. Qualification test shall be performed at the worksite and the Contractor shall notify the Contracting Officer 24 hours prior to conducting tests. Special welding procedures and welders qualified by others may be accepted as permitted by AWS D1.4.

1.4 DELIVERY AND STORAGE

Reinforcement and accessories shall be stored off the ground on platforms, skids, or other supports.

PART 2 PRODUCTS

2.1 DOWELS

Dowels shall conform to ASTM A 675/A 675M, Grade 80. Steel pipe conforming to ASTM A 53, Schedule 80, may be used as dowels provided the ends are closed with metal or plastic inserts or with mortar.

2.2 FABRICATED BAR MATS

Fabricated bar mats shall conform to ASTM A 184/A 184M.

2.3 REINFORCING STEEL

Reinforcing steel shall be deformed bars conforming to ASTM A 615/A 615M or ASTM A 706/A 706M, or KS D 3504, grades and sizes as indicated. Cold drawn wire used for spiral reinforcement shall conform to ASTM A 82. In highly corrosive environments or when directed by the Contracting Officer, reinforcing steel shall conform to ASTM A 767/A 767M or ASTM A 775/A 775M as appropriate.

2.4 WELDED WIRE FABRIC

Welded wire fabric shall conform to ASTM A 185, ASTM A 496, ASTM A 497 or KS D 7017. When directed by the Contracting Officer for special applications, epoxy coated steel welded wire fabric shall conform to ASTM A 884/A 884M.

2.5 WIRE TIES

Wire ties shall be 16 gauge or heavier black annealed steel wire.

2.6 SUPPORTS

Bar supports for formed surfaces shall be designed and fabricated in accordance with CRSI MSP-1 and shall be steel or precast concrete blocks. Precast concrete blocks shall have wire ties and shall be not less than 100 by 100 mm (4 inches square) when supporting reinforcement on ground. Precast concrete block shall have compressive strength equal to that of the surrounding concrete. Where concrete formed surfaces will be exposed to weather or where surfaces are to be painted, steel supports within 13 mm (1/2 inch) of concrete surface shall be galvanized, plastic protected or of stainless steel. Concrete supports used in concrete exposed to view shall have the same color and texture as the finish surface. For slabs on grade, supports shall be precast concrete blocks, plastic coated steel fabricated with bearing plates, or specifically designed wire-fabric supports fabricated of plastic.

2.7 SYNTHETIC FIBER REINFORCEMENT

Synthetic fiber shall be polypropylene with a denier less than 100 and a nominal fiber length of 50 mm (2 inches).

PART 3 EXECUTION

3.1 REINFORCEMENT

Reinforcement shall be fabricated to shapes and dimensions shown and shall conform to the requirements of ACI 318M or ACI 318/318R. Reinforcement shall be cold bent unless otherwise authorized. Bending may be accomplished in the field or at the mill. Bars shall not be bent after embedment in concrete. Safety caps shall be placed on all exposed ends of vertical concrete reinforcement bars that pose a danger to life safety. Wire tie ends shall face away from the forms.

3.1.1 Placement

Reinforcement shall be free from loose rust and scale, dirt, oil, or other deleterious coating that could reduce bond with the concrete. Reinforcement shall be placed in accordance with ACI 318M or ACI 318/318R at locations shown plus or minus one bar diameter. Reinforcement shall not be continuous through expansion joints and shall be as indicated through construction or contraction joints. Concrete coverage shall be as indicated or as required by ACI 318M or ACI 318/318R. If bars are moved more than one bar diameter to avoid interference with other reinforcement, conduits or embedded items, the resulting arrangement of bars, including additional bars required to meet structural requirements, shall be approved before concrete is placed.

3.1.2 Splicing

Splices of reinforcement shall conform to ACI 318/318R and shall be made only as required or indicated. Splicing shall be by lapping or by mechanical or welded butt connection; except that lap splices shall not be used for bars larger than No. 11 unless otherwise indicated. Welding shall conform to AWS D1.4. Welded butt splices shall be full penetration butt welds. Lapped bars shall be placed in contact and securely tied or spaced transversely apart to permit the embedment of the entire surface of each bar in concrete. Lapped bars shall not be spaced farther apart than one-fifth the required length of lap or 150 mm (6 inches). Mechanical butt splices shall be in accordance with the recommendation of the manufacturer of the mechanical splicing device. Butt splices shall develop 125 percent of the specified minimum yield tensile strength of the spliced bars or of the smaller bar in transition splices. Bars shall be flame dried before butt splicing. Adequate jigs and clamps or other devices shall be provided to support, align, and hold the longitudinal centerline of the bars to be butt spliced in a straight line.

3.2 WELDED-WIRE FABRIC PLACEMENT

Welded-wire fabric shall be placed in slabs as indicated. Fabric placed in slabs on grade shall be continuous between expansion, construction, and contraction joints. Fabric placement at joints shall be as indicated. Lap splices shall be made in such a way that the overlapped area equals the distance between the outermost crosswires plus 50 mm (2 inches). Laps shall be staggered to avoid continuous laps in either direction. Fabric shall be wired or clipped together at laps at intervals not to exceed 1.22 m (4 feet). Fabric shall be positioned by the use of supports.

3.3 DOWEL INSTALLATION

Dowels shall be installed in slabs on grade at locations indicated and at right angles to joint being doweled. Dowels shall be accurately positioned and aligned parallel to the finished concrete surface before concrete placement. Dowels shall be rigidly supported during concrete placement. One end of dowels shall be coated with a bond breaker.

3.4 SYNTHETIC FIBER REINFORCED CONCRETE

When Synthetic fiber reinforcement is used in concrete slabs as an aid in preventing plastic or shrinkage cracking in placements susceptible to this condition. Fiber reinforcement shall be added to the concrete mix in accordance with the applicable sections of ASTM C 1116 and the recommendations of the manufacturer and in an amount of 0.1 percent by volume. Fiber reinforcement shall not be used as a substitute for wire mesh and where service temperature may exceed 150 degrees C (300 degrees F). Concentrations above 0.1 percent by volume are not cost-effective.

SECTION 03300

CAST-IN-PLACE STRUCTURAL CONCRETE

TABLE OF CONTENTS

PART 1 GENERAL

This specification covers the requirements for cast-in-place concrete materials, mixing, placement, and finishes. This specification covers concrete work primarily for buildings, but may also be used for other applications such as wharves, docks, drainage structures, warehouse type slabs, and driveways.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 117/117R	(1990; Errata) Standard Tolerances for Concrete Construction and Materials
ACI 211.1	(1991) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 211.2	(1998) Standard Practice for Selecting Proportions for Structural Lightweight Concrete
ACI 213R	(1987) Guide for Structural Lightweight Aggregate Concrete
ACI 214.3R	(1988; R 1997) Simplified Version of the Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 301	(1999) Standard Specifications for Structural Concrete
ACI 303R	(1991) Guide to Cast-In-Place Architectural Concrete Practice
ACI 305R	(1999) Hot Weather Concreting
ACI 318/318R	(1999) Building Code Requirements for Structural Concrete and Commentary

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(1991; R 1996) Burlap Cloth Made From Jute or Kenaf

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31/C 31M	(2000) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(1999ael) Concrete Aggregates
ASTM C 39/C 39M	(2000) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 42/C 42M	(1999) Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 78	(1994) Flexural Strength of Concrete (Using Simple Beam With Third-Point Loading)
ASTM C 94/C 94M	(2000) Ready-Mixed Concrete
ASTM C 131	(1996) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates

ASTM C 143/C 143M	(2000) Slump of Hydraulic Cement Concrete
ASTM C 150	(1999a) Portland Cement
ASTM C 171	(1997a) Sheet Materials for Curing Concrete
ASTM C 172	(1999) Sampling Freshly Mixed Concrete
ASTM C 173	(1994ael) Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 192/C 192M	(2000) Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	(1997el) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(2000) Air-Entraining Admixtures for Concrete
ASTM C 309	(1998a) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 330	(2000) Lightweight Aggregates for Structural Concrete
ASTM C 494/C 494M	(1999a) Chemical Admixtures for Concrete
ASTM C 496	(1996) Splitting Tensile Strength of Cylindrical Concrete Specimens
ASTM C 552	(2000) Cellular Glass Thermal Insulation
ASTM C 567	(2000) Unit Weight of Structural Lightweight Concrete
ASTM C 578	(1995) Rigid, Cellular Polystyrene Thermal Insulation
ASTM C 591	(1994) Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C 595	(2000a) Blended Hydraulic Cements
ASTM C 595M	(1997) Blended Hydraulic Cements (Metric)
ASTM C 618	(2000) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 685	(2000) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 881	(1999) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 937	(1997) Grout Fluidifier for Preplaced-Aggregate Concrete
ASTM C 940	(1998a) Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C 989	(1999) Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM C 1017/C 1017M	(1998) Chemical Admixtures for Use in Producing Flowing

Concrete

ASTM C 1059	(1999) Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C 1064/C 1064M	(1999) Temperature of Freshly Mixed Portland Cement Concrete
ASTM C 1077	(1998) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1107	(1999) Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C 1116	(2000) Fiber-Reinforced Concrete and Shotcrete
ASTM C 1240	(2000) Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar and Grout
ASTM D 75	(1987; R 1997) Sampling Aggregates
ASTM D 1751	(1999) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R 1996el) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM E 96	(2000) Water Vapor Transmission of Materials
ASTM E 1155	(1996) Determining Floor Flatness and Levelness Using the F-Number System
ASTM E 1155M	(1996) Determing Floor Flatness and Levelness Using the F-Number System (Metric)

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 94	(1995) Surface Retarders
COE CRD-C 104	(1980) Method of Calculation of the Fineness Modulus of Aggregate
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 540	(1971; R 1981) Standard Specification for Nonbituminous Inserts for Contraction Joints in Portland Cement Concrete Airfield Pavements, Sawable Type
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstop

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(1997) NIST Handbook 44: Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring

Devices

NATIONAL READY-MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(1996) Concrete Plant Standards
NRMCA TMMB 100	(1994) Truck Mixer Agitator and Front Discharge Concrete Carrier Standards
NRMCA QC 3	(1984) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

KOREAN INDUSTRIAL STANDARDS (KS)

KS A 1552	(1997) Jute Bag
KS F 2402	(1979) Testing Method for Slump of Portland Cement Concrete
KS F 2405	(1997) Method of Test for Compressive Strength of Concrete
KS F 2408	(1995) Method Of Test For Flexural Strength Of Concrete (Using Simple Beam With Third-Point Loading)
KS F 2526	(1997) Concrete Aggregate
KS F 2527	(1997) Crushed Aggregate for Concrete
KS F 2534	(1997) Light Weight Aggregate for Structural Concrete
KS F 2540	(1974) Liquid Membrane-Forming Compounds for Curing Concrete
KS F 2560	(1997) Chemical Admixture for Concrete
KS F 4007	(1982) Sheet Materials for Curing Concrete
KS F 4009	(1999) Ready Mixed Concrete
KS L 5201	(1989) Portland Cement
KS L 5204	(1987) White Portland Cement
KS L 5210	(1986) Portland Blast-Furnace Slag Cement
KS L 5211	(1997) Portland Fly-Ash Cement
KS L 5401	(1997) Portland Pozzolan Cement
KS L 5405	(1997) Fly Ash
KS L 5508	(1997) Fly Ash and Other Pozzolans for Use with Lime
KS M 3808	(1997) Form Polystyrene Thermal Insulation Material
KS M 3809	(1997) Thermal Insulation Material Made of Rigid Urethane Foam

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Mixture Proportions; G.

The results of trial mixture design studies along with a statement giving the maximum nominal coarse aggregate size and the proportions of ingredients that will be used in the manufacture of each strength or class of concrete, at least 14 days prior to commencing concrete placing operations. Aggregate weights shall be based on the saturated surface dry condition. The statement shall be accompanied by test results from an approved independent commercial testing laboratory, showing that mixture design studies have been made with materials proposed for the project and that the proportions selected will produce concrete of the qualities indicated. No substitutions shall be made in the materials used in the mixture design studies without additional tests to show that the quality of the concrete is satisfactory.

Lightweight Aggregate Concrete; G.

Written recommendations from lightweight aggregate supplier on batching and mixing cycles.

Dry Shake Finish; G.

Manufacturer's written instructions on application of dry shake material 15 days prior to start of construction.

SD-04 Samples

Surface Retarder; G.

Sample of surface retarder material with manufacturer's instructions for application in conjunction with air-water cutting.

SD-06 Test Reports

Testing and Inspection for Contractor Quality Control; G.

Certified copies of laboratory test reports, including mill tests and all other test data, for portland cement, blended cement, pozzolan, ground granulated blast furnace slag, silica fume, aggregate, admixtures, and curing compound proposed for use on this project.

SD-07 Certificates

Qualifications; G.

Written documentation for Contractor Quality Control personnel.

1.3 GENERAL REQUIREMENTS

1.3.1 Tolerances

Except as otherwise specified herein, tolerances for concrete batching, mixture properties, and construction as well as definition of terms and application practices shall be in accordance with ACI 117/117R. Level and grade tolerance measurements of slabs shall be made as soon as possible after finishing; when forms or shoring are used, the measurements shall be made prior to removal.

1.3.1.1 Floors

For the purpose of this Section the following terminology correlation between ACI 117/117R and this Section shall apply:

Floor Profile Quality Classification From ACI 117/117R	This Section
Conventional Bullfloated	Same
Conventional Straightedged	Same
Flat	Float Finish or Trowel Finish
Very Flat	Same. Use only with F-system

Levelness tolerance shall not apply where design requires floors to be sloped to drains or sloped for other reasons.

1.3.1.2 Floors by the Straightedge System

The flatness of the floors shall be carefully controlled and the tolerances shall be measured by the straightedge system as specified in paragraph 4.5.7 of ACI 117/117R, using a 3 m (10 foot) straightedge, within 72 hours after floor slab installation and before shores and/or forms are removed. Tolerances shall be met at any and every location at which the straightedge can be placed.

1.3.2 Strength Requirements and w/c Ratio

1.3.2.1 Strength Requirements

Specified compressive strength (f'c) shall be as follows:

COMPRESSIVE STRENGTH	STRUCTURE OR PORTION OF STRUCTURE
27.5 MPa (4000 psi) at 28 days	containers for liquids, and in other structures where loading, durability, or wear requirements dictate
20 MPa (3000 psi) at 28 days	most building work

Concrete slabs on-grade shall have a 28-day flexural strength of 4.5 MPa.(650 psi.) Concrete made with high-early strength cement shall have a 7-day strength equal to the specified 28-day strength for concrete made with Type I or II portland cement. Compressive strength shall be determined in accordance with ASTM C 39/C 39M or KS F 2405. Flexural strength shall be determined in accordance with ASTM C 78 or KS F 2408.

a. Evaluation of Concrete Compressive Strength. Compressive strength specimens (152 by 305 mm (6 by 12 inch) cylinders) shall be fabricated by the Contractor and laboratory cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39/C 39M or KS F 2405. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result falls below the specified strength f'c by more than 3.5 MPa. (500 psi.) A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test. Additional analysis or testing, including taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

b. Investigation of Low-Strength Compressive Test Results. When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than 3.5 MPa (500 psi) or if tests of field-cured cylinders indicate deficiencies in protection and curing, steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. When the strength of concrete in place is considered potentially deficient, cores shall be obtained and tested in accordance with ASTM C 42/C 42M. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the strength of the structure. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and if no single core is less than 75 percent of the specified strength requirement. Non-destructive tests (tests other than test cylinders or cores) shall not be used as a basis for acceptance or rejection. The Contractor shall perform the coring and repair the holes. Cores will be tested by the Government.

c. Load Tests. If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be directed by the Contracting Officer in accordance with the requirements of ACI 318/318R. Concrete work evaluated by structural analysis or by results of a load test as being understrength shall be corrected in a manner satisfactory to the Contracting Officer. All investigations, testing, load tests, and correction of deficiencies shall be performed by and at the expense of the Contractor and must be approved by the Contracting Officer, except that if all concrete is found to be in compliance with the drawings and specifications, the cost of investigations, testing, and load tests will be at the expense of the Government.

d. Evaluation of Concrete Flexural Strength. Flexural strength specimens (beams) shall be fabricated by the Contractor and laboratory cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 78 or KS F 2408. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified flexural strength and no individual test result falls below the specified flexural strength by more than 350 kPa. (50 psi.) A "test" is defined as the average of two companion beams. Additional analysis or testing, including taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the slab is considered potentially deficient.

1.3.2.2 Water-Cement Ratio

Maximum water-cement ratio (w/c) for normal weight concrete shall be in accordance with EM 1110-2-2000. These w/c's may cause higher strengths than that required above for compressive or flexural strength. The maximum w/c required will be the equivalent w/c as determined by conversion from the weight ratio of water to cement plus pozzolan, silica fume, and ground granulated blast furnace slag (GGBF slag) by the weight equivalency method as described in ACI 211.1. In the case where silica fume or GGBF slag is used, the weight of the silica fume and GGBF slag shall be included in the equations of ACI 211.1 for the term P which is used to denote the weight of pozzolan.

1.3.3 Air Entrainment

Except as otherwise specified for lightweight concrete, all normal weight concrete shall be air entrained to contain between 4 and 7 percent total air, except that when the nominal maximum size coarse aggregate is 19 mm (3/4 inch) or smaller it shall be between 4.5 and 7.5 percent. Concrete with specified strength over 35 MPa (5000 psi) may have 1.0 percent less air than specified above. Specified air content shall be attained at point of placement into the forms. Air content for normal weight concrete shall be determined in accordance with ASTM C 231

1.3.4 Slump

Slump of the concrete, as delivered to the point of placement into the forms, shall be within the following limits. Slump shall be determined in accordance with ASTM C 143/C 143M or KS F 2402.

Structural Element	Slump Minimum	Slump Maximum
Walls, columns and beams	50 mm (2 in.)	100 mm (4 in.)
Foundation walls, substructure walls, footings, slabs	25 mm (1 in.)	75 mm (3 in.)
Any structural concrete approved for placement by pumping:		
At pump	50 mm (2 in.)	150 mm (6 in.)
At discharge of line	25 mm (1 in.)	100 mm (4 in.)

When use of a plasticizing admixture conforming to ASTM C 1017/C 1017M or when a Type F or G high range water reducing admixture conforming to ASTM C 494/C 494M is permitted to increase the slump of concrete, concrete shall have a slump of 50 to 100 mm (2 to 4 inches) before the admixture is added and a maximum slump of 200 mm (8 inches) at the point of delivery after the admixture is added. For troweled floors, slump of structural lightweight concrete with normal weight sand placed by pump shall not exceed 125 mm (5 inches) at the point of placement. For other slabs, slump of lightweight concrete shall not exceed 100 mm (4 inches) at point of placement.

1.3.5 Concrete Temperature

The temperature of the concrete as delivered shall not exceed 32 degrees C. (90 degrees F.) When the ambient temperature during placing is 5 degrees C (40 degrees F) or less, or is expected to be at any time within 6 hours after placing, the temperature of the concrete as delivered shall be between 12 and 25 degrees C. (55 and 75 degrees F.)

1.3.6 Size of Coarse Aggregate

The largest feasible nominal maximum size aggregate (NMSA) specified in paragraph AGGREGATES shall be used in each placement. However, nominal maximum size of aggregate shall not exceed any of the following: three-fourths of the minimum cover for reinforcing bars, three-fourths of the minimum clear spacing between reinforcing bars, one-fifth of the narrowest dimension between sides of forms, or one-third of the thickness of slabs or toppings.

1.3.7 Special Properties and Products

Concrete may contain admixtures other than air entraining agents, such as water reducers, superplasticizers, or set retarding agents to provide special properties to the concrete, if specified or approved. Any of these materials to be used on the project shall be used in the mix design studies.

1.4 MIXTURE PROPORTIONS

Concrete shall be composed of portland cement, other cementitious and pozzolanic materials as specified, aggregates, water and admixtures as specified.

1.4.1 Proportioning Studies for Normal Weight Concrete

Trial design batches, mixture proportioning studies, and testing requirements for various classes and types of concrete specified shall be the responsibility of the Contractor. Except as specified for flexural strength concrete, mixture proportions shall be based on compressive strength as determined by test specimens fabricated in accordance with ASTM C 192/C 192M and tested in accordance with ASTM C 39/C 39M or KS F 2405. Samples of all materials used in mixture proportioning studies shall be representative of those proposed for use in the project and shall be accompanied by the manufacturer's or producer's test reports indicating compliance with these specifications. Trial mixtures having proportions, consistencies, and air content suitable for the work shall be made based on methodology described in ACI 211.1, using at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required on the project. The maximum water-cement ratios required in subparagraph Water-Cement Ratio will be the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement plus pozzolan, silica fume, and ground granulated blast furnace slag (GGBF slag) by the weight equivalency method as described in ACI 211.1. In the case where silica fume or GGBF slag is used, the weight of the silica fume and GGBF slag shall be included in the equations in ACI 211.1 for the term P, which is used to denote the weight of pozzolan. If pozzolan is used in the concrete mixture, the minimum pozzolan content shall be 15 percent by weight of the total cementitious material, and the maximum shall be 35 percent. Laboratory trial mixtures shall be designed for maximum permitted slump and air content. Separate sets of trial mixture studies shall be made for each combination of cementitious materials and each combination of admixtures proposed for use. No combination of either shall be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerator or a retarder may be used without separate trial mixture study. Separate trial mixture studies shall also be made for concrete for any conveying or placing method proposed which requires special properties and for concrete to be placed in unusually difficult placing locations. The temperature of concrete in each trial batch shall be reported. For each water-cement ratio, at least three test cylinders for each test age shall be made and cured in accordance with ASTM C 192/C 192M. They shall be tested at 7 and 28 days in accordance with ASTM C 39/C 39M or KS F 2405. From these test results, a curve shall be plotted showing the relationship between water-cement ratio and strength for each set of trial mix studies. In addition, a curve shall be plotted showing the relationship between 7 day and 28 day strengths. Each mixture shall be designed to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.

1.4.2 Proportioning Studies for Flexural Strength Concrete

Trial design batches, mixture proportioning studies, and testing requirements shall conform to the requirements specified in paragraph Proportioning Studies for Normal Weight Concrete, except that proportions shall be based on flexural strength as determined by test specimens (beams) fabricated in accordance with ASTM C 192/C 192M and tested in accordance with ASTM C 78 or KS F 2408. Procedures given in ACI 211.1 shall be modified as necessary to accommodate flexural strength.

1.4.3 Average Compressive Strength Required for Mixtures

The mixture proportions selected during mixture design studies shall produce a required average compressive strength (f'cr) exceeding the specified compressive strength (f'c) by the amount indicated below. This required average compressive strength, f'cr, will not be a required acceptance criteria during concrete production. However, whenever the daily average compressive strength at 28 days drops below f'cr during concrete production, or daily average 7-day strength drops below a strength correlated with the 28-day f'cr, the mixture shall be adjusted, as approved, to bring the daily average back up to f'cr. During production, the required f'cr shall be adjusted, as appropriate, based on the standard deviation being attained on the job.

1.4.3.1 Computations from Test Records

Where a concrete production facility has test records, a standard deviation shall be established in accordance with the applicable provisions of ACI 214.3R. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected; shall represent concrete produced to meet a specified strength or strengths (f'c) within 7 MPa (1,000 psi) of that specified for proposed work; and shall consist of at least 30 consecutive tests. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days. Required average compressive strength f'cr used as the basis for selection of concrete proportions shall be the larger of the equations that follow using the standard deviation as determined above:

f'cr = f'c + 1.34S where units are in MPa

f'cr = f'c + 2.33S - 3.45 where units are in MPa

f'cr = f'c + 1.34S where units are in psi

f'cr = f'c + 2.33S - 500 where units are in psi

Where S = standard deviation

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS	MODIFICATION FACTOR FOR STANDARD DEVIATION
15	1.16
20	1.08
25	1.03
30 or more	1.00

1.4.3.2 Computations without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength f'cr shall be determined as follows:

a. If the specified compressive strength f'c is less than 20 MPa, (3,000 psi,): f'cr = f'c + 6.9 MPa (f'cr = f'c + 1000 psi)

b. If the specified compressive strength f'c is 20 to 35 MPa, (3,000 to 5,000 psi,): f'cr = f'c + 8.3 MPa (f'cr = f'c + 1,200 psi)

c. If the specified compressive strength f'c is over 35 MPa, (5,000 psi,): f'cr = f'c + 9.7 MPa (f'cr = f'c + 1,400 psi)

1.4.4 Average Flexural Strength Required for Mixtures

The mixture proportions selected during mixture design studies for flexural strength mixtures and the mixture used during concrete production shall be designed and adjusted during concrete production as approved, except that the overdesign for average flexural strength shall simply be 15 percent greater than the specified flexural strength at all times.

1.4.5 Mix Design for Bonded Topping for Heavy Duty Floors

The concrete mix design for bonded topping for heavy duty floors shall contain the greatest practical proportion of coarse aggregate within the specified proportion limits. The mix shall be designed to produce concrete having a 28-day strength of at least 34.5 MPa. (5000 psi.) Concrete for the topping shall consist of the following proportions, by weight:

1.00 part portland cement
1.15 to 1.25 parts fine aggregate
1.80 to 2.00 parts coarse aggregate

Maximum w/c shall be 0.33. The topping concrete shall not be air-entrained. The concrete shall be mixed so as to produce a mixture of the driest consistency possible to work with a sawing motion of the strike-off and which can be floated and compacted as specified without producing water or excess cement at the surface. In no case shall slump exceed 25 mm (1 inch) as determined by ASTM C 143/C 143M.

1.5 STORAGE OF MATERIALS

Cement and other cementitious materials shall be stored in weathertight buildings, bins, or silos which will exclude moisture and contaminants and keep each material completely separated. Aggregate stockpiles shall be arranged and used in a manner to avoid excessive segregation and to prevent contamination with other materials or with other sizes of aggregates. Aggregate shall not be stored directly on ground unless a sacrificial layer is left undisturbed. Reinforcing bars and accessories shall be stored above the ground on platforms, skids or other supports. Other materials shall be stored in such a manner as to avoid contamination and deterioration. Admixtures which have been in storage at the project site for longer than 6 months or which have been subjected to freezing shall not be used unless retested and proven to meet the specified requirements. Materials shall be capable of being accurately identified after bundles or containers are opened.

1.6 GOVERNMENT ASSURANCE INSPECTION AND TESTING

Day-to day inspection and testing shall be the responsibility of the Contractor Quality Control (CQC) staff. However, representatives of the Contracting Officer can and will inspect construction as considered appropriate and will monitor operations of the Contractor’s CQC staff. Government inspection or testing will not relieve the Contractor of any of his CQC responsibilities.

1.6.1 Materials

The Government will sample and test aggregates, cementitious materials, other materials, and concrete to determine compliance with the specifications as considered appropriate. The Contractor shall provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D

75. Other materials will be sampled from storage at the jobsite or from other locations as considered appropriate. Samples may be placed in storage for later testing when appropriate.

1.6.2 Fresh Concrete

Fresh concrete will be sampled as delivered in accordance with ASTM C 172 and tested in accordance with these specifications, as considered necessary.

1.6.3 Hardened Concrete

Tests on hardened concrete will be performed by the Government when such tests are considered necessary.

1.6.4 Inspection

Concrete operations may be tested and inspected by the Government as the project progresses. Failure to detect defective work or material will not prevent rejection later when a defect is discovered nor will it obligate the Government for final acceptance.

PART 2 PRODUCTS

2.1 CEMENTITIOUS MATERIALS

Cementitious Materials shall be portland cement, portland-pozzolan cement, portland blast-furnace slag cement, or portland cement in combination with pozzolan or ground granulated blast furnace slag or silica fume and shall conform to appropriate specifications listed below. Use of cementitious materials in concrete which will have surfaces exposed in the completed structure shall be restricted so there is no change in color, source, or type of cementitious material.

2.1.1 Portland Cement

ASTM C 150, Type I, Type II or KS L 5201. White portland cement shall be Type I, Type II or KS L 5204. White Type III shall be used only in specific areas of the structure, when approved in writing.

2.1.2 High-Early-Strength Portland Cement

ASTM C 150, Type III. Type III cement shall be used only in isolated instances and only when approved in writing.

2.1.3 Blended Cements

ASTM C 595, Type IP or KS L 5401 for Portland-Pozzolan Cement. Type IS or KS L 5210 for Portland Blast-Furnace Slag Cement.

2.1.4 Pozzolan (Fly Ash)

ASTM C 618, Class C, F or KS L 5405 with the optional requirements for multiple factor, drying shrinkage, and uniformity from Table 2A of ASTM C 618. Requirement for maximum alkalies from Table 1A of ASTM C 618 shall apply. If pozzolan is used, it shall never be less than 15 percent nor more than 35 percent by weight of the total cementitious material. Only one class of pozzolan, from a single source shall be used.

2.1.5 Ground Granulated Blast-Furnace (GGBF) Slag

ASTM C 989, Grade 120.

2.1.6 Silica Fume

Silica fume concrete shall be used where low permeability and enhanced durability are necessary and justified by additional cost, such as marine structures, other places where low permeability is needed, and severe abrasion resistance. Silica fume shall conform to ASTM C 1240. Available alkalies shall conform to the optimal limit given in Table 2 of ASTM C 1240. Silica fume may be furnished as a dry, densified material or as a slurry. In accordance with paragraph Technical Service for Specialized Concrete, the Contractor shall provide at no cost to the Government the services of a manufacturer's technical representative experienced in mixing, proportioning, placement procedures, and curing of concrete containing silica fume.

2.2 AGGREGATES

Aggregates shall conform to the following.

2.2.1 Fine Aggregate

Fine aggregate shall conform to the quality and gradation requirements of ASTM C 33, KS F 2526, or KS F 2527.

2.2.2 Coarse Aggregate

Coarse aggregate shall conform to ASTM C 33, Class 5S.

2.2.3 Lightweight Aggregate

Lightweight fine and coarse aggregate shall conform to the quality and gradation requirements of ASTM C 330 or KS F 2534. Lightweight aggregate shall be prewetted in accordance with the Manufacturer's instructions unless otherwise specified. For pumped concrete, prewetting shall be sufficient to ensure that slump loss through the pump line does not exceed 100 mm. (4 inches.)

2.2.4 Materials for Bonded Topping for Heavy Duty Floors

In addition to the requirements specified above, coarse aggregate used for this purpose shall be a well graded, hard, sound diabase, trap rock, emery, granite or other natural or manufactured aggregate having equivalent hardness and wearing qualities and shall have a percentage of loss not to exceed 30 after 500 revolutions when tested in accordance with ASTM C 131. Gradation of the aggregates when tested in accordance with ASTM C 136 shall be as follows:

<u>Coarse Aggregate</u>

Sieve Size	Cumulative Percent By Weight Passing
19 mm (3/4 in.)	100
12.5 mm (1/2 in.)	50-100
9.5 mm (3/8 in.)	25-50
4.75 mm (No. 4)	0-15
2.36 mm (No. 8)	0-8

<u>Fine Aggregate</u>

Cumulative Percent

Sieve Size	By Weight Passing
9.5 mm (3/8 in.)	100
4.75 mm (No. 4)	95-100
2.36 mm (No. 8)	65-80
1.18 mm (No. 16)	45-65
0.600 mm (No. 30)	25-45
0.300 mm (No. 50)	5-15
0.150 mm (No. 100)	0-5

2.3 CHEMICAL ADMIXTURES

Chemical admixtures, when required or permitted, shall conform to the appropriate specification listed. Admixtures shall be furnished in liquid form and of suitable concentration for easy, accurate control of dispensing.

2.3.1 Air-Entraining Admixture

ASTM C 260 or KS F 2560 and shall consistently entrain the air content in the specified ranges under field conditions.

2.3.2 Accelerating Admixture

ASTM C 494/C 494M, Type C or E, except that calcium chloride or admixtures containing calcium chloride shall not be used.

2.3.3 Water-Reducing or Retarding Admixture

ASTM C 494/C 494M, Type A, B, D or KS F 2560, except that the 6-month and 1-year compressive and flexural strength tests are waived.

2.3.4 High-Range Water Reducer

when high-range water reducing admixture is used as allowed in paragraph 1.3.4 SLUMP, high-range water reducing admixture shall comply with ASTM C 494/C 494M, Type F or G, except that the 6-month and 1-year strength requirements are waived. The admixture shall be used only when approved in writing, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan and upon performance of separate mixture design studies.

2.3.5 Surface Retarder

COE CRD-C 94.

2.3.6 Expanding Admixture

Aluminum powder type expanding admixture conforming to ASTM C 937.

2.3.7 Other Chemical Admixtures

When a plasticizing admixture is allowed in paragraph 1.3.4 SLUMP, chemical admixtures for use in producing flowing concrete shall comply with ASTM C 1017, Type I or II. These admixtures shall be used only when approved in writing, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan and upon performance of separate mixture design studies.

2.4 CURING MATERIALS

2.4.1 Impervious-Sheet

Impervious-sheet materials shall conform to ASTM C 171 or KS F 4007, type optional, except, that polyethylene sheet shall not be used.

2.4.2 Membrane-Forming Compound

Membrane-Forming curing compound shall conform to ASTM C 309, Type 1-D or 2, except that only a styrene acrylate or chlorinated rubber compound meeting Class B requirements shall be used for surfaces that are to be painted or are to receive bituminous roofing, or waterproofing, or floors that are to receive adhesive applications of resilient flooring. The curing compound selected shall be compatible with any subsequent paint, roofing, waterproofing, or flooring specified. Nonpigmented compound shall contain a fugitive dye, and shall have the reflective requirements in ASTM C 309 waived.

2.4.3 Burlap and Cotton Mat

Burlap and cotton mat used for curing shall conform to AASHTO M 182 or KS A 1552.

2.5 WATER

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water may be used if it meets the requirements of COE CRD-C 400.

2.6 NONSHRINK GROUT

Nonshrink grout shall conform to ASTM C 1107, Grade A, B or C, and shall be a commercial formulation suitable for the proposed application.

2.7 NONSLIP SURFACING MATERIAL

Nonslip surfacing material shall consist of 55 percent, minimum, aluminum oxide or silicon-dioxide abrasive ceramically bonded together to form a homogeneous material sufficiently porous to provide a good bond with portland cement paste; or factory-graded emery aggregate consisting of not less than 45 percent aluminum oxide and 25 percent ferric oxide. The aggregate shall be well graded from particles retained on the 0.600 mm (No. 30) sieve to particles passing the 2.36 mm (No. 8) sieve.

2.8 LATEX BONDING AGENT

Latex agents for bonding fresh to hardened concrete shall conform to ASTM C 1059.

2.9 EPOXY RESIN

Epoxy resins for use in repairs shall conform to ASTM C 881, Type V, Grade 2. Class as appropriate to the existing ambient and surface temperatures.

2.10 EMBEDDED ITEMS

Embedded items shall be of the size and type indicated or as needed for the application. Dovetail slots shall be galvanized steel. Hangers for suspended ceilings shall be as specified in Section 09510 ACOUSTICAL CEILINGS. Inserts for shelf angles and bolt hangers shall be of malleable iron or cast or wrought steel.

2.11 FLOOR HARDENER

Floor hardener shall be a colorless aqueous solution containing zinc silicofluoride, magnesium silicofluoride, or sodium silicofluoride. These silicofluorides can be used individually or in combination. Proprietary hardeners may be used if approved in writing by the Contracting Officer.

2.12 PERIMETER INSULATION

Perimeter insulation shall be polystyrene conforming to ASTM C 578, Type II or KS M 3808; polyurethane conforming to ASTM C 591, Type II or KS M 3809; or cellular glass conforming to ASTM C 552, Type I or IV.

2.13 VAPOR BARRIER

Vapor barrier shall be polyethylene sheeting with a minimum thickness of 0.15 mm (6 mils) or other equivalent material having a vapor permeance rating not exceeding 30 nanograms per Pascal per second per square meter (0.5 perms) as determined in accordance with ASTM E 96.

2.14 JOINT MATERIALS

2.14.1 Joint Fillers, Sealers, and Waterstops

Expansion joint fillers shall be preformed materials conforming to ASTM D 1751, ASTM or D 1752. Materials for waterstops shall be in accordance with Section 03150 EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS. Materials for and sealing of joints shall conform to the requirements of Section 07900 JOINT SEALING or 02593 COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS.

2.14.2 Contraction Joints in Slabs

Sawable type contraction joint inserts shall conform to COE CRD-C 540. Nonsawable joint inserts shall have sufficient stiffness to permit placement in plastic concrete without undue deviation from a straight line and shall conform to the physical requirements of COE CRD-C 540, with the exception of Section 3.4 "Resistance to Sawing". Plastic inserts shall be polyvinyl chloride conforming to the materials requirements of COE CRD-C 572.

2.15 DRY SHAKE FLOOR TOPPING MATERIAL

Dry shake floor topping material shall be a premixed ready-to-use dry shake. It shall be proportioned, mixed and packaged at the factory, and delivered to the jobsite in sealed, moisture resistant bags, ready to apply, finish and cure. The manufacturer of the dry shake material shall have at least 10 years experience in the manufacture of such material. Any material from a manufacturer who makes any disclaimer of the materials performance shall not be used.

PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

Before commencing concrete placement, the following shall be performed. Surfaces to receive concrete shall be clean and free from frost, ice, mud, and water. Forms shall be in place, cleaned, coated, and adequately supported, in accordance with Section 03100 STRUCTURAL CONCRETE FORMWORK. Reinforcing steel shall be in place, cleaned, tied, and adequately supported, in accordance with Section 03200 CONCRETE REINFORCEMENT. Transporting and conveying equipment shall be in-place, ready for use, clean, and free of hardened concrete and foreign material. Equipment for consolidating concrete shall be at the placing site and in proper working order. Equipment and material for curing and for protecting concrete from weather or mechanical damage shall be at the placing site, in proper working condition and in sufficient amount for the entire placement. When hot, windy conditions during concreting appear probable, equipment and material shall be at the placing site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.1 Foundations

3.1.1.1 Concrete on Earth Foundations

Earth (subgrade, base, or subbase courses) surfaces upon which concrete is to be placed shall be clean, damp, and free from debris, frost, ice, and standing or running water. Prior to placement of concrete, the foundation shall be well drained and shall be satisfactorily graded and uniformly compacted.

3.1.1.2 Preparation of Rock

Rock surfaces upon which concrete is to be placed shall be free from oil, standing or running water, ice, mud, drummy rock, coating, debris, and loose, semidetached or unsound fragments. Joints in rock shall be cleaned to a satisfactory depth, as determined by the Contracting Officer, and to firm rock on the sides. Immediately before the concrete is placed, rock surfaces shall be cleaned thoroughly by the use of air-water jets or sandblasting as specified below for Previously Placed Concrete. Rock surfaces shall be kept continuously moist for at least 24 hours immediately prior to placing concrete thereon. All horizontal and approximately horizontal surfaces shall be covered, immediately before the concrete is placed, with a layer of mortar proportioned similar to that in the concrete mixture. Concrete shall be placed before the mortar stiffens.

3.1.1.3 Excavated Surfaces in Lieu of Forms

Concrete for footings and walls may be placed directly against the soil provided the earth or rock has been carefully trimmed, is uniform and stable, and meets the compaction requirements of Section 02315 EXCAVATION, FILLING, AND BACKFILLING FOR BUILDINGS. The concrete shall be placed without becoming contaminated by loose material, and the outline of the concrete shall be within the specified tolerances.

3.1.2 Preparation of Previously Placed Concrete

Concrete surfaces to which other concrete is to be bonded shall be abraded in an approved manner that will expose sound aggregate uniformly without damaging the concrete. Laitance and loose particles shall be removed. Surfaces shall be thoroughly washed and shall be moist but without free water when concrete is placed.

3.1.3 Vapor Barrier

Vapor barrier shall be provided beneath the interior on-grade concrete floor slabs. The greatest widths and lengths practicable shall be used to eliminate joints wherever possible. Joints shall be lapped a minimum of 300 mm. (12 inches.) Torn, punctured, or damaged vapor barrier material shall be removed and new vapor barrier shall be provided prior to placing concrete. For minor repairs, patches may be made using laps of at least 300 mm. (12 inches.) Lapped joints shall be sealed and edges patched with pressure-sensitive adhesive or tape not less than 50 mm (2 inches) wide and compatible with the membrane. Vapor barrier shall be placed directly on underlying subgrade, base course, or capillary water barrier, unless it consists of crushed material or large granular material which could puncture the vapor barrier. In this case, the surface shall be choked with a light layer of sand, as approved, before placing the vapor barrier. A 50 mm (2 inch) layer of compacted, clean concrete sand (fine aggregate) shall be placed on top of the vapor barrier before placing concrete. Concrete placement shall be controlled so as to prevent damage to the vapor barrier, or any covering sand.

3.1.4 Perimeter Insulation

Perimeter insulation shall be installed at locations indicated. Adhesive shall be used where insulation is applied to the interior surface of foundation walls and may be used for exterior application.

3.1.5 Embedded Items

Before placement of concrete, care shall be taken to determine that all embedded items are firmly and securely fastened in place as indicated on the drawings, or required. Conduit and other embedded items shall be clean and free of oil and other foreign matter such as loose coatings or rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable materials to prevent the entry of concrete into voids. Welding shall not be performed on embedded metals within 300 mm (1 feet) of the surface of the concrete. Tack welding shall not be performed on or to embedded items.

3.2 CONCRETE PRODUCTION

Batch-type equipment shall be used for producing concrete. Ready-mixed concrete shall be batched, mixed, and transported in accordance with ASTM C 94/C 94M or KS F 4009, except as otherwise specified. Truck mixers or agitators shall comply with NRMCA TMMB 100. Ready-mix plant equipment and facilities shall be certified in accordance with NRMCA QC 3. Approved batch tickets shall be furnished for each load of ready-mixed concrete. Site-mixed concrete shall be produced in accordance with ACI 301, and plant shall conform to NRMCA CPMB 100.

3.3 LIGHTWEIGHT AGGREGATE CONCRETE

In addition to the requirements specified for normal weight concrete, lightweight aggregate concrete shall conform to the following. The batching and mixing cycle shall be as directed based on written recommendations from the aggregate supplier which the Contractor shall furnish. Unless otherwise directed, the mixer shall be charged with approximately 2/3 of the total mixing water and all of the aggregate. This shall be mixed for at least 1-1/2 minutes in a stationary mixer or 15 revolutions at mixing speed in a truck mixer. The remaining ingredients shall then be added and mixing continued as specified for normal weight concrete. Lightweight aggregate concrete shall not be vibrated to the extent that large particles of aggregate float to the surface. During finishing, lightweight aggregate concrete shall not be worked to the extent that mortar is driven down and lightweight coarse aggregate appears at the surface. Lightweight aggregate concrete to be pumped shall have a cement content of at least 335 kg per cubic meter. (564 lb. per cu. yd.) A field trial run of lightweight aggregate concrete placement and finishing shall be made in accordance with ACI 213R.

3.4 TRANSPORTING CONCRETE TO PROJECT SITE

Concrete shall be transported to the placing site in truck mixers or agitators.

3.5 CONVEYING CONCRETE ON SITE

Concrete shall be conveyed from transporting unit to forms as rapidly as possible and within the time interval specified by methods which will prevent segregation or loss of ingredients using concrete pump. Concrete may be conveyed by positive displacement pump when approved. The pumping equipment shall be piston or squeeze pressure type; pneumatic placing equipment shall not be used. The pipeline shall be rigid steel pipe or heavy-duty flexible hose. The inside diameter of the pipe shall be at least 3 times the nominal maximum-size coarse aggregate in the concrete mixture to be pumped but not less than 100 mm. (4 inches.) Aluminum pipe shall not be used.

3.6 PLACING CONCRETE

Mixed concrete shall be discharged within 1-1/2 hours or before the mixer drum has revolved 300 revolutions, whichever comes first after the introduction of the mixing water to the cement and aggregates. When the concrete temperature exceeds 30 degrees C, (85 degrees F,) the time shall be reduced to 45 minutes. Concrete shall be placed within 15 minutes after it has been discharged from the transporting unit. Concrete shall be handled from mixer or transporting unit to forms in a continuous manner until the approved unit of operation is completed. Adequate scaffolding, ramps and walkways shall be provided so that personnel and equipment are not supported by in-place reinforcement. Placing will not be permitted when the sun, heat, wind, or limitations of facilities furnished by the Contractor prevent proper consolidation, finishing and curing. Sufficient placing capacity shall be provided so that concrete can be kept free of cold joints.

3.6.1 Depositing Concrete

Concrete shall be deposited as close as possible to its final position in the forms, and there shall be no vertical drop greater than 1.5 meters (5 feet) except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it will be effectively consolidated in horizontal layers not more than 300 mm (12 inches) thick, except that all slabs shall be placed in a single layer. Concrete to receive other construction shall be screeded to the proper level. Concrete shall be deposited continuously in one layer or in layers so that fresh concrete is deposited on in-place concrete that is still plastic. Fresh concrete shall not be deposited on concrete that has hardened sufficiently to cause formation of seams or planes of weakness within the section. Concrete that has surface dried, partially hardened, or contains foreign material shall not be used. When temporary spreaders are used in the forms, the spreaders shall be removed as their service becomes unnecessary. Concrete shall not be placed in slabs over columns and walls until concrete in columns and walls has been in-place at least two hours or until the concrete begins to lose its plasticity. Concrete for beams, girders, brackets, column capitals, haunches, and drop panels shall be placed at the same time as concrete for adjoining slabs.

3.6.2 Consolidation

Immediately after placing, each layer of concrete shall be consolidated by internal vibrators, except for slabs 100 mm (4 inches) thick or less. The vibrators shall at all times be adequate in effectiveness and number to properly consolidate the concrete; a spare vibrator shall be kept at the jobsite during all concrete placing operations. The vibrators shall have a frequency of not less than 10,000 vibrations per minute, an amplitude of at least 0.6 mm, (0.025 inch,) and the head diameter shall be appropriate for the structural member and the concrete mixture being placed. Vibrators shall be inserted vertically at uniform spacing over the area of placement. The distance between insertions shall be approximately 1-1/2 times the radius of action of the vibrator so that the area being vibrated will overlap the adjacent just-vibrated area by a reasonable amount. The vibrator shall penetrate rapidly to the bottom of the layer and at least 150 mm (6 inches) into the preceding layer if there is such. Vibrator shall be held stationary until the concrete is consolidated and then vertically withdrawn slowly while operating. Form vibrators shall not be used unless specifically approved and unless forms are constructed to withstand their use. Vibrators shall not be used to move concrete within the forms. Slabs 100 mm (4 inches) and less in thickness shall be consolidated by properly designed vibrating screeds or other approved technique. Excessive vibration of lightweight concrete resulting in segration or flotation of coarse aggregate shall be prevented. Frequency and amplitude of vibrators shall be determined in accordance with COE CRD-C 521. Grate tampers ("jitterbugs") shall not be used.

3.6.3 Cold Weather Requirements

Special protection measures, approved by the Contracting Officer, shall be used if freezing temperatures are anticipated before the expiration of the specified curing period. The ambient temperature of the air where concrete is to be placed and the temperature of surfaces to receive concrete shall be not less than 5 degrees C. (40 degrees F.) The temperature of the concrete when placed shall be not less than 10 degrees C (50 degrees F) nor more than 25 degrees C. (75 degrees F.) Heating of the mixing water or aggregates will be required to regulate the concrete placing temperature. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals or other materials shall not be incorporated in the concrete to prevent freezing. Upon written approval, an accelerating admixture conforming to ASTM C 494/C 494M, Type C or E may be used, provided it contains no calcium chloride. Calcium chloride shall not be used.

3.6.4 Hot Weather Requirements

When the ambient temperature during concrete placing is expected to exceed 30 degrees C, (85 degrees F,) the concrete shall be placed and finished with procedures previously submitted and as specified herein. The concrete temperature at time of delivery to the forms shall not exceed the temperature shown in the table below when measured in accordance with ASTM C 1064/C 1064M. Cooling of the mixing water or aggregates or placing concrete in the cooler part of the day may be required to obtain an adequate placing temperature. A retarder may be used, as approved, to facilitate placing and finishing. Steel forms and reinforcements shall be cooled as approved prior to concrete placement when steel temperatures are greater than 49 degrees C. (120 degrees F.) Conveying and placing equipment shall be cooled if necessary to maintain proper concrete-placing temperature.

Maximum Allowable Concrete Placing Temperature

Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature Degrees
Greater than 60	33 C (90 F)
40-60	30 C (85 F)
Less than 40	27 C (80 F)

3.6.5 Prevention of Plastic Shrinkage Cracking

During hot weather with low humidity, and particularly with appreciable wind, as well as interior placements when space heaters produce low humidity, the Contractor shall be alert to the tendency for plastic shrinkage cracks to develop and shall institute measures to prevent this. Particular care shall be taken if plastic shrinkage cracking is potentially imminent and especially if it has developed during a previous placement. Periods of high potential for plastic shrinkage cracking can be anticipated by use of Fig. 2.1.5 of ACI 305R. In addition the concrete placement shall be further protected by erecting shades and windbreaks and by applying fog sprays of water, sprinkling, ponding or wet covering. Plastic shrinkage cracks that occur shall be filled by injection of epoxy resin as directed, after the concrete hardens. Plastic shrinkage cracks shall never be troweled over or filled with slurry.

3.6.6 Placing Concrete Underwater

Concrete shall be deposited in water by a tremie or concrete pump. The methods and equipment used shall be subject to approval. Concrete buckets shall not be used for underwater placement of concrete except to deliver concrete to the tremie. The tremie shall be watertight and sufficiently large to permit a free flow of concrete. The concrete shall be deposited so that it enters the mass of the previously placed concrete from within, displacing water with a minimum disturbance to the surface of the concrete. The discharge end of the pump line or tremie shaft shall be kept continuously submerged in the concrete. The underwater seal at start of placing shall not produce undue turbulence in the water. The tremie shaft shall be kept full of concrete to a point well above the water surface. Placement shall proceed without interruption until the concrete has been brought to the required height. The tremie shall not be moved horizontally during a placing operation, and a sufficient number of tremies shall be provided so that the maximum horizontal flow of concrete will be limited to 5 m. (15 feet.) Concrete shall not be deposited in running water or in water with a temperature below 2 degrees C. (35 degrees F.)

3.6.7 Placing Concrete in Congested Areas

Special care shall be used to ensure complete filling of the forms, elimination of all voids, and complete consolidation of the concrete when placing concrete in areas congested with reinforcing bars, embedded items, waterstops and other tight spacing. An appropriate concrete mixture shall be used, and the nominal maximum size of aggregate (NMSA) shall meet the specified criteria when evaluated for the congested area. Vibrators with heads of a size appropriate for the clearances available shall be used, and the consolidation operation shall be closely supervised to ensure complete and thorough consolidation at all points. Where necessary, splices of reinforcing bars shall be alternated to reduce congestion. Where two mats of closely spaced reinforcing are required, the bars in each mat shall be placed in matching alignment to reduce congestion.

3.7 JOINTS

Joints shall be located and constructed as indicated or approved. Joints not indicated on the drawings shall be located and constructed to minimize the impact on the strength of the structure. In general, such joints shall be located near the middle of the spans of supported slabs, beams, and girders unless a beam intersects a girder at this point, in which case the joint in the girder shall be offset a distance equal to twice the width of the beam. Joints in walls and columns shall be at the underside of floors, slabs, beams, or girders and at the tops of footings or floor slabs, unless otherwise approved. Joints shall be perpendicular to the main reinforcement. All reinforcement shall be continued across joints; except that reinforcement or other fixed metal items shall not be continuous through expansion joints, or through construction or contraction joints in slabs on grade. Reinforcement shall be 50 mm (2 inches) clear from each joint. Except where otherwise indicated, construction joints between interior slabs on grade and vertical surfaces shall consist of 1.5 kg per square meter (30 pound) asphalt-saturated felt, extending for the full depth of the slab. The perimeters of the slabs shall be free of fins, rough edges, spalling, or other unsightly appearance. Reservoir for sealant for construction and contraction joints in slabs shall be formed to the dimensions shown on the drawings by removing snap-out joint-forming inserts, by sawing sawable inserts, or by sawing to widen the top portion of sawed joints. Joints to be sealed shall be cleaned and sealed as indicated and in accordance with Section 07900 JOINT SEALING.

3.7.1 Construction Joints

For concrete other than slabs on grade, construction joints shall be located as indicated or approved. Concrete shall be placed continuously so that each unit is monolithic in construction. Fresh concrete shall not be placed against adjacent hardened concrete until it is at least 24 hours old. Construction joints shall be located as indicated or approved. Where concrete work is interrupted by weather, end of work shift or other similar type of delay, location and type of construction joint shall be subject to approval of the Contracting Officer. Unless otherwise indicated and except for slabs on grade, reinforcing steel shall extend through construction joints. Construction joints in slabs on grade shall be keyed or doweled as shown. Concrete columns, walls, or piers shall be in place at least 2 hours, or until the concrete begins to lose its plasticity, before placing concrete for beams, girders, or slabs thereon. In walls having door or window openings, lifts shall terminate at the top and bottom of the opening. Other lifts shall terminate at such levels as to conform to structural requirements or architectural details. Where horizontal construction joints in walls or columns are required, a strip of 25 mm (1 inch) square-edge lumber, beveled and oiled to facilitate removal, shall be tacked to the inside of the forms at the construction joint. Concrete shall be placed to a point 25 mm (1 inch) above the underside of the strip. The strip shall be removed 1 hour after the concrete has been placed, and any irregularities in the joint line shall be leveled off with a wood float, and all laitance shall be removed. Prior to placing additional concrete, horizontal construction joints shall be prepared as specified in paragraph Previously Placed Concrete.

3.7.2 Contraction Joints in Slabs on Grade

Contraction joints shall be located and detailed as shown on the drawings. Contraction Joints shall be produced by forming a weakened plane in the concrete slab by use of rigid inserts impressed in the concrete during placing operations, or by use of snap-out plastic joint forming inserts or sawing a continuous slot with a concrete saw. Regardless of method used to produce the weakened plane, it shall be 1/4 the depth of the slab thickness and between 3 and 5 mm (1/8 and 3/16 inch) wide. For saw-cut joints, cutting shall be timed properly with the set of the concrete. Cutting shall be started as soon as the concrete has hardened sufficiently to prevent raveling of the edges of the saw cut. Cutting shall be completed before shrinkage stresses become sufficient to produce cracking. Reservoir for joint sealant shall be formed as previously specified.

3.7.3 Expansion Joints

Installation of expansion joints and sealing of these joints shall conform to the requirements of Section 03150 EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS and Section 07900 JOINT SEALING.

3.7.4 Waterstops

Waterstops shall be installed in conformance with the locations and details shown on the drawings using materials and procedures specified in Section 03150 EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS.

3.7.5 Dowels and Tie Bars

Dowels and tie bars shall be installed at the locations shown on the drawings and to the details shown, using materials and procedures specified in Section

03200 CONCRETE REINFORCEMENT and herein. Conventional smooth "paving" dowels shall be installed in slabs using approved methods to hold the dowel in place during concreting within a maximum alignment tolerance of 1 mm in 100 mm. (1/8 inch in 12 inches.) "Structural" type deformed bar dowels, or tie bars, shall be installed to meet the specified tolerances. Care shall be taken during placing adjacent to and around dowels and tie bars to ensure there is no displacement of the dowel or tie bar and that the concrete completely embeds the dowel or tie bar and is thoroughly consolidated.

3.8 FINISHING FORMED SURFACES

Forms, form materials, and form construction are specified in Section 03100 STRUCTURAL CONCRETE FORMWORK. Finishing of formed surfaces shall be as specified herein. Unless another type of architectural or special finish is specified, surfaces shall be left with the texture imparted by the forms except that defective surfaces shall be repaired. Unless painting of surfaces is required, uniform color of the concrete shall be maintained by use of only one mixture without changes in materials or proportions for any structure or portion of structure that requires a Class A or B finish. Except for major defects, as defined hereinafter, surface defects shall be repaired as specified herein within 24 hours after forms are removed. Repairs of the so-called "plaster-type" will not be permitted in any location. Tolerances of formed surfaces shall conform to the requirements of ACI 117/A117R. These tolerances apply to the finished concrete surface, not to the forms themselves; forms shall be set true to line and grade. Form tie holes requiring repair and other defects whose depth is at least as great as their surface diameter shall be repaired as specified in paragraph Damp-Pack Mortar Repair. Defects whose surface diameter is greater than their depth shall be repaired as specified in paragraph Repair of Major Defects. Repairs shall be finished flush with adjacent surfaces and with the same surface texture. The cement used for all repairs shall be a blend of job cement with white cement proportioned so that the final color after curing and aging will be the same as the adjacent concrete. Concrete with excessive honeycomb, or other defects which affect the strength of the member, will be rejected. Repairs shall be demonstrated to be acceptable and free from cracks or loose or drummy areas at the completion of the contract and, for Class A and B Finishes, shall be inconspicuous. Repairs not meeting these requirements will be rejected and shall be replaced.

3.8.1 Class A Finish and Class B Finish

Class A and B finish is required where indicated on the drawings. Fins, ravelings, and loose material shall be removed, all surface defects over 12 mm (1/2 inch) in diameter or more than 12 mm (1/2 inch) deep, shall be repaired and, except as otherwise indicated or as specified in Section 03100 STRUCTURAL CONCRETE FORMWORK, holes left by removal of form ties shall be reamed and filled. Defects more than 12 mm (1/2 inch) in diameter shall be cut back to sound concrete, but in all cases at least 25 mm (1 inch) deep. The Contractor shall prepare a sample panel for approval (as specified in PART 1) before commencing repair, showing that the surface texture and color match will be attained. Metal tools shall not be used to finish repairs in Class A surfaces.

3.8.2 Class C and Class D Finish

Class C and B finish is required where indicated on the drawings. Fins, ravelings, and loose material shall be removed, and, except as otherwise indicated or as specified in Section 03100 STRUCTURAL CONCRETE FORMWORK, holes left by removal of form ties shall be reamed and filled. Honeycomb and other defects more than 12 mm (1/2 inch) deep or more than 50 mm (2 inches) in diameter shall be repaired. Defects more than 50 mm (2 inches) in diameter shall be cut back to sound concrete, but in all cases at least 25 mm (1 inch) deep.

3.8.3 Architectural and Special Finishes

Architectural concrete finishes are specified in Section 03330 CAST-IN-PLACE ARCHITECTURAL CONCRETE. Special finishes shall conform to the requirements specified herein.

3.8.3.1 Smooth Finish

After other concrete construction is complete in each overall separate contiguous area of the structure, smooth finish shall be applied to the areas indicated on the drawings. A mortar mix consisting of one part portland cement and two parts well-graded sand passing a 0.6 mm (No. 30 sieve), with water added to give the consistency of thick paint, shall be used. Where the finished surface will not receive other applied surface, white cement shall be used to replace part of the job cement to produce an approved color, which shall be uniform throughout the surfaces of the structure. After the surface has been thoroughly wetted and allowed to approach surface dryness, the mortar shall be vigorously applied to the area by clean burlap pads or by cork or wood-floating, to completely fill all surface voids. Excess grout shall be scraped off with a trowel. As soon as it can be accomplished without pulling the mortar from the voids, the area shall be rubbed with burlap pads having on their surface the same sand-cement mix specified above but without any mixing water, until all of the visible grout film is removed. The burlap pads used for this operation shall be stretched tightly around a board to prevent dishing the mortar in the voids. The finish of any area shall be completed in the same day, and the limits of a finished area shall be made at natural breaks in the surface. The surface shall be continuously moist cured for 48 hours commencing immediately after finishing operations in each area. The temperature of the air adjacent to the surface shall be not less than 10 degrees C (50 degrees F) for 24 hours prior to, and 48 hours after, the application. In hot, dry weather the smooth finish shall be applied in shaded areas or at night, and shall never be applied when there is significant hot, dry wind.

3.8.3.2 Exposed Coarse-Aggregate Finish

Coarse aggregate shall meet the specified quality requirements. Coarse aggregate shall be exposed by an approved method. The finish shall be similar to and shall closely match the finish on the sample panel put on display during the bidding period, and the finish on the approved pre-construction test panel fabricated by the Contractor.

3.8.3.3 Sandblast Finish

The concrete surface shall be blasted at an approved age with approved wet sandblasting procedures to obtain a brush, light, medium or heavy finish which will match the descriptive photographs in ACI 303R. The finish shall be similar to and shall closely match the finish on the approved pre-construction test panel fabricated by the Contractor.

3.8.3.4 Tooled Finish

The thoroughly cured concrete shall be dressed at an approved age with approved electric, air, or hand tools to a uniform texture with a hand-tooled, rough, fine-pointed, crandalled or bush-hammered surface texture. The finish shall be similar to and shall closely match the finish on the approved pre-construction test panel fabricated by the Contractor.

3.9 REPAIRS

3.9.1 Damp-Pack Mortar Repair

Form tie holes requiring repair and other defects whose depth is at least as great as their surface diameter but not over 100 mm (4 inches) shall be repaired by the damp-pack mortar method. Form tie holes shall be reamed and other similar defects shall be cut out to sound concrete. The void shall then be thoroughly cleaned, thoroughly wetted, brush-coated with a thin coat of neat cement grout and filled with mortar. Mortar shall be a stiff mix of 1 part portland cement to 2 parts fine aggregate passing the 1.18 mm (No. 16 mesh) sieve, and minimum amount of water. Only sufficient water shall be used to produce a mortar which, when used, will stick together on being molded into a ball by a slight pressure of the hands and will not exude water but will leave the hands damp. Mortar shall be mixed and allowed to stand for 30 to 45 minutes before use with remixing performed immediately prior to use. Mortar shall be thoroughly tamped in place in thin layers using a hammer and hardwood block. Holes passing entirely through walls shall be completely filled from the inside face by forcing mortar through to the outside face. All holes shall be packed full. Damp-pack repairs shall be moist cured for at least 48 hours.

3.9.2 Repair of Major Defects

Major defects will be considered to be those more than 12 mm (1/2 inch) deep or, for Class A and B finishes, more than 12 mm (1/2 inch) in diameter and, for Class C and D finishes, more than 50 mm (2 inches) in diameter. Also included are any defects of any kind whose depth is over 100 mm (4 inches) or whose surface diameter is greater than their depth. Major defects shall be repaired as specified below.

3.9.2.1 Surface Application of Mortar Repair

Defective concrete shall be removed, and removal shall extend into completely sound concrete. Approved equipment and procedures which will not cause cracking or microcracking of the sound concrete shall be used. If reinforcement is encountered, concrete shall be removed so as to expose the reinforcement for at least 50 mm (2 inches) on all sides. All such defective areas greater than 7800 square mm (12 square inches) shall be outlined by saw cuts at least 25 mm (1 inch) deep. Defective areas less than 7800 square mm (12 square inches) shall be outlined by a 25 mm (1 inch) deep cut with a core drill in lieu of sawing. All saw cuts shall be straight lines in a rectangular pattern in line with the formwork panels. After concrete removal, the surface shall be thoroughly cleaned by high pressure washing to remove all loose material. Surfaces shall be kept continually saturated for the first 12 of the 24 hours immediately before placing mortar and shall be damp but not wet at the time of commencing mortar placement. The Contractor, at his option, may use either hand-placed mortar or mortar placed with a mortar gun. If hand-placed mortar is used, the edges of the cut shall be perpendicular to the surface of the concrete. The prepared area shall be brush-coated with a thin coat of neat cement grout. The repair shall then be made using a stiff mortar, preshrunk by allowing the mixed mortar to stand for 30 to 45 minutes and then remixed, thoroughly tamped into place in thin layers. If hand-placed mortar is used, the Contractor shall test each repair area for drumminess by firm tapping with a hammer and shall inspect for cracks, both in the presence of the Contracting Officer's representative, immediately before completion of the contract, and shall replace any showing drumminess or cracking. If mortar placed with a mortar gun is used, the gun shall be a small compressed air-operated gun to which the mortar is slowly hand fed and which applies the mortar to the surface as a high-pressure stream, as approved. Repairs made using shotcrete equipment will not be accepted. The mortar used shall be the same mortar as specified for damp-pack mortar repair. If gun-placed mortar is used, the edges of the cut shall be beveled toward the center at a slope of 1:1. All surface applied mortar repairs shall be continuously moist cured for at least 7 days. Moist curing shall consist of several layers of saturated burlap applied to the surface immediately after placement is complete and covered with polyethylene sheeting, all held closely in place by a sheet of plywood or similar material rigidly braced against it. Burlap shall be kept continually wet.

3.9.2.2 Repair of Deep and Large Defects

Deep and large defects will be those that are more than 150 mm (6 inches) deep and also have an average diameter at the surface more than 450 mm (18 inches) or that are otherwise so identified by the Project Office. Such defects shall be repaired as specified herein or directed, except that defects which affect the strength of the structure shall not be repaired and that portion of the structure shall be completely removed and replaced. Deep and large defects shall be repaired by procedures approved in advance including forming and placing special concrete using applied pressure during hardening. Preparation of the repair area shall be as specified for surface application of mortar. In addition, the top edge (surface) of the repair area shall be sloped at approximately 20 degrees from the horizontal, upward toward the side from which concrete will be placed. The special concrete shall be a concrete mixture with low water content and low slump, and shall be allowed to age 30 to 60 minutes before use. Concrete containing a specified expanding admixture may be used in lieu of the above mixture; the paste portion of such concrete mixture shall be designed to have an expansion between 2.0 and 4.0 percent when tested in accordance with ASTM C 940. A full width "chimney" shall be provided at the top of the form on the placing side to ensure filling to the top of the opening. A pressure cap shall be used on the concrete in the chimney with simultaneous tightening and revibrating the form during hardening to ensure a tight fit for the repair. The form shall be removed after 24 hours and immediately the chimney shall be carefully chipped away to avoid breaking concrete out of the repair; the surface of the repair concrete shall be dressed as required.

3.9.3 Resinous and Latex Material Repair

In lieu of the portland cement bonding coats or based mortars specified above, an epoxy resin mortar based on epoxy resin or a mortar based on latex bonding agent may be used.

3.10 FINISHING UNFORMED SURFACES

The finish of all unformed surfaces shall meet the requirements of paragraph Tolerances in PART 1, when tested as specified herein.

3.10.1 General

The ambient temperature of spaces adjacent to unformed surfaces being finished and of the base on which concrete will be placed shall be not less than 10 degrees C. (50 degrees F.) In hot weather all requirements of paragraphs Hot Weather Requirements and Prevention of Plastic Shrinkage Cracking shall be met. Unformed surfaces that are not to be covered by additional concrete or backfill shall have a float finish, with additional finishing as specified below, and shall be true to the elevation shown on the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown on the drawings, properly consolidated, and left true and regular. Unless otherwise shown on the drawings, exterior surfaces shall be sloped for drainage, as directed. Where drains are provided, interior floors shall be evenly sloped to the drains. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. Grate tampers or "jitterbugs" shall not be used for any surfaces. The dusting of surfaces with dry cement or other materials or the addition of any water during finishing shall not be permitted. If bleedwater is present prior to finishing, the excess water shall be carefully dragged off or removed by absorption with porous materials such as burlap. During finishing operations, extreme care shall be taken to prevent over finishing or working water into the surface; this can cause "crazing" (surface shrinkage cracks which appear after hardening) of the surface. Any slabs with surfaces which exhibit significant crazing shall be removed and replaced. During finishing operations, surfaces shall be checked with a 10 foot straightedge, applied in both directions at regular intervals while the concrete is still plastic, to detect high or low areas.

3.10.2 Rough Slab Finish

Rough-slab finish alone is used when a bonded surface course for heavy use industrial floor is specified, or where roof fill or thick mortar setting bed is used. Rough slab finish must be retained as the first operation for all subsequent finishing. As a first finishing operation for unformed surfaces and as final finish for slabs to receive mortar setting beds, the surface shall receive a rough slab finish prepared as follows. Areas indicated on the drawings shall receive only a rough slab finish. The concrete shall be uniformly placed across the slab area, consolidated as previously specified, and then screeded with straightedge strikeoffs immediately after consolidation to bring the surface to the required finish level with no coarse aggregate visible. Side forms and screed rails shall be provided, rigidly supported, and set to exact line and grade. Allowable tolerances for finished surfaces apply only to the hardened concrete, not to forms or screed rails. Forms and screed rails shall be set true to line and grade. "Wet screeds" shall not be used.

3.10.3 Floated Finish

Slabs to receive more than a rough slab finish shall next be given a wood float finish. Areas as indicated on the drawings shall be given only a float finish. The screeding shall be followed immediately by darbying or bull floating before bleeding water is present, to bring the surface to a true, even plane. Then, after the concrete has stiffened so that it will withstand a man's weight without imprint of more than 6 mm (1/4 inch) and the water sheen has disappeared, it shall be floated to a true and even plane free of ridges. Floating shall be performed by use of suitable hand floats or power driven equipment. Sufficient pressure shall be used on the floats to bring a film of moisture to the surface. Hand floats shall be made of wood, magnesium, or aluminum. Lightweight concrete or concrete that exhibits stickiness shall be floated with a magnesium float. Care shall be taken to prevent over-finishing or incorporating water into the surface.

3.10.4 Troweled Finish

Areas as indicated on the drawings shall be given a trowel finish. After floating is complete and after the surface moisture has disappeared, unformed surfaces shall be steel-troweled to a smooth, even, dense finish, free from blemishes including trowel marks. In lieu of hand finishing, an approved power finishing machine may be used in accordance with the directions of the machine manufacturer. Additional trowelings shall be performed, either by hand or machine until the surface has been troweled 3 times, with waiting period between each. Care shall be taken to prevent blistering and if such occurs, troweling shall immediately be stopped and operations and surfaces corrected. A final hard steel troweling shall be done by hand, with the trowel tipped, and using hard pressure, when the surface is at a point that the trowel will produce a ringing sound. The finished surface shall be thoroughly consolidated and shall be essentially free of trowel marks and be uniform in texture and appearance. The concrete mixture used for troweled finished areas shall be adjusted, if necessary, in order to provide sufficient fines (cementitious material and fine sand) to finish properly.

3.10.5 Superflat Finish

Areas as indicated on the drawings shall be constructed as superflat floors. Extreme care shall be taken to meet specified tolerances. If necessary, special heavy duty, laser guided machines built especially for this work shall be used and shall have experienced, factory-trained operators. Finishing operations shall include use of long-handled 3 meter (10 foot) "highway type" cutting straightedges plus any other tools necessary to meet the surface tolerance requirements. Surface finish shall conform to paragraph Troweled Finish.

3.10.6 Non-Slip Finish

Non-slip floors shall be constructed in accordance with the following subparagraphs.

3.10.6.1 Broomed

Areas as indicated on the drawings shall be given a broomed finish. After floating, the surface shall be lightly steel troweled, and then carefully scored by pulling a hair or coarse fiber push-type broom across the surface. Brooming shall be transverse to traffic or at right angles to the slope of the slab. After the end of the curing period, the surface shall be vigorously broomed with a coarse fiber broom to remove all loose or semi-detached particles.

3.10.6.2 Abrasive Aggregate

Areas as indicated on the drawings shall be given an abrasive aggregate finish. The concrete surface shall be given a float finish. Abrasive aggregate shall then immediately be uniformly sprinkled over the floated surface at a total rate of not less than 1.25 kg per square meter (0.25 psf) spread in two applications at right angles to each other. The surface shall then be troweled to a smooth, even finish that is uniform in texture and appearance and free from blemishes including trowels marks. Immediately after curing, cement paste and laitance covering the abrasive aggregate shall be removed by steel brushing, rubbing with abrasive stone, or sandblasting to expose the abrasive particles.

3.10.7 Dry Shake Finish

Areas as indicated on the drawings shall be constructed with a dry shake finish. Dry shake floor armoring topping, dry shake conductive and spark resistant floor topping or dry shake non-metallic, light reflective floor topping shall be used to surface the floor. The base slab shall be constructed and the dry shake material applied in accordance with the manufacturer's written instructions, which shall be furnished by the Contractor. The dry shake material shall be applied in a two-stage application. Total application shall be at the rate recommended by the manufacturer but at a rate not less than 7.5 kg per square meter. (1.5 psf.) The first application shall be at the rate of two-thirds of the total and shall be applied immediately following floating of total area. The dry shake material shall first be applied to the floated concrete adjacent to forms, entryways, columns, and walls where moisture will be lost first. Dry shake material shall be distributed evenly using an approved mechanical spreader. The material shall not be hand thrown on the surface. Finishing machines with float shoes shall be used as soon as dry shake has absorbed moisture (indicated by darkening of surface); floating shall be done just sufficiently to bring moisture from base slab through the shake. Immediately following floating of the first shake, the remaining one-third of the total specified shake shall be applied in the same manner and machine floated. Surface shall be further compacted by a third mechanical floating if time and setting characteristics will allow. At no time shall water be added to the surface. As surface further stiffens, indicated by loss of sheen, it shall be hand or mechanically troweled with blades relatively flat. All marks and pinholes shall be removed in the final raised trowel operation. Floors finished with dry shake material shall be cured using a curing compound recommended by the manufacturer of the dry shake material. Membrane curing compound shall be applied immediately after the floor surface has hardened sufficiently so surface will not be marred by the application. Compound shall be applied uniformly over the entire surface at a coverage which will provide moisture retention in excess of the requirements of ASTM C 309. When dry, the coating shall be protected from droppings of plaster, paint, dirt, and other debris by a covering of scuffproof, non-staining building paper. Floor shall remain covered and be kept free of traffic and loads for at least 10 days after completion. Adequate provision shall be made for maintaining the concrete temperature at 10 degrees C (50 degrees F) or above during the curing period. The curing compound shall remain in place for not less than 30 days. The curing compound shall be removed by a manufacturer recommended method prior to turning the facility over to the Government.

3.10.8 Heavy Duty Floors

Areas as indicated on the drawings shall have heavy duty floors constructed as follows:

3.10.8.1 General

Heavy duty floor shall be constructed by placing a heavy duty bonded topping on a base slab which has had a rough slab finish left 50 mm (2 inches) below final grade. Concrete in the base slab shall be thoroughly hardened but not more than 30 hours old. The temperature of the fresh concrete topping shall not vary more than 5 degrees C (10 degrees F) plus or minus from the temperature of the base slab. The ambient temperature of the space adjacent to the concrete placement and of the base slab shall be between 10 and 30 degrees C. (50 and 90 degrees F.)

3.10.8.2 Preparation of Base Slab

The base slab shall be kept continuously damp until topping is placed. The surface of the base slab shall be thoroughly cleaned with an air-water jet immediately before placing the topping. A thin coat of neat cement grout of about the consistency of thick cream shall be thoroughly scrubbed into the existing surface immediately ahead of the overlay placing. At the time the neat cement grout is placed, the existing concrete surface shall be damp but shall have no free water present. The overlay concrete shall be deposited before the grout coat has had time to stiffen.

3.10.8.3 Placing and Finishing

Concrete shall be placed, as nearly as practicable in final position, in accordance with uniform layer. The overlay shall be placed and screeded slightly above the required finished grade, compacted by rolling with rollers weighing not less than 4.5 kg (10 pounds) per linear 25 mm (1 inch) of roller width or by approved tamping equipment and finish screeded to established grade. Grid type tampers shall not be used. The concrete, while still green but sufficiently hardened to bear a person's weight without deep imprint, shall be floated to a true even plane with no coarse aggregate visible. Floating shall be performed with an approved disc-type mechanical float which has integral impact mechanism. The surface of the overlay shall then be left undisturbed until the concrete has hardened enough to prevent excess fines from being worked to the top. Joints shall be formed to match those in the base slab.

3.10.8.4 Curing and Protection

Concrete shall be maintained in a moist condition and shall be protected against rapid temperature change, mechanical injury, and injury from rain or flowing water, for a curing period of not less than 10 days. Concrete shall be maintained in a moist condition at temperatures above 10 and below 30 degrees C (above 50 and below 90 degrees F) throughout the specified curing period. Concrete shall be protected from a temperature change greater than 3 degrees C (5 degrees F) per hour and from rapid drying for the first 24 hours following the removal of temperature protection. Curing activities shall begin as soon as free water has disappeared from the concrete surface after placing and finishing. Curing shall be moist curing accomplished by the following method. Surfaces shall be covered with a double layer of burlap, wetted before placing, and overlapped at least 150 mm. (6 inches.) Burlap shall be kept continually wet and in intimate contact with the surface. Burlap shall be kept covered with a polyethylene sheeting at least 0.1 mm (4 mils) thick. All traffic shall be kept from the floor during the curing period and heavy traffic shall be kept off till 28-day age.

3.11 FLOOR HARDENER

Areas as indicated on the drawings, where extreme dust-free area or where requested by using agency shall be treated with floor hardener. Floor hardener shall be applied after the concrete has been cured and then air dried for 14 days. Unless manufacturer’s instruction, three coats shall be applied, each the day after the preceding coat was applied. For the first application, 0.5 kg (one pound) of the silocofluoride shall be dissolved in 4 liters (one gallon) of water. For subsequent applications, the solution shall be 1.0 kg (two pounds) of silicofluoride to each 4 liters (gallon) of water. Floor should be mopped with clear water shortly after the preceding application has dried to remove encrusted salts. Proprietary hardeners shall be applied in accordance with the manufacturer's instructions. During application, area should be well ventilated. Precautions shall be taken when applying silicofluorides due to the toxicity of the salts. Any compound that contacts glass or aluminum should be immediately removed with clear water.

3.12 EXTERIOR SLAB AND RELATED ITEMS

3.12.1 Pavements

Pavements shall be constructed where shown on the drawings. After forms are set and underlying material prepared as specified, the concrete shall be placed uniformly throughout the area and thoroughly vibrated. As soon as placed and vibrated, the concrete shall be struck off and screeded to the crown and cross section and to such elevation above grade that when consolidated and finished, the surface of the pavement will be at the required elevation. The entire surface shall be tamped with the strike off, or consolidated with a vibrating screed, and this operation continued until the required compaction and reduction of internal and surface voids are accomplished. Care shall be taken to prevent bringing excess paste to the surface. Immediately following the final consolidation of the surface, the pavement shall be floated longitudinally from bridges resting on the side forms and spanning but not touching the concrete. If necessary, additional concrete shall be placed and screeded, and the float operated until a satisfactory surface has been produced. The floating operation shall be advanced not more than half the length of the float and then continued over the new and previously floated surfaces. After finishing is completed but while the concrete is still plastic, minor irregularities and score marks in the pavement surface shall be eliminated by means of long-handled cutting straightedges. Straightedges shall be 3.75 m (12 feet) in length and shall be operated from the sides of the pavement and from bridges. A straightedge operated from the side of the pavement shall be equipped with a handle 1 m (3 feet) longer than one-half the width of the pavement. The surface shall then be tested for trueness with a 3.75 (12 foot) straightedge held in successive positions parallel and at right angles to the center line of the pavement, and the whole area covered as necessary to detect variations. The straightedge shall be advanced along the pavement in successive stages of not more than one-half the length of the straightedge. Depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. Projections above the required elevation shall also be struck off and refinished. The straightedge testing and finishing shall continue until the entire surface of the concrete is true. Before the surface sheen has disappeared and well before the concrete becomes nonplastic, the surface of the pavement shall be given a nonslip sandy surface texture by belting with approved "belt" and procedures, or use of a burlap drag. A strip of clean, wet burlap from 1.0 to 1.5 m (3 to 5 feet) wide and 0.7 m (2 feet) longer than the pavement width shall be carefully pulled across the surface. Edges and joints shall be rounded with an edger having a radius of 3 mm. (1/8 inch.) Curing shall be as specified.

3.12.2 Sidewalks

Concrete shall be 100 mm (4 inches) minimum thickness. Contraction joints shall be provided at 1.75 m (5 feet) spaces unless otherwise indicated. Contraction joints shall be cut 25 mm (1 inch) deep with a jointing tool after the surface has been finished. Transverse expansion joints 12 mm (1/2 inch) thick shall be provided at changes in direction and where sidewalk abuts curbs, steps, rigid pavement, or other similar structures. Sidewalks shall be given a lightly broomed finish. A transverse slope of 1 mm per 50 mm (1/4 inch per foot) shall be provided, unless otherwise indicated. Variations in cross section shall be limited to 1 mm per 250 mm. (1/4 inch in 5 feet.)

3.12.3 Curbs and Gutters

Concrete shall be formed, placed, and finished by hand using a properly shaped "mule" or constructed using a slipform machine specially designed for this work. Contraction joints shall be cut 75 mm (3 inches) deep with a jointing tool after the surface has been finished. Expansion joints (12 mm (1/2 inch) wide) shall be provided at 35 m (100 feet) maximum spacing unless otherwise indicated. Exposed surfaces shall be finished using a stiff bristled brush.

3.12.4 Pits and Trenches

Pits and trenches shall be constructed as indicated on the drawings. Bottoms and walls shall be placed monolithically or waterstops and keys, shall be provided as approved.

3.13 CURING AND PROTECTION

3.13.1 General

Curing compound is not allowed. Moist curing is always permitted. Concrete shall be cured by an approved method for the period of time given below:

Concrete with Type III cement	3 days
All other concrete	7 days

Immediately after placement, concrete shall be protected from premature drying, extremes in temperatures, rapid temperature change, mechanical injury and damage from rain and flowing water for the duration of the curing period. Air and forms in contact with concrete shall be maintained at a temperature above 10 degrees C (50 degrees F) for the first 3 days and at a temperature above 0 degrees C (32 degrees F) for the remainder of the specified curing period. Exhaust fumes from combustion heating units shall be vented to the outside of the enclosure, and heaters and ducts shall be placed and directed so as not to cause areas of overheating and drying of concrete surfaces or to create fire hazards. Materials and equipment needed for adequate curing and protection shall be available and at the site prior to placing concrete. No fire or excessive heat, including welding, shall be permitted near or in direct contact with the concrete at any time. Except as otherwise permitted by paragraph Membrane Forming Curing Compounds, moist curing shall be provided for any areas to receive floor hardener, any paint or other applied coating, or to which other concrete is to be bonded. Concrete containing silica fume shall be initially cured by fog misting during finishing, followed immediately by continuous moist curing. Except for plastic coated burlap, impervious sheeting alone shall not be used for curing.

3.13.2 Moist Curing

Concrete to be moist-cured shall be maintained continuously wet for the entire curing period, commencing immediately after finishing. If water or curing materials used stain or discolor concrete surfaces which are to be permanently exposed, the concrete surfaces shall be cleaned as approved. When wooden forms are left in place during curing, they shall be kept wet at all times. If steel forms are used in hot weather, nonsupporting vertical forms shall be broken loose from the concrete soon after the concrete hardens and curing water continually applied in this void. If the forms are removed before the end of the curing period, curing shall be carried out as on unformed surfaces, using suitable materials. Surfaces shall be cured by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap. Burlap and mats shall be clean and free from any contamination and shall be completely saturated before being placed on the concrete. The Contractor shall have an approved work system to ensure that moist curing is continuous 24 hours per day.

3.13.3 Impervious Sheeting

The designated concrete surfaces may be cured using impervious sheets. However, except for plastic coated burlap, impervious sheeting alone shall not be used for curing. Impervious-sheet curing shall only be used on horizontal or nearly horizontal surfaces. Surfaces shall be thoroughly wetted and be completely covered with the sheeting. Sheeting shall be at least 450 mm (18 inches) wider than the concrete surface to be covered. Covering shall be laid with light-colored side up. Covering shall be lapped not less than 300 mm (12 inches) and securely weighted down or shall be lapped not less than 100 mm (4 inches) and taped to form a continuous cover with completely closed joints. The sheet shall be weighted to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

3.13.4 Ponding or Immersion

Concrete shall be continually immersed throughout the curing period. Water shall not be more than 10 degrees C (20 degrees F) less than the temperature of the concrete.

3.13.5 Cold Weather Curing and Protection

When the daily ambient low temperature is less than 0 degrees C (32 degrees F) the temperature of the concrete shall be maintained above 5 degrees C (40 degrees F) for the first seven days after placing. During the period of protection removal, the air temperature adjacent to the concrete surfaces shall be controlled so that concrete near the surface will not be subjected to a temperature differential of more than 13 degrees C (25 degrees F) as determined by suitable temperature measuring devices furnished by the Government, as required, and installed adjacent to the concrete surface and 50 mm (2 inches) inside the surface of the concrete. The installation of the thermometers shall be made by the Contractor as directed.

3.14 SETTING BASE PLATES AND BEARING PLATES

After being properly positioned, column base plates, bearing plates for beams and similar structural members, and machinery and equipment base plates shall be set to the proper line and elevation with damp-pack bedding mortar, except where nonshrink grout is indicated. The thickness of the mortar or grout shall be approximately 1/24 the width of the plate, but not less than 20 mm. (3/4 inch.) Concrete and metal surfaces in contact with grout shall be clean and free of oil and grease, and concrete surfaces in contact with grout shall be damp and free of laitance when grout is placed. Nonshrink grout shall be used for heavy machinery bases or where design requires precision setting of plates or requires that bedding material have high resistance to shear, impact, or vibration, and where good damp packing is difficult or impossible.

3.14.1 Damp-Pack Bedding Mortar

Damp-pack bedding mortar shall consist of 1 part cement and 2-1/2 parts fine aggregate having water content such that a mass of mortar tightly squeezed in the hand will retain its shape but will crumble when disturbed. The space between the top of the concrete and bottom of the bearing plate or base shall be packed with the bedding mortar by tamping or ramming with a bar or rod until it is completely filled.

3.14.2 Nonshrink Grout

Nonshrink grout shall be a ready-mixed material requiring only the addition of water. Water content shall be the minimum that will provide a flowable mixture and completely fill the space to be grouted without segregation, bleeding, or reduction of strength.

3.14.2.1 Mixing and Placing of Nonshrink Grout

Mixing and placing shall be in conformance with the material manufacturer's instructions and as specified therein. Ingredients shall be thoroughly dry-mixed before adding water. After adding water, the batch shall be mixed for 3 minutes. Batches shall be of size to allow continuous placement of freshly mixed grout. Grout not used within 30 minutes after mixing shall be discarded. The space between the top of the concrete or machinery-bearing surface and the plate shall be filled solid with the grout. Forms shall be of wood or other equally suitable material for completely retaining the grout on all sides and on top and shall be removed after the grout has set. The placed grout shall be carefully worked by rodding or other means to eliminate voids; however, overworking and breakdown of the initial set shall be avoided. Grout shall not be retempered or subjected to vibration from any source. Where learances are unusually small, placement shall be under pressure with a grout pump. Temperature of the grout, and of surfaces receiving the grout, shall be maintained at 18 to 30 degrees C (65 to 85 degrees F) until after setting.

3.14.2.2 Treatment of Exposed Surfaces

For metal-oxidizing nonshrink grout, exposed surfaces shall be cut back 25 mm (1 inch) and immediately covered with a parge coat of mortar consisting of 1 part portland cement and 2-1/2 parts fine aggregate by weight, with sufficient water to make a plastic mixture. The parge coat shall have a smooth finish. For other mortars or grouts, exposed surfaces shall have a smooth-dense finish and be left untreated. Curing shall comply with paragraph CURING AND PROTECTION.

3.15 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL

The Contractor shall perform the inspection and tests described below and, based upon the results of these inspections and tests, shall take the action required and shall submit specified reports. When, in the opinion of the Contracting Officer, the concreting operation is out of control, concrete placement shall cease and the operation shall be corrected. The laboratory performing the tests shall be onsite and shall conform with ASTM C 1077. Materials may be subjected to check testing by the Government from samples obtained at the manufacturer, at transfer points, or at the project site. The Government will inspect the laboratory, equipment, and test procedures prior to start of concreting operations for conformance with ASTM C 1077.

STANDARD TECHNICAL SPECIFICATIONS

FOR

O&MA PROJECTS, KOREA

Volume II

October 1, 2003

DEPARTMENT OF THE ARMY
INSTALLATION MANAGEMENT AGENCY
KOREA REGION OFFICE

DIVISION 04 MASONRY

SECTION 04200

MASONRY

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 530.1	(1999) Specifications for Masonry Structures and Related Commentaries
ACI 318/318M	(2002) Building Code Requirements for Structural Concrete and Commentary
ACI SP-66	(1994) ACI Detailing Manual

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 82	(2001) Steel Wire, Plain, for Concrete Reinforcement
ASTM A 153/A 153M	(2001a) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 167	(1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 615/A 615M	(2001b) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 616/A 616M	(1996a) Rail Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM B 370	(1998) Copper Sheet and Strip for Building Construction
ASTM C 27	(1998) Fireclay and High Alumina Refractory Brick
ASTM C 55	(2001a) Concrete Brick
ASTM C 62	(2001) Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C 67	(2002) Sampling and Testing Brick and Structural Clay Tile
ASTM C 73	(1999a) Calcium Silicate Brick (Sand-Lime Brick)
ASTM C 90	(2002) Loadbearing Concrete Masonry Units
ASTM C 91	(2001) Masonry Cement
ASTM C 94/C 94M	(2000e2) Ready-Mixed Concrete
ASTM C 129	(2001) Nonloadbearing Concrete Masonry Units
ASTM C 140	(2001ae1) Sampling and Testing Concrete Masonry Units and Related Units
ASTM C 144	(1999) Aggregate for Masonry Mortar

ASTM C 150	(2002) Portland Cement
ASTM C 207	(1991; R 1997) Hydrated Lime for Masonry Purposes
ASTM C 216	(2001a) Facing Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C 270	(2001a) Mortar for Unit Masonry
ASTM C 315	(2002) Clay Flue Linings
ASTM C 476	(2001) Grout for Masonry
ASTM C 494/C 494M	(1999ae1) Chemical Admixtures for Concrete
ASTM C 578	(2001) Rigid, Cellular Polystyrene Thermal Insulation
ASTM C 641	(1998e1) Staining Materials in Lightweight Concrete Aggregates
ASTM C 652	(2001a) Hollow Brick (Hollow Masonry Units Made From Clay or Shale)
ASTM C 744	(1999) Prefaced Concrete and Calcium Silicate Masonry Units
ASTM C 780	(2000) Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
ASTM C 1019	(2000b) Sampling and Testing Grout
ASTM C 1072	(2000a) Measurement of Masonry Flexural Bond Strength
ASTM C 1142	(1995; R 2001) Extended Life Mortar for Unit Masonry
ASTM C 1289	(2001) Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board
ASTM D 2000	(2001) Rubber Products in Automotive Applications
ASTM D 2240	(2002) Rubber Property - Durometer Hardness
ASTM D 2287	(1996; R 2001) Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds
ASTM E 119	(2000a) Fire Tests of Building Construction and Materials
ASTM E 447	(1997) Compressive Strength of Masonry Prisms
ASTM E 514	(1990; R 1996e1) Water Penetration and Leakage Through Masonry

INTERNATIONAL CODE COUNCIL (ICC)

ICC Plumbing Code	(2000) International Plumbing Code (IPA)

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3504	(1988) Steel Bar for Concrete Reinforcement

KS D 8308	(1986) Zinc Hot Dip Galvanizing
KS F 2560	(1997) Chemical Admixtures For Concrete
KS F 4002	(1997) Hollow Concrete Blocks
KS F 4004	(1997) Concrete Bricks
KS L 4201	(1997) Clay Bricks
KS L 5109	(1996) TESTING METHOD FOR MECHANICAL MIXING OF HYDRAULIC CEMENT PASTES AND MORTARS OF PLASTIC CONSISTENCY
KS L 5219	(1996) Masonry Cement
KS M 3808	(1997) Foam Polystyrene Thermal Insulation Material

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Masonry Work; G.

Drawings including plans, elevations, and details of wall reinforcement; details of reinforcing bars at corners and wall intersections; offsets; tops, bottoms, and ends of walls; control and expansion joints; and wall openings. Bar splice locations shall be shown. Drawings shall be provided showing the location and layout of glass block units. If the Contractor opts to furnish inch-pound CMU products, drawings showing elevation of walls exposed to view and indicating the location of all cut CMU products shall be submitted for approval. Bent bars shall be identified on a bending diagram and shall be referenced and located on the drawings. Wall dimensions, bar clearances, and wall openings greater than one masonry unit in area shall be shown. No approval will be given to the shop drawings until the Contractor certifies that all openings, including those for mechanical and electrical service, are shown. If, during construction, additional masonry openings are required, the approved shop drawings shall be resubmitted with the additional openings shown along with the proposed changes. Location of these additional openings shall be clearly highlighted. The minimum scale for wall elevations shall be 1 to 50 (1/4 inch per foot). Reinforcement bending details shall conform to the requirements of ACI SP-66.

SD-03 Product Data

Clay or Shale Brick; G. Concrete Brick; G. Insulation; G.

Manufacturer's descriptive data.

Cold Weather Installation; G.

Cold weather construction procedures.

SD-04 Samples

Concrete Masonry Units (CMU); G. Concrete Brick; G. Clay or Shale Brick; G. Anchors, Ties, and Bar Positioners; G.

Two of each type used.

Expansion-Joint Materials; G.

One piece of each type used.

Joint Reinforcement; G.

One piece of each type used, including corner and wall intersection pieces, showing at least two cross wires.

SD-06 Test Reports

Efflorescence Test; G. Field Testing of Mortar; G. Field Testing of Grout; G. Masonry Cement; G. Fire-rated CMU; G.

Test reports from an approved independent laboratory. Test reports on a previously tested material shall be certified as the same as that proposed for use in this project.

Special Inspection; G.

Copies of masonry inspector reports.

SD-07 Certificates

Clay or Shale Brick; G. Concrete Brick; G. Concrete Masonry Units (CMU); G. Control Joint Keys; G. Anchors, Ties, and Bar Positioners; G. Expansion-Joint Materials; G. Joint Reinforcement; G. Reinforcing Steel Bars and Rods; G. Masonry Cement; G. Mortar Coloring; G. Insulation; G. Precast Concrete Items; G. Mortar Admixtures; G. Grout Admixtures; G.

Certificates of compliance stating that the materials meet the specified requirements.

Insulation; G.

Certificate attesting that the polyurethane or polyisocyanurate insulation furnished for the project contains recovered material, and showing an estimated percent of such recovered material.

1.3 SAMPLE MASONRY PANELS

Sample panels shall be required for structures having over 185 square meters (2,000 square feet) of exterior wall area, including openings, and for smaller structures where appearance is important. After material samples are approved and prior to starting masonry work, sample masonry panels shall be constructed for each type and color of masonry required. At least 48 hours prior to constructing the sample panel or panels, the Contractor shall submit written notification to the Contracting Officer's Representative. Sample panels shall not be built in, or as part of the structure, but shall be located where directed.

1.3.1 Configuration

Panels shall be L-shaped or otherwise configured to represent all of the wall elements. Panels shall be of the size necessary to demonstrate the acceptable level of workmanship for each type of masonry represented on the project. The minimum size of a straight panel or a leg of an L-shaped panel shall be 2.5 m (8 feet long) by 1.2 m (4 feet high).

1.3.2 Composition

Panels shall show full color range, texture, and bond pattern of the masonry work. The Contractor's method for mortar joint tooling; grouting of reinforced vertical cores, collar joints, bond beams, and lintels; positioning, securing, and lapping of reinforcing steel; positioning and lapping of joint reinforcement (including prefabricated corners); and cleaning of masonry work shall be demonstrated during the construction of the panels. Installation or application procedures for anchors, wall ties, glass block units, CMU control joints, brick expansion joints, insulation, flashing, brick soldier, row lock courses and weep holes shall be shown in the sample panels. The panels shall contain a masonry bonded corner that includes a bond beam corner. Panels shall show parging and installation of electrical boxes and conduit. Panels that represent reinforced masonry shall contain a 600 mm by 600 mm (2 foot by 2 foot) opening placed at least 600 mm (2 feet) above the panel base and 600 mm (2 feet) away from all free edges, corners, and control joints. Required reinforcing shall be provided around this opening as well as at wall corners and control joints.

1.3.3 Construction Method

Where anchored veneer walls are required, the Contractor shall demonstrate and receive approval for the method of construction; i.e., either bring up the two wythes together or separately, with the insulation and appropriate ties placed within the specified tolerances across the cavity. Temporary provisions shall be demonstrated to preclude mortar or grout droppings in the cavity and to provide a clear open air space of the dimensions shown on the drawings. Where masonry is to be grouted, the Contractor shall demonstrate and receive approval on the method that will be used to bring up the masonry wythes; support the reinforcing bars; and grout cells, bond beams, lintels, and collar joints using the requirements specified herein. If sealer is specified to be applied to the masonry units, sealer shall be applied to the sample panels. Panels shall be built on a properly designed concrete foundation.

1.3.4 Usage

The completed panels shall be used as the standard of workmanship for the type of masonry represented. Masonry work shall not commence until the sample panel for that type of masonry construction has been completed and approved. Panels shall be protected from the weather and construction operations until the masonry work has been completed and approved. After completion of the work, the sample panels, including all foundation concrete, shall become the property of the Contractor and shall be removed from the construction site.

1.4 DELIVERY, HANDLING, AND STORAGE

Materials shall be delivered, handled, stored, and protected to avoid chipping, breakage, and contact with soil or contaminating material.

1.4.1 Masonry Units

Concrete masonry units shall be covered or protected from inclement weather and shall conform to the moisture content as specified in ASTM C 90 when delivered to the jobsite. In addition, glass block units shall be stored with their finish surfaces covered. Prefabricated lintels shall be marked on top sides to show either the lintel schedule number or the number and size of top and bottom bars.

1.4.2 Reinforcement, Anchors, and Ties

Steel reinforcing bars, coated anchors, ties, and joint reinforcement shall be stored above the ground. Steel reinforcing bars and uncoated ties shall be free of loose mill scale and rust.

1.4.3 Cementitious Materials, Sand and Aggregates

Cementitious and other packaged materials shall be delivered in unopened containers, plainly marked and labeled with manufacturers' names and brands. Cementitious material shall be stored in dry, weathertight enclosures or be completely covered. Cement shall be handled in a manner that will prevent the inclusion of foreign materials and damage by water or dampness. Sand and aggregates shall be stored in a manner to prevent contamination or segregation.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

The source of materials which will affect the appearance of the finished work shall not be changed after the work has started except with Contracting Officer's approval.

2.2 CLAY OR SHALE BRICK

Color range and texture of clay or shale brick shall be as indicated and shall conform to the approved sample. Grade SW in accordance with ASTM C 62 or Class 1 in accordance with KS L 4201 shall be used for brick in contact with earth or grade and for all exterior work. Grade SW or MW in accordance with ASTM C 62 or Class 1 in accordance with KS L 4201 shall be used in other brickwork. Brick shall be tested for efflorescence. Clay or shale brick units shall be delivered factory-blended to provide a uniform appearance and color range in the completed wall.

2.2.1 Solid Clay or Shale Brick

Solid clay or shale shall conform to ASTM C 62 or KS L 4201. Brick size shall be modular and the nominal size of the brick used shall be 57 mm (2.2 inches) thick, 90 mm (3.5 inches) wide, and 190 mm (7.5 inches) long or as indicated on the drawings. Minimum compressive strength of the brick shall conform to ASTM C 62 or KS L 4201.

2.2.2 Hollow Clay or Shale Brick

Hollow clay or shale brick shall conform to ASTM C 652 or KS L 4201. Brick size shall be modular and the nominal size of the brick used shall be 57 mm (2.2 inches) thick, 90 mm (3.5 inches) wide, and 190 mm (7.5 inches) long or as indicated on the drawings. Where vertical reinforcement is shown in hollow brick, the minimum cell dimension shall be 64 mm (2-1/2 inches) and the units shall be designed to provide precise vertical alignment of the cells. Minimum compressive strength of the brick shall conform to ASTM C 62 or KS L 4201.

2.3 CONCRETE BRICK

Concrete brick shall conform to ASTM C 55 or KS F 4004, Class C, Grade 1. Concrete brick may be used where necessary for filling out in concrete masonry unit construction.

2.4 CONCRETE MASONRY UNITS (CMU)

Hollow and solid concrete masonry units shall conform to ASTM C 90, Normal weight, or KS F 4002 Class C. Cement shall have a low alkali content and be of one brand.

2.4.1 Aggregates

Lightweight aggregates and blends of lightweight and heavier aggregates in proportions used in producing the units, shall comply with the following requirements when tested for stain-producing iron compounds in accordance with ASTM C 641: by visual classification method, the iron stain deposited on the filter paper shall not exceed the "light stain" classification.

2.4.2 Kinds and Shapes

Units shall be modular in size and shall include closer, jamb, header, lintel, and bond beam units and special shapes and sizes to complete the work as indicated. In exposed interior masonry surfaces, units having a bullnose shall be used for vertical external corners except at door, window, and louver jambs. Radius of the bullnose shall be 25 mm (1 inch). Units used in exposed masonry surfaces in any one building shall have a uniform fine to medium texture and a uniform color.

2.4.3 Fire-Rated CMU

Concrete masonry units used in fire-rated construction shown on the drawings shall be of minimum equivalent thickness for the fire rating indicated and the corresponding type of aggregates indicated in TABLE I. Units containing more than one of the aggregates listed in TABLE I will be rated on the aggregate requiring the greater minimum equivalent thickness to produce the required fire rating.

TABLE I

FIRE-RATED CONCRETE MASONRY UNITS
See note (a) below

	Minimum equivalent thickness in mm (inches) for fire rating of:		
Aggregate Type	4 hours	3 hours	2 hours
Pumice	120 (4.7)	100 (4.0)	75 (3.0)
Expanded slag	130 (5.0)	110 (4.2)	85 (3.3)
Expanded clay, shale, or slate	145 (5.7)	120 (4.8)	95 (3.7)
Limestone, scoria, cinders or unexpanded slag	150 (5.9)	130 (5.0)	100 (4.0)
Calcareous gravel	160 (6.2)	135 (5.3)	105 (4.2)
Siliceous gravel	170 (6.7)	145 (5.7)	115 (4.5)

(a) Minimum equivalent thickness shall equal net volume as determined in conformance with ASTM C 140 divided by the product of the actual length and height of the face shell of the unit in millimeters (inches). Where walls are to receive plaster or be faced with brick, or otherwise form an assembly; the thickness of plaster or brick or other material in the assembly will be included in determining the equivalent thickness.

2.5 PRECAST CONCRETE ITEMS

Trim, lintels, copings, splash blocks and door sills shall be factory-made units from a plant regularly engaged in producing precast concrete units. Unless otherwise indicated, concrete shall be 28 MPa (4000 psi) minimum conforming to Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE using 13 mm (1/2 inch) to No. 4 nominal-size coarse aggregate, and minimum reinforcement shall be the reinforcement required for handling of the units. Clearance of 20 mm (3/4 inch) shall be maintained between reinforcement and faces of units. Unless precast-concrete items have been subjected during manufacture to saturated-steam pressure of at least 827 kPa (120 psi) for at least 5 hours, the items, after casting, shall be either damp-cured for 24 hours or steam-cured and shall then be aged under cover for 28 days or longer. Cast-concrete members weighing over 35 kg (80 pounds) shall have built-in loops of galvanized wire or other approved provisions for lifting and anchoring. Units shall have beds and joints at right angles to the face, with sharp true arises and shall be cast with drip grooves on the underside where units overhang walls. Exposed-to-view surfaces shall be free of surface voids, spalls, cracks, and chipped or broken edges. Precast units exposed-to-view shall be of uniform appearance and color. Unless otherwise specified, units shall have a smooth dense finish. Prior to use, each item shall be wetted and inspected for crazing. Items showing evidence of dusting, spalling, crazing, or having surfaces treated with a protective coating will be rejected.

2.5.1 Lintels

Precast lintels, unless otherwise shown, shall be of a thickness equal to the wall and reinforced with two No. 4 bars for the full length. Top of lintels shall be labeled "TOP" or otherwise identified and each lintel shall be clearly marked to show location in the structure.

2.5.2 Sills and Copings

Sills and copings shall be cast with washes. Sills for windows having mullions shall be cast in sections with head joints at mullions and a 6 mm (1/4 inch) allowance for mortar joints. The ends of sills, except a 20 mm (3/4 inch) wide margin at exposed surfaces, shall be roughened for bond. Treads of door sills shall have rounded nosings.

2.5.3 Splash Blocks

Splash blocks shall be as detailed. Reinforcement shall be the manufacturer's standard.

2.6 MORTAR

Mortar shall be Type S or Type N in accordance with the proportion specification of ASTM C 270 except Type S cement-lime mortar proportions shall be 1 part cement, 1/2 part lime and 4-1/2 parts aggregate; Type N cement-lime mortar proportions shall be 1 part cement, 1 part lime and 6 parts aggregate; when masonry cement ASTM C 91 or KS L 5219 is used the maximum air content shall be limited to 12 percent and performance equal to cement-lime mortar shall be verified. Type S mortar is recommended by ASTM C 270 for exterior, at or below grade, applications. Type N mortar is recommended by ASTM C 270 for exterior above grade and interior application. Evaluation of performance shall be based on ASTM C 780 and ASTM C 1072. Pointing mortar in showers and kitchens shall contain ammonium stearate, or aluminum tri-stearate, or calcium stearate in an amount equal to 3 percent by weight of cement used. Cement shall have a low alkali content and be of one brand. Aggregates shall be from one source.

2.6.1 Admixtures

In cold weather, a non-chloride based accelerating admixture may be used subject to approval. Accelerating admixture shall be non-corrosive, shall contain less than 0.2 percent chlorides, and shall conform to ASTM C 494, Type C.

2.6.2 Coloring

Mortar coloring shall be added to the mortar used for exposed masonry surfaces to produce a uniform color matching. Mortar coloring shall not exceed 3 percent of the weight of cement for carbon black and ten percent of the weight of cement for all other pigments. Mortar coloring shall be chemically inert, of finely ground limeproof pigment, and furnished in accurately pre-measured and packaged units that can be added to a measured amount of cement.

2.7 GROUT

Grout shall conform to ASTM C 476. Cement used in grout shall have a low alkali content. Grout slump shall be between 200 and 250 mm. (8 and 10 inches.) Grout shall be used subject to the limitations of Table III. Proportions shall not be changed and materials with different physical or chemical characteristics shall not be used in grout for the work unless additional evidence is furnished that the grout meets the specified requirements.

2.7.1 Admixtures

In cold weather, a non-chloride based accelerating admixture may be used subject to approval. Accelerating admixture shall be non-corrosive, shall contain less than 0.2 percent chlorides, and shall conform to ASTM C 494, Type C or KS F 2560.

2.7.2 Grout Barriers

Grout barriers for vertical cores shall consist of fine mesh wire, fiberglass, or expanded metal.

2.8 ANCHORS, TIES, AND BAR POSITIONERS

Anchors and ties shall be fabricated without drips or crimps and shall be zinc-coated in accordance with ASTM A 153, Class B-2 or KS D 8308, HDZ 50. Steel wire used for anchors and ties shall be fabricated from steel wire conforming to ASTM A 82 or KS D 3504. Anchors and ties shall be sized to provide a minimum of 16 mm (5/8 inch) mortar cover from either face.

2.8.1 Wire Mesh Ties

Wire mesh for tying 100 mm (4 inch) thick concrete masonry unit partitions to other intersecting masonry partitions shall be 13 mm (1/2 inch) mesh of minimum 16 gauge steel wire. Minimum lengths shall be not less than 300 mm (12 inches).

2.8.2 Wall Ties

Wall ties used for continuous joint reinforcement to anchor the outer wythe to the inner wythe of anchored veneer construction shall be rectangular-shaped or Z-shaped fabricated of 5 mm (3/16 inch) diameter zinc-coated steel wire. Rectangular wall ties shall be no less than 100 mm (4 inches) wide. Wall ties may also be of a continuous type conforming to paragraph JOINT REINFORCEMENT. Adjustable type wall ties, if approved for use, shall consist of two essentially U-shaped elements fabricated of 5 mm (3/16 inch) diameter zinc-coated steel wire. Adjustable ties shall be of the double pintle to eye type and shall allow a maximum of 13 mm (1/2 inch) eccentricity between each element of the tie. Play between pintle and eye opening shall be not more than 2 mm (1/16 inch). The pintle and eye elements shall be formed so that both can be in the same plane.

2.8.3 Dovetail Anchors

Dovetail anchors shall be of the flexible wire type, 5 mm (3/16 inch) diameter zinc-coated steel wire, triangular shaped, and attached to a 12 gauge or heavier steel dovetail section. These anchors shall be used for anchorage of veneer wythes or composite-wall facings extending over the face of concrete columns, beams, or walls. Cells within vertical planes of these anchors shall be filled solid with grout for full height of walls or partitions, or solid units may be used. Dovetail slots are specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

2.8.4 Adjustable Anchors

Adjustable anchors used to anchor masonry to structural steel columns or beams shall be 5 mm (3/16 inch) diameter steel wire, triangular-shaped. Anchors attached to steel shall be 8 mm (5/16 inch) diameter steel bars placed to provide 2 mm (1/16 inch) play between flexible anchors and structural steel members. Spacers shall be welded to rods and columns. Equivalent welded-on steel anchor rods or shapes standard with the flexible-anchor manufacturer may be furnished when approved. Welds shall be cleaned and given one coat of zinc-rich touch up paint.

2.8.5 Bar Positioners

Bar positioners, used to prevent displacement of reinforcing bars during the course of construction, shall be factory fabricated from 9 gauge steel wire or equivalent, and coated with a hot-dip galvanized finish. Not more than one wire shall cross the cell.

2.9 JOINT REINFORCEMENT

Joint reinforcement shall be factory fabricated from steel wire conforming to ASTM A 82, welded construction. Tack welding will not be acceptable in reinforcement used for wall ties. Wire shall have zinc coating conforming to ASTM A 153, class B-2, or KS D 8308, HDZ 50. All wires shall be a minimum of 9 gauge. Reinforcement shall be ladder type design, having one longitudinal wire in the mortar bed of each face shell for hollow units and one wire for solid units. Joint reinforcement shall be placed a minimum of 16 mm (5/8 inch) cover from either face. The distance between crosswires shall not exceed 400 mm (16 inches). Joint reinforcement for straight runs shall be furnished in flat sections not less than 3 m (10 feet) long. Joint reinforcement shall be provided with factory formed corners and intersections. If approved for use, joint reinforcement may be furnished with adjustable wall tie features.

2.10 REINFORCING STEEL BARS AND RODS

Reinforcing steel bars and rods shall conform to ASTM A 615, Grade 60, or KS D 3504, SD 40.

2.11 CONTROL JOINT KEYS

Control joint keys shall be a factory fabricated solid section of natural or synthetic rubber (or combination thereof) conforming to ASTM D 2000 or polyvinyl chloride conforming to ASTM D 2287. The material shall be resistant to oils and solvents. The control joint key shall be provided with a solid shear section not less than 16 mm (5/8 inch) thick and 10 mm (3/8 inch) thick flanges, with a tolerance of plus or minus 2 mm (1/16 inch). The control joint key shall fit neatly, but without forcing, in masonry unit jamb sash grooves. The control joint key shall be flexible at a temperature of minus 34 degrees C (minus 30 degrees F) after five hours exposure, and shall have a durometer hardness of not less than 70 when tested in accordance with ASTM D 2240.

2.12 EXPANSION-JOINT MATERIALS

Backer rod and sealant shall be adequate to accommodate joint compression equal to 50 percent of the width of the joint. The backer rod shall be compressible rod stock of polyethylene foam, polyurethane foam, butyl rubber foam, or other flexible, nonabsorptive material as recommended by the sealant manufacturer. Sealant shall conform to Section 07920 JOINT SEALING.

2.13 INSULATION

2.13.1 Rigid Board-Type Insulation

Rigid board-type insulation shall be extruded polystyrene, polyurethane, or polyisocyanurate. Polystyrene shall conform to ASTM C 578 or KS M 3808. Polyurethane or polyisocyanurate shall conform to ASTM C 1289, Type I, Class 2, faced with aluminum foil on both sides of the foam. The insulation shall be a standard product and shall be marked with not less than the manufacturer's trademark or name, the specification number, the permeance and R-values.

2.13.1.1 Insulation Thickness and Air Space

The cavity space shall allow for a maximum insulation thickness of 50 mm (2 inches) and a minimum air space of 20 mm (3/4 inch.)

2.13.1.2 Aged R-Value

The insulation shall provide a minimum aged R-value of 2 (11, in IP units) for the overall thickness. The aged R-value shall be determined at 24 degrees C (75 degrees F) in accordance with the appropriate referenced specification. The stated R-value of the insulation shall be certified by an independent testing laboratory or certified by an independent Registered Professional Engineer if tests are conducted in the manufacturer's laboratory.

2.13.1.3 Recovered Material

Insulation shall contain the highest practicable percentage of recovered material derived from solid waste (but material reused in the manufacturing process cannot be counted toward the percentage of recovered material). Where two materials have the same price and performance, the one containing the higher recovered material content shall be provided. The polyurethane or polyisocyanurate foam shall have a minimum recovered material content of 9 percent by weight of the core material.

2.13.2 Insulation Adhesive

Insulation adhesive shall be specifically prepared to adhere the insulation to the masonry and, where applicable, to the thru-wall flashing. The adhesive shall not deleteriously affect the insulation, and shall have a record of satisfactory and proven performance for the conditions under which to be used.

2.14 FLASHING

Flashing shall be as specified in Section 07600 SHEET METALWORK, GENERAL.

2.15 WEEP HOLE VENTILATORS

Weephole ventilators shall be prefabricated aluminum grill type vents designed to prevent insect entry with maximum air entry. Ventilators shall be sized to match modular construction with a standard 10 mm (3/8 inch) mortar joint.

PART 3 EXECUTION

3.1 ENVIRONMENTAL REQUIREMENTS

3.1.1 Hot Weather Installation

The following precautions shall be taken if masonry is erected when the ambient air temperature is more than 37 degrees C (99 degrees F) in the shade and the relative humidity is less than 50 percent. All masonry materials shall be shaded from direct sunlight; mortar beds shall be spread no more than 1.2 m (4 feet) ahead of masonry; masonry units shall be set within one minute of spreading mortar; and after erection, masonry shall be protected from direct exposure to wind and sun for 48 hours.

3.1.2 Cold Weather Installation

Before erecting masonry when ambient temperature or mean daily air temperature falls below 4 degrees C (40 degrees F), a written statement of proposed cold weather construction procedures shall be submitted for approval. The following precautions shall be taken during all cold weather erection.

3.1.2.1 Preparation

Ice or snow formed on the masonry bed shall be thawed by the application of heat. Heat shall be applied carefully until the top surface of the masonry is dry to the touch. Sections of masonry deemed frozen and damaged shall be removed before continuing construction of those sections.

a. Air Temperature 4 to 0 degrees C (40 to 32 Degrees F). Sand or mixing water shall be heated to produce mortar temperatures between 4 degrees C and 49 degrees C (40 degrees F and 120 degrees F).

b. Air Temperature 0 to minus 4 degrees C (32 to 25 Degrees F). Sand and mixing water shall be heated to produce mortar temperatures between 4 degrees C and 49 degrees C (40 degrees F and 120 degrees F). Temperature of mortar on boards shall be maintained above freezing.

c. Air Temperature minus 4 to minus 7 degrees C (25 to 20 Degrees F). Sand and mixing water shall be heated to provide mortar temperatures between 4 degrees C and 49 degrees C (40 degrees F and 120 degrees F). Temperature of mortar on boards shall be maintained above freezing. Sources of heat shall be used on both sides of walls under construction. Windbreaks shall be employed when wind is in excess of 24 km/hour (15 mph).

d. Air Temperature minus 7 degrees C (20 Degrees F) and below. Sand and mixing water shall be heated to provide mortar temperatures between 4 degrees C and 49 degrees C (40 degrees F and 120 degrees F). Enclosure and auxiliary heat shall be provided to maintain air temperature above 0 degrees C (32 degrees F). Temperature of units when laid shall not be less than minus 7 degrees C (20 degrees F).

3.1.2.2 Completed Masonry and Masonry Not Being Worked On

a. Mean daily air temperature 4 degrees C to 0 degrees C (40 degrees F to 32 degrees F). Masonry shall be protected from rain or snow for 24 hours by covering with weather-resistive membrane.

b. Mean daily air temperature 0 degrees C to minus 4 degrees C (32 degrees F to 25 degrees F). Masonry shall be completely covered with weather-resistant membrane for 24 hours.

c. Mean Daily Air Temperature minus 4 degrees C to minus 7 degrees C (25 Degrees F to 20 Degrees F). Masonry shall be completely covered with insulating blankets or equally protected for 24 hours.

d. Mean Daily Temperature minus 7 degrees C (20 Degrees F) and Below. Masonry temperature shall be maintained above 0 degrees C (32 degrees F) for 24 hours by enclosure and supplementary heat, by electric heating blankets, infrared heat lamps, or other approved methods.

3.2 LAYING MASONRY UNITS

Masonry units shall be laid in running bond or the indicated pattern. Facing courses shall be level with back-up courses, unless the use of adjustable ties has been approved in which case the tolerances shall be plus or minus 13 mm (1/2 inch). Each unit shall be adjusted to its final position while mortar is still soft and plastic. Units that have been disturbed after the mortar has stiffened shall be removed, cleaned, and relaid with fresh mortar. Air spaces, cavities, chases, expansion joints, and spaces to be grouted shall be kept free from mortar and other debris. Units used in exposed masonry surfaces shall be selected from those having the least amount of chipped edges or other imperfections detracting from the appearance of the finished work. Vertical joints shall be kept plumb. Units being laid and surfaces to receive units shall be free of water film and frost. Solid units shall be laid in a nonfurrowed full bed of mortar. Mortar for veneer wythes shall be beveled and sloped toward the center of the wythe from the cavity side. Units shall be shoved into place so that the vertical joints are tight. Vertical joints of brick and the vertical face shells of concrete masonry units, except where indicated at control, expansion, and isolation joints, shall be completely filled with mortar. Mortar will be permitted to protrude up to 13 mm (1/2 inch) into the space or cells to be grouted. Means shall be provided to prevent mortar from dropping into the space below. In double wythe construction, the inner wythe may be brought up not more than 400 mm (16 inches) ahead of the outer wythe. Collar joints shall be filled with mortar or grout during the laying of the facing wythe, and filling shall not lag the laying of the facing wythe by more than 200 mm (8 inches).

3.2.1 Surface Preparation

Surfaces upon which masonry is placed shall be cleaned of laitance, dust, dirt, oil, organic matter, or other foreign materials and shall be slightly roughened to provide a surface texture with a depth of at least 3 mm (1/8 inch). Sandblasting shall be used, if necessary, to remove laitance from pores and to expose the aggregate.

3.2.2 Forms and Shores

Forms and shores shall be sufficiently rigid to prevent deflections which may result in cracking or other damage to supported masonry and sufficiently tight to prevent leakage of mortar and grout. Supporting forms and shores shall not be removed in less than 10 days.

3.2.3 Concrete Masonry Units

Units in piers, pilasters, columns, starting courses on footings, solid foundation walls, lintels, and beams, and where cells are to be filled with grout shall be full bedded in mortar under both face shells and webs. Other units shall be full bedded under both face shells. Head joints shall be filled solidly with mortar for a distance in from the face of the unit not less than the thickness of the face shell. Foundation walls below grade shall be grouted solid. Jamb units shall be of the shapes and sizes to conform with wall units. Solid units may be incorporated in the masonry work where necessary to fill out at corners, gable slopes, and elsewhere as approved. Double walls shall be stiffened at wall-mounted plumbing fixtures by use of strap anchors, two above each fixture and two below each fixture, located to avoid pipe runs, and extending from center to center of the double wall. Walls and partitions shall be adequately reinforced for support of wall-hung plumbing fixtures when chair carriers are not specified.

3.2.4 Clay or Shale Brick Units

Brick facing shall be laid with the better face exposed. Brick shall be laid in running bond with each course bonded at corners, unless otherwise indicated. Molded brick shall be laid with the frog side down. Brick that is cored, recessed, or has other deformations may be used in sills, treads, soldier courses, except where deformations will be exposed to view.

3.2.4.1 Wetting of Units

Wetting of clay, shale brick, or hollow brick units having an initial rate of absorption of more than 0.155 gm per minute per square cm (1 gm per minute per square inch) of bed surface shall be in conformance with ASTM C 67. The method of wetting shall ensure that each unit is nearly saturated but surface dry when laid.

3.2.4.2 Solid Units

Bed, head, and collar joints shall be completely filled with mortar.

3.2.4.3 Hollow Units

Hollow units shall be laid as specified for concrete masonry units.

3.2.5 Tolerances

Masonry shall be laid plumb, true to line, with courses level. Bond pattern shall be kept plumb throughout. Corners shall be square unless noted otherwise. Masonry shall be laid within the following tolerances in Table II (plus or minus unless otherwise noted):

TABLE II

TOLERANCES

Variation from the plumb in the lines and surfaces of columns, walls and arises

In adjacent masonry units:	3 mm (1/8 inch)
In 3 m (10 feet):	6 mm (1/4 inch)
In 6 m (20 feet):	10 mm (3/8 inch)
In 12 m (40 feet) or more:	13 mm (1/2 inch)

Variations from the plumb for external corners, expansion joints, and other conspicuous lines

In 6 m (20 feet):	6 mm (1/4 inch)
In 12 m (40 feet) or more:	13 mm (1/2 inch)

Variations from the level for exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines

In 6 m (20 feet):	6 mm (1/4 inch)
In 12 m (40 feet) or more:	13 mm (1/2 inch)

Variation from level for bed joints and top surfaces of bearing walls

In 3 m (10 feet):	6 mm (1/4 inch)
In 12 m (40 feet) or more:	13 mm (1/2 inch)

Variations from horizontal lines

In 3 m (10 feet):	6 mm (1/4 inch)
In 6 m (20 feet):	10 mm (3/8 inch)
In 12 m (40 feet) or more:	13 mm (1/2 inch)

Variations in cross sectional dimensions of columns and in thickness of walls

Minus 6 mm (1/4 inch)
Plus 13 mm (1/2 inch)

3.2.6 Cutting and Fitting

Full units of the proper size shall be used wherever possible, in lieu of cut units. Cutting and fitting, including that required to accommodate the work of others, shall be done by masonry mechanics using power masonry saws. Concrete masonry units may be wet or dry cut. Wet cut units, before being placed in the work, shall be dried to the same surface-dry appearance as uncut units being laid in the wall. Cut edges shall be clean, true and sharp. Openings in the masonry shall be made carefully so that wall plates, cover plates or escutcheons required by the installation will completely conceal the openings and will have bottoms parallel with the masonry bed joints. Reinforced masonry lintels shall be provided above openings over 300 mm (12 inches) wide for pipes, ducts, cable trays, and other wall penetrations, unless steel sleeves are used.

3.2.7 Jointing

Joints shall be tooled when the mortar is thumbprint hard. Horizontal joints shall be tooled last. Joints shall be brushed to remove all loose and excess mortar. Mortar joints shall be finished as follows:

3.2.7.1 Flush Joints

Joints in concealed masonry surfaces and joints at electrical outlet boxes in wet areas shall be flush cut. Flush cut joints shall be made by cutting off the mortar flush with the face of the wall. Joints in unparged masonry walls below grade shall be pointed tight. Flush joints for architectural units, such as fluted units, shall completely fill both the head and bed joints.

3.2.7.2 Tooled Joints

Joints in exposed exterior and interior masonry surfaces shall be tooled slightly concave or as indicated on the drawings. Joints shall be tooled with a jointer slightly larger than the joint width so that complete contact is made along the edges of the unit. Tooling shall be performed so that the mortar is compressed and the joint surface is sealed. Jointer of sufficient length shall be used to obtain a straight and true mortar joint.

3.2.7.3 Door and Window Frame Joints

On the exposed interior side of exterior frames, joints between frames and abutting masonry walls shall be raked to a depth of 10 mm (3/8 inch). On the exterior side of exterior frames, joints between frames and abutting masonry walls shall be raked to a depth of 10 mm (3/8 inch).

3.2.8 Joint Widths

Joint widths shall be as follows:

3.2.8.1 Concrete Masonry Units

Concrete masonry units shall have 10 mm (3/8 inch) joints.

3.2.8.2 Brick

Brick joint widths shall be the difference between the actual and nominal dimensions of the brick in either height or length. Brick expansion joint widths shall be as shown.

3.2.9 Embedded Items

Spaces around built-in items shall be filled with mortar. Openings around flush-mount electrical outlet boxes in wet locations shall be pointed with mortar. Anchors, ties, wall plugs, accessories, flashing, pipe sleeves and other items required to be built-in shall be embedded as the masonry work progresses. Anchors, ties and joint reinforcement shall be fully embedded in the mortar. Cells receiving anchor bolts and cells of the first course below bearing plates shall be filled with grout.

3.2.10 Unfinished Work

Unfinished work shall be stepped back for joining with new work. Toothing may be resorted to only when specifically approved. Loose mortar shall be removed and the exposed joints shall be thoroughly cleaned before laying new work.

3.2.11 Masonry Wall Intersections

Each course shall be masonry bonded at corners and elsewhere as shown. Masonry walls shall be anchored or tied together at corners and intersections with bond beam reinforcement and prefabricated corner or tee pieces of joint reinforcement as shown.

3.2.12 Partitions

Partitions shall be continuous from floor to underside of floor or roof deck where shown. Openings in firewalls around joists or other structural members shall be filled as indicated or approved. Where suspended ceilings on both sides of partitions are indicated, the partitions other than those shown to be continuous may be stopped approximately 100 mm (4 inches) above the ceiling level. An isolation joint shall be placed in the intersection between partitions and structural or exterior walls as shown. Interior partitions having 100 mm (4 inch) nominal thick units shall be tied to intersecting partitions of 100 mm (4 inch) units, 125 mm (5 inches) into partitions of 150 mm (6 inch) units, and 175 (7 inches) into partitions of 200 mm (8 inch) or thicker units. Cells within vertical plane of ties shall be filled solid with grout for full height of partition or solid masonry units may be used. Interior partitions having masonry walls over 100 mm (4 inches) thick shall be tied together with joint reinforcement. Partitions containing joint reinforcement shall be provided with prefabricated pieces at corners and intersections or partitions.

3.3 ANCHORED VENEER CONSTRUCTION

The inner and outer wythes shall be completely separated by a continuous airspace as shown on the drawings. Both the inner and the outer wythes shall be laid up together except when adjustable joint reinforcement assemblies are approved for use. When both wythes are not brought up together, through-wall flashings shall be protected from damage until they are fully enclosed in the wall. The airspace between the wythes shall be kept clear and free of mortar droppings by temporary wood strips laid on the wall ties and carefully lifted out before placing the next row of ties. A coarse gravel or drainage material shall be placed behind the weep holes in the cavity to a minimum depth of 100 mm (4 inches) of coarse aggregate or 250 mm (10 inches) of drainage material to keep mortar droppings from plugging the weep holes.

3.4 WEEP HOLES

Weep holes shall be provided not more than 600 mm (24 inches) on centers in mortar joints of the exterior wythe above wall flashing, over foundations, bond beams, and any other horizontal interruptions of the cavity. Weep holes shall be formed by placing short lengths of well-greased No. 10, 8 mm (5/16 inch) nominal diameter, braided cotton sash cord in the mortar and withdrawing the cords after the wall has been completed, or weep holes shall be constructed using weep hole ventilators. Other approved methods may be used for providing weep holes. Weep holes shall be kept free of mortar and other obstructions.

3.5 COMPOSITE WALLS

Masonry wythes shall be tied together with joint reinforcement or with unit wall ties. Facing shall be anchored to concrete backing with wire dovetail anchors set in slots built in the face of the concrete as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. The facing wythe shall be anchored or tied to the backup at a maximum spacing of 400 mm (16 inches) on center vertically and 600 mm (24 inches) on center horizontally. Unit ties shall be spaced not over 600 mm (24 inches) on centers horizontally, in courses not over 400 mm (16 inches) apart vertically, staggered in alternate courses. Ties shall be laid not closer than 16 mm (5/8 inch) to either masonry face. Ties shall not extend through control joints. Collar joints between masonry facing and masonry backup shall be filled solidly with grout.

3.6 MORTAR

Mortar shall be mixed in a mechanically operated mortar mixer for at least 3 minutes, but not more than 5 minutes. Measurement of ingredients for mortar shall be by volume. Ingredients not in containers, such as sand, shall be accurately measured by the use of measuring boxes. Water shall be mixed with the dry ingredients in sufficient amount to provide a workable mixture which will adhere to the vertical surfaces of masonry units. Mortar that has stiffened because of loss of water through evaporation shall be retempered by adding water to restore the proper consistency and workability. Mortar that has reached its initial set or that has not been used within 2-1/2 hours after mixing shall be discarded.

3.7 REINFORCING STEEL

Reinforcement shall be cleaned of loose, flaky rust, scale, grease, mortar, grout, or other coating which might destroy or reduce its bond prior to placing grout. Bars with kinks or bends not shown on the drawings shall not be used. Reinforcement shall be placed prior to grouting. Unless otherwise indicated, vertical wall reinforcement shall extend to within 50 mm (2 inches) of tops of walls.

3.7.1 Positioning Bars

Vertical bars shall be accurately placed within the cells at the positions indicated on the drawings. A minimum clearance of 13 mm (1/2 inch) shall be maintained between the bars and masonry units. Minimum clearance between parallel bars shall be one diameter of the reinforcement. Vertical reinforcing may be held in place using bar positioners located near the ends of each bar and at intermediate intervals of not more than 192 diameters of the reinforcement. Column and pilaster ties shall be wired in position around the vertical steel. Ties shall be in contact with the vertical reinforcement and shall not be placed in horizontal bed joints.

3.7.2 Splices

Bars shall be lapped a minimum of 48 diameters of the reinforcement. Welded or mechanical connections shall develop at least 125 percent of the specified yield strength of the reinforcement.

3.8 JOINT REINFORCEMENT

Joint reinforcement shall be installed at 400 mm (16 inches) on center or as indicated. Reinforcement shall be lapped not less than 150 mm (6 inches). Prefabricated sections shall be installed at corners and wall intersections. The longitudinal wires of joint reinforcement shall be placed to provide not less than 16 mm (5/8 inch) cover to either face of the unit.

3.9 PLACING GROUT

Cells containing reinforcing bars shall be filled with grout. Hollow masonry units in walls or partitions supporting plumbing, heating, or other mechanical fixtures, voids at door and window jambs, and other indicated spaces shall be filled solid with grout. Cells under lintel bearings on each side of openings shall be filled solid with grout for full height of openings. Walls below grade, lintels, and bond beams shall be filled solid with grout. Units other than open end units may require grouting each course to preclude voids in the units. Grout not in place within 1-1/2 hours after water is first added to the batch shall be discarded. Sufficient time shall be allowed between grout lifts to preclude displacement or cracking of face shells of masonry units. If blowouts, flowouts, misalignment, or cracking of face shells should occur during construction, the wall shall be torn down and rebuilt.

3.9.1 Vertical Grout Barriers for Fully Grouted Walls

Grout barriers shall be provided not more than 10 m (30 feet) apart, or as required, to limit the horizontal flow of grout for each pour.

3.9.2 Horizontal Grout Barriers

Grout barriers shall be embedded in mortar below cells of hollow units receiving grout.

3.9.3 Grout Holes and Cleanouts

3.9.3.1 Grout Holes

Grouting holes shall be provided in slabs, spandrel beams, and other in-place overhead construction. Holes shall be located over vertical reinforcing bars or as required to facilitate grout fill in bond beams. Additional openings spaced not more than 400 mm (16 inches) on centers shall be provided where grouting of all hollow unit masonry is indicated. Openings shall not be less than 100 mm (4 inches) in diameter or 75 by 100 mm (3 by 4 inches) in horizontal dimensions. Upon completion of grouting operations, grouting holes shall be plugged and finished to match surrounding surfaces.

3.9.3.2 Cleanouts for Hollow Unit Masonry Construction

Cleanout holes shall be provided at the bottom of every pour in cores containing vertical reinforcement when the height of the grout pour exceeds 1.5 m (5 feet). Where all cells are to be grouted, cleanout courses shall be constructed using bond beam units in an inverted position to permit cleaning of all cells. Cleanout holes shall be provided at a maximum spacing of 800 mm (32 inches) where all cells are to be filled with grout. A new series of cleanouts shall be established if grouting operations are stopped for more than 4 hours. Cleanouts shall not be less than 75 by 100 mm (3 by 4 inch) openings cut from one face shell. Manufacturer's standard cutout units may be used at the Contractor's option. Cleanout holes shall not be closed until masonry work, reinforcement, and final cleaning of the grout spaces have been completed and inspected. For walls which will be exposed to view, cleanout holes shall be closed in an approved manner to match surrounding masonry.

3.9.3.3 Cleanouts for Solid Unit Masonry Construction

Cleanouts for construction of walls consisting of a grout filled cavity between solid masonry wythes shall be provided at the bottom of every pour by omitting every other masonry unit from one wythe. A new series of cleanouts shall be established if grouting operations are stopped for more than 4 hours. Cleanout holes shall not be plugged until masonry work, reinforcement, and final cleaning of the grout spaces have been completed and inspected. For walls which will be exposed to view, cleanout holes shall be closed in an approved manner to match surrounding masonry.

3.9.4 Grouting Equipment

3.9.4.1 Grout Pumps

Pumping through aluminum tubes will not be permitted. Pumps shall be operated to produce a continuous stream of grout without air pockets, segregation, or contamination. Upon completion of each day's pumping, waste materials and debris shall be removed from the equipment, and disposed of outside the masonry.

3.9.4.2 Vibrators

Internal vibrators shall maintain a speed of not less than 5,000 impulses per minute when submerged in the grout. At least one spare vibrator shall be maintained at the site at all times. Vibrators shall be applied at uniformly spaced points not further apart than the visible effectiveness of the machine. Duration of vibration shall be limited to time necessary to produce satisfactory consolidation without causing segregation.

3.9.5 Grout Placement

Masonry shall be laid to the top of a pour before placing grout. Grout shall not be placed in two-wythe solid unit masonry cavity until mortar joints have set for at least 3 days during hot weather and 5 days during cold damp weather. Grout shall not be placed in hollow unit masonry until mortar joints have set for at least 24 hours. Grout shall be placed using a hand bucket, concrete hopper, or grout pump to completely fill the grout spaces without segregation of the aggregates. Vibrators shall not be inserted into lower pours that are in a semi-solidified state. The height of grout pours and type of grout used shall be limited by the dimensions of grout spaces as indicated in Table III. Low-lift grout methods may be used on pours up to and including 1.5 m (5 feet) in height. High-lift grout methods shall be used on pours exceeding 1.5 m (5 feet) in height.

3.9.5.1 Low-Lift Method

Grout shall be placed at a rate that will not cause displacement of the masonry due to hydrostatic pressure of the grout. Mortar protruding more than 13 mm (1/2 inch) into the grout space shall be removed before beginning the grouting operation. Grout pours 300 mm (12 inches) or less in height shall be consolidated by mechanical vibration or by puddling. Grout pours over 300 mm (12 inches) in height shall be consolidated by mechanical vibration and reconsolidated by mechanical vibration after initial water loss and settlement has occurred. Vibrators shall not be inserted into lower pours that are in a semi-solidified state. Low-lift grout shall be used subject to the limitations of Table III.

3.9.5.2 High-Lift Method

Mortar droppings shall be cleaned from the bottom of the grout space and from reinforcing steel. Mortar protruding more than 6 mm (1/4 inch) into the grout space shall be removed by dislodging the projections with a rod or stick as the work progresses. Reinforcing, bolts, and embedded connections shall be rigidly held in position before grouting is started. CMU units shall not be pre-wetted. Grout, from the mixer to the point of deposit in the grout space shall be placed as rapidly as practical by pumping and placing methods which will prevent segregation of the mix and cause a minimum of grout splatter on reinforcing and masonry surfaces not being immediately encased in the grout lift. The individual lifts of grout shall be limited to 1.2 m (4 feet) in height. The first lift of grout shall be placed to a uniform height within the pour section and vibrated thoroughly to fill all voids. This first vibration shall follow immediately behind the pouring of the grout using an approved mechanical vibrator. After a waiting period sufficient to permit the grout to become plastic, but before it has taken any set, the succeeding lift shall be poured and vibrated 300 to 450 mm (12 to 18 inches) into the preceding lift. If the placing of the succeeding lift is going to be delayed beyond the period of workability of the preceding, each lift shall be reconsolidated by reworking with a second vibrator as soon as the grout has taken its settlement shrinkage. The waiting, pouring, and reconsolidation steps shall be repeated until the top of the pour is reached. The top lift shall be reconsolidated after the required waiting period. The high-lift grouting of any section of wall between vertical grout barriers shall be completed to the top of a pour in one working day unless a new series of cleanout holes is established and the resulting horizontal construction joint cleaned. High-lift grout shall be used subject to the limitations in Table III.

TABLE III

POUR HEIGHT AND TYPE OF GROUT FOR VARIOUS GROUT SPACE DIMENSIONS

Maximum Grout Pour Height (m)(feet) (4)	Grout Type	Grouting Procedure	Minimum Dimensions of the Total Clear Areas Within Grout Spaces and Cells (mm)(in.) (1, 2)	
			Multiwythe Masonry (3)	Hollow-unit Masonry
0.3(1)	Fine	Low Lift	20(3/4)	40 x 50 (1-1/2 x 2)
1.5(5)	Fine	Low Lift	50(2)	50 x 75 (2 x 3)
2.4(8)	Fine	High Lift	50(2)	50 x 75 (2 x 3)
3.6(12)	Fine	High Lift	65(2-1/2)	65 x 75 (2-1/2 x 3)
7.3(24)	Fine	High Lift	75(3)	75 x 75 (3 x 3)
0.3(1)	Coarse	Low Lift	40(1-1/2)	40 x 75 (1-1/2 x 3)
1.5(5)	Coarse	Low Lift	50(2)	65 x 75 (2-1/2 x 3)
2.4(8)	Coarse	High Lift	50(2)	75 x 75 (3 x 3)
3.6(12)	Coarse	High Lift	65(2-1/2)	75 x 75 (3 x 3)
7.3(24)	Coarse	High Lift	75(3)	75 x 100 (3 x 4)

Notes:

(1) The actual grout space or cell dimension must be larger than the sum of the following items:

a) The required minimum dimensions of total clear areas given in the table above;

b) The width of any mortar projections within the space;

c) The horizontal projections of the diameters of the horizontal reinforcing bars within a cross section of the grout space or cell.

(2) The minimum dimensions of the total clear areas shall be made up of one or more open areas, with at least one area being 20 mm (3/4 inch) or greater in width.

(3) For grouting spaces between masonry wythes.

(4) Where only cells of hollow masonry units containing reinforcement are grouted, the maximum height of the pour shall not exceed the distance between horizontal bond beams.

3.10 BOND BEAMS

Bond beams shall be filled with grout and reinforced as indicated on the drawings. Grout barriers shall be installed under bond beam units to retain the grout as required. Reinforcement shall be continuous, including around corners, except through control joints or expansion joints, unless otherwise indicated on the drawings. Where splices are required for continuity, reinforcement shall be lapped 48 bar diameters. A minimum clearance of 13 mm (1/2 inch) shall be maintained between reinforcement and interior faces of units.

3.11 CONTROL JOINTS

Control joints shall be provided as indicated and shall be constructed by using special control-joint units or sash jamb units with control joint key in accordance with the details shown on the drawings. Sash jamb units shall have a 19 by 19 mm (3/4 by 3/4 inch) groove near the center at end of each unit. The vertical mortar joint at control joint locations shall be continuous, including through all bond beams. This shall be accomplished by utilizing half blocks in alternating courses on each side of the joint. The control joint key shall be interrupted in courses containing continuous bond beam steel. In single wythe exterior masonry walls, the exterior control joints shall be raked to a depth of 20 mm (3/4 inch); backer rod and sealant shall be installed in accordance with Section 07900 JOINT SEALING. Exposed interior control joints shall be raked to a depth of 6 mm (1/4 inch). Concealed control joints shall be flush cut.

3.12 BRICK EXPANSION JOINTS AND CONCRETE MASONRY VENEER JOINTS

Brick expansion joints and concrete masonry veneer joints shall be provided and constructed as shown on the drawings. Joints shall be kept free of mortar and other debris.

3.13 SHELF ANGLES

Shelf angles shall be adjusted as required to keep the masonry level and at the proper elevation. Shelf angles shall be galvanized. Shelf angles shall be provided in sections not longer than 3 m (10 feet) and installed with a 6 mm (1/4-inch) gap between sections. Shelf angles shall be mitered and welded at building corners with each angle not shorter than 1.2 m (4 feet), unless limited by wall configuration.

3.14 LINTELS

3.14.1 Masonry Lintels

Masonry lintels shall be constructed with lintel units filled solid with grout in all courses and reinforced with a minimum of two No. 4 bars in the bottom course unless otherwise indicated on the drawings. Lintel reinforcement shall extend beyond each side of masonry opening 40 bar diameters or 600 mm (24 inches), whichever is greater. Reinforcing bars shall be supported in place prior to grouting and shall be located 15 mm (1/2-inch) above the bottom inside surface of the lintel unit.

3.14.2 Precast Concrete and Steel Lintels

Precast concrete and steel lintels shall be as shown on the drawings. Lintels shall be set in a full bed of mortar with faces plumb and true. Steel and precast lintels shall have a minimum bearing length of 200 mm (8 inches) unless otherwise indicated on the drawings.

3.15 SILLS AND COPINGS

Sills and copings shall be set in a full bed of mortar with faces plumb and true.

3.16 ANCHORAGE TO CONCRETE AND STRUCTURAL STEEL

3.16.1 Anchorage to Concrete

Anchorage of masonry to the face of concrete columns, beams, or walls shall be with dovetail anchors spaced not over 400 mm (16 inches) on centers vertically and 600 mm (24 inches) on center horizontally.

3.16.2 Anchorage to Structural Steel

Masonry shall be anchored to vertical structural steel framing with adjustable steel wire anchors spaced not over 400 mm (16 inches) on centers vertically, and if applicable, not over 600 mm (24 inches) on centers horizontally.

3.17 PARGING

The outside face of below-grade exterior concrete-masonry unit walls enclosing usable rooms and spaces, except crawl spaces, shall be parged with type S mortar. Parging shall not be less than 13 mm (1/2-inch) thick troweled to a smooth dense surface so as to provide a continuous unbroken shield from top of footings to a line 150 mm (6 inches) below adjacent finish grade, unless otherwise indicated. Parging shall be coved at junction of wall and footing. Parging shall be damp-cured for 48 hours or more before backfilling. Parging shall be protected from freezing temperatures until hardened.

3.18 INSULATION

Anchored veneer walls shall be insulated, where shown, by installing board-type insulation on the cavity side of the inner wythe. Board type insulation shall be applied directly to the masonry or thru-wall flashing with adhesive. Insulation shall be neatly fitted between obstructions without impaling of insulation on ties or anchors. The insulation shall be applied in parallel courses with vertical joints breaking midway over the course below and shall be applied in moderate contact with adjoining units without forcing, and shall be cut to fit neatly against adjoining surfaces.

3.19 SPLASH BLOCKS

Splash blocks shall be located as shown.

3.20 POINTING AND CLEANING

After mortar joints have attained their initial set, but prior to hardening, mortar and grout daubs or splashings shall be completely removed from masonry-unit surfaces that will be exposed or painted. Before completion of the work, defects in joints of masonry to be exposed or painted shall be raked out as necessary, filled with mortar, and tooled to match existing joints. Immediately after grout work is completed, scum and stains which have percolated through the masonry work shall be removed using a high pressure stream of water and a stiff bristled brush. Masonry surfaces shall not be cleaned, other than removing excess surface mortar, until mortar in joints has hardened. Masonry surfaces shall be left clean, free of mortar daubs, dirt, stain, and discoloration, including scum from cleaning operations, and with tight mortar joints throughout. Metal tools and metal brushes shall not be used for cleaning.

3.20.1 Concrete Masonry Unit and Concrete Brick Surfaces

Exposed concrete masonry unit and concrete brick surfaces shall be dry-brushed at the end of each day's work and after any required pointing, using stiff-fiber bristled brushes.

3.20.2 Clay or Shale Brick Surfaces

Exposed clay or shale brick masonry surfaces shall be cleaned as necessary to obtain surfaces free of stain, dirt, mortar and grout daubs, efflorescence, and discoloration or scum from cleaning operations. After cleaning, the sample panel of similar material shall be examined for discoloration or stain as a result of cleaning. If the sample panel is discolored or stained, the method of cleaning shall be changed to assure that the masonry surfaces in the structure will not be adversely affected. The exposed masonry surfaces shall be water-soaked and then cleaned with a solution proportioned 30 milliliters

(1/2 cup) trisodium phosphate and 30 milliliters (1/2 cup) laundry detergent to 1 liter (one gallon) of water or cleaned with a proprietary masonry cleaning agent specifically recommended for the color and texture by the clay products manufacturer. The solution shall be applied with stiff fiber brushes, followed immediately by thorough rinsing with clean water. Proprietary cleaning agents shall be used in conformance with the cleaning product manufacturer's printed recommendations. Efflorescence shall be removed in conformance with the brick manufacturer's recommendations.

3.21 BEARING PLATES

Bearing plates for beams, joists, joist girders and similar structural members shall be set to the proper line and elevation with damp-pack bedding mortar, except where non-shrink grout is indicated. Bedding mortar and non-shrink grout shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.22 PROTECTION

Facing materials shall be protected against staining. Top of walls shall be covered with nonstaining waterproof covering or membrane when work is not in progress. Covering of the top of the unfinished walls shall continue until the wall is waterproofed with a complete roof or parapet system. Covering shall extend a minimum of 600 mm (2 feet) down on each side of the wall and shall be held securely in place. Before starting or resuming, top surface of masonry in place shall be cleaned of loose mortar and foreign material.

3.23 TEST REPORTS

3.23.1 Field Testing of Mortar

Except for structures having 185 square meters (2,000 square feet) or less of wall area, including openings, at least three specimens of mortar shall be taken each day. A layer of mortar 13 to 16 mm (1/2 to 5/8 inch) thick shall be spread on the masonry units and allowed to stand for one minute. The specimens shall then be prepared and tested for compressive strength in accordance with ASTM C 780.

3.23.2 Field Testing of Grout

Except for structures having 185 square meters (2,000 square feet) or less of wall area, including openings. Field sampling and testing of grout shall be in accordance with the applicable provisions of ASTM C 1019. A minimum of three specimens of grout per day shall be sampled and tested. Each specimen shall have a minimum ultimate compressive strength of 13.8 MPa (2000 psi) at 28 days.

3.23.3 Efflorescence Test

Brick which will be exposed to weathering shall be tested for efflorescence. Tests shall be scheduled far enough in advance of starting masonry work to permit retesting if necessary. Sampling and testing shall conform to the applicable provisions of ASTM C 67. Units meeting the definition of "effloresced" will be subjected to rejection.

DIVISION 05 METALS

SECTION 05090

WELDING, STRUCTURAL

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC ASD Spec	(1989) Specification for Structural Steel Buildings - Allowable Stress Design and Plastic Design

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ASNT RP SNT-TC-1A	(1996) Recommended Practice SNT-TC-1A

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(1998) Standard Symbols for Welding, Brazing and Nondestructive Examination
AWS A3.0	(1994) Standard Welding Terms and Definitions
AWS D1.1	(1998) Structural Welding Code - Steel
AWS Z49.1	(1999) Safety in Welding and Cutting and Allied Processes

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 0052	(1992) Symbolic Representation of Welds

KS D 7004	(1992) Covered Electrodes for Mild Steel
KS D 7005	(1992) Gas Welding Rods for Mild Steel
KS D 7006	(1992) Covered Electrodes for High Tensile Strength Steel
KS D 7012	(1990) Covered Electrodes for Copper and Copper Alloy
KS D 7014	(1992) Stainless Steel Covered Electrodes

1.2 DEFINITIONS

Definitions of welding terms shall be in accordance with AWS A3.0.

1.3 GENERAL REQUIREMENTS

The design of welded connections shall conform to AISC ASD Spec unless otherwise indicated or specified. Material with welds will not be accepted unless the welding is specified or indicated on the drawings or otherwise approved. Welding shall be as specified in this section, except where additional requirements are shown on the drawings or are specified in other sections. Welding shall not be started until welding procedures, inspectors, nondestructive testing personnel, welders, welding operators, and tackers have been qualified and the submittals approved by the Contracting Officer. Qualification testing shall be performed at or near the work site. Each Contractor performing welding shall maintain records of the test results obtained in welding procedure, welder, welding operator, and tacker performance qualifications.

1.3.1 Pre-erection Conference

A pre-erection conference shall be held, prior to the start of the field welding, to bring all affected parties together and to gain a naturally clear understanding of the project and the Welding Procedure Specifications (WPS) (which the Contractor shall develop and submit for all welding, including welding done using prequalified procedures). Attendees shall include all Contractor's welding production and inspection personnel and appropriate Government personnel. Items for discussion could include: responsibilities of various parties; welding procedures and processes to be followed; welding sequence (both within a joint and joint sequence within the building); inspection requirements and procedures, both visual and ultrasonic; welding schedule; fabrication of mock-up model; and other items deemed necessary by the attendees.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Welding Procedure Qualifications; G. Welder, Welding Operator, and Tacker Qualification; G. Inspector Qualification; G. Previous Qualifications; G. Prequalified Procedures; G.

Copies of the welding procedure specifications; the procedure qualification test records; and the welder, welding operator, or tacker qualification test records.

SD-06 Test Reports

Quality Control; G.

A quality assurance plan and records of tests and inspections.

1.5 WELDING PROCEDURE QUALIFICATIONS

Except for prequalified (per AWS D1.1) and previously qualified procedures, each Contractor performing welding shall record in detail and shall qualify the welding procedure specification for any welding procedure followed in the fabrication of weldments. Qualification of welding procedures shall conform to AWS D1.1 and to the specifications in this section. Copies of the welding procedure specification and the results of the procedure qualification test for each type of welding which requires procedure qualification shall be submitted for approval. Approval of any procedure, however, will not relieve the Contractor of the sole responsibility for producing a finished structure meeting all the requirements of these specifications. This information shall be submitted on the forms in Appendix E of AWS D1.1. Welding procedure specifications shall be individually identified and shall be referenced on the detail drawings and erection drawings, or shall be suitably keyed to the contract drawings. In case of conflict between this specification and AWS D1.1, this specification governs.

1.5.1 Previous Qualifications

Welding procedures previously qualified by test may be accepted for this contract without requalification if the following conditions are met:

a. Testing was performed by an approved testing laboratory, technical consultant, or the Contractor's approved quality control organization.

b. The qualified welding procedure conforms to the requirements of this specification and is applicable to welding conditions encountered under this contract.

c. The welder, welding operator, and tacker qualification tests conform to the requirements of this specification and are applicable to welding conditions encountered under this contract.

1.5.2 Prequalified Procedures

Welding procedures which are considered prequalified as specified in AWS D1.1 will be accepted without further qualification. The Contractor shall submit for approval a listing or an annotated drawing to indicate the joints not prequalified. Procedure qualification shall be required for these joints.

1.5.3 Retests

If welding procedure fails to meet the requirements of AWS D1.1, the procedure specification shall be revised and requalified, or at the Contractor's option, welding procedure may be retested in accordance with AWS D1.1. If the welding procedure is qualified through retesting, all test results, including those of test welds that failed to meet the requirements, shall be submitted with the welding procedure.

1.6 WELDER, WELDING OPERATOR, AND TACKER QUALIFICATION

Each welder, welding operator, and tacker assigned to work on this contract shall be qualified in accordance with the applicable requirements of AWS D1.1 and as specified in this section. Welders, welding operators, and tackers who make acceptable procedure qualification test welds will be considered qualified for the welding procedure used.

1.6.1 Previous Personnel Qualifications

At the discretion of the Contracting Officer, welders, welding operators, and tackers qualified by test within the previous 6 months may be accepted for this contract without requalification if all the following conditions are met:

a. Copies of the welding procedure specifications, the procedure qualification test records, and the welder, welding operator, and tacker qualification test records are submitted and approved in accordance with the specified requirements for detail drawings.

b. Testing was performed by an approved testing laboratory, technical consultant, or the Contractor's approved quality control organization.

c. The previously qualified welding procedure conforms to the requirements of this specification and is applicable to welding conditions encountered under this contract.

d. The welder, welding operator, and tacker qualification tests conform to the requirements of this specification and are applicable to welding conditions encountered under this contract.

1.6.2 Certificates

Before assigning any welder, welding operator, or tacker to work under this contract, the Contractor shall submit the names of the welders, welding operators, and tackers to be employed, and certification that each individual is qualified as specified. The certification shall state the type of welding and positions for which the welder, welding operator, or tacker is qualified, the code and procedure under which the individual is qualified, the date qualified, and the name of the firm and person certifying the qualification tests. The certification shall be kept on file, and 3 copies shall be furnished. The certification shall be kept current for the duration of the contract.

1.6.3 Renewal of Qualification

Requalification of a welder or welding operator shall be required under any of the following conditions:

a. It has been more than 6 months since the welder or welding operator has used the specific welding process for which he is qualified.

b. There is specific reason to question the welder or welding operator's ability to make welds that meet the requirements of these specifications.

c. The welder or welding operator was qualified by an employer other than those firms performing work under this contract, and a qualification test has not been taken within the past 12 months. Records showing periods of employment, name of employer where welder, or welding operator, was last employed, and the process for which qualified shall be submitted as evidence of conformance.

d. A tacker who passes the qualification test shall be considered eligible to perform tack welding indefinitely in the positions and with the processes for which he is qualified, unless there is some specific reason to question the tacker's ability. In such a case, the tacker shall be required to pass the prescribed tack welding test.

1.7 INSPECTOR QUALIFICATION

Inspector qualifications shall be in accordance with AWS D1.1. Nondestructive testing personnel shall be qualified in accordance with the requirements of ASNT RP SNT-TC-1A for Levels I or II in the applicable nondestructive testing method. The inspector may be supported by assistant welding inspectors who are not qualified to ASNT RP SNT-TC-1A, and assistant inspectors may perform specific inspection functions under the supervision of the qualified inspector.

1.8 SYMBOLS

Symbols shall be in accordance with AWS A2.4 or KS B 0052, unless otherwise indicated.

1.9 SAFETY

Safety precautions during welding shall conform to AWS Z49.1.

PART 2 PRODUCTS

2.1 WELDING EQUIPMENT AND MATERIALS

All welding equipment, electrodes, welding wire, and fluxes shall be capable of producing satisfactory welds when used by a qualified welder or welding operator performing qualified welding procedures. All welding equipment and materials shall comply with the applicable requirements of AWS D1.1 or KS D 7004, 7005, 7006, 7012, and 7014.

PART 3 EXECUTION

3.1 WELDING OPERATIONS

3.1.1 Requirements

Workmanship and techniques for welded construction shall conform to the requirements of AWS D1.1 and AISC ASD Spec. When AWS D1.1 and the AISC ASD Spec specification conflict, the requirements of AWS D1.1 shall govern.

3.1.2 Identification

Welds shall be identified in one of the following ways:

a. Written records shall be submitted to indicate the location of welds made by each welder, welding operator, or tacker.

b. Each welder, welding operator, or tacker shall be assigned a number, letter, or symbol to identify welds made by that individual. The Contracting Officer may require welders, welding operators, and tackers to apply their symbol next to the weld by means of rubber stamp, felt-tipped marker with waterproof ink, or other methods that do not cause an indentation in the metal. For seam welds, the identification mark shall be adjacent to the weld at 1 meter (3-foot) intervals. Identification with die stamps or electric etchers shall not be allowed.

3.2 QUALITY CONTROL

Testing shall be done by an approved inspection or testing laboratory or technical consultant, or if approved, the Contractor's inspection and testing personnel may be used instead of the commercial inspection or testing laboratory or technical consultant. The Contractor shall perform visual and one of the nondestructive tests such as radiographic, ultrasonic, magnetic particle, and dye penetrant inspection to determine conformance with paragraph 3.3 STANDARDS OF ACCEPTANCE. Procedures and techniques for inspection shall be in accordance with applicable requirements of AWS D1.1, except that in radiographic inspection only film types designated as "fine grain" or "extra fine", shall be employed.

3.3 STANDARDS OF ACCEPTANCE

Dimensional tolerances for welded construction, details of welds, and quality of welds shall be in accordance with the applicable requirements of AWS D1.1 and the contract drawings. Nondestructive testing shall be by visual inspection and one of radiographic, ultrasonic, magnetic particle, or dye penetrant methods. The minimum extent of nondestructive testing shall be random 30 percent of welds or joints, as indicated on the drawings.

3.3.1 Nondestructive Examination

The welding shall be subject to inspection and tests in the mill, shop, and field. Inspection and tests in the mill or shop will not relieve the Contractor of the responsibility to furnish weldments of satisfactory quality. When materials or workmanship do not conform to the specification requirements, the Government reserves the right to reject material or workmanship or both at any time before final acceptance of the structure containing the weldment.

3.3.2 DESTRUCTIVE TESTS

When metallographic specimens are removed from any part of a structure, the Contractor shall make repairs. The Contractor shall employ qualified welders or welding operators, and shall use the proper joints and welding procedures, including peening or heat treatment if required, to develop the full strength of the members and joints cut and to relieve residual stress.

3.4 GOVERNMENT INSPECTION AND TESTING

In addition to the inspection and tests performed by the Contractor for quality control, the Government will perform inspection and testing for acceptance to the extent determined by the Contracting Officer. The costs of such inspection and testing will be borne by the Contractor if unsatisfactory welds are discovered, or by the Government if the welds are satisfactory. The work may be performed by the Government's own forces or under a separate contract for inspection and testing. The Government reserves the right to perform supplemental nondestructive and destructive tests to determine compliance with paragraph STANDARDS OF ACCEPTANCE.

3.5 CORRECTIONS AND REPAIRS

When inspection or testing indicates defects in the weld joints, the welds shall be repaired using a qualified welder or welding operator as applicable. Corrections shall be in accordance with the requirements of AWS D1.1 and the specifications. Defects shall be repaired in accordance with the approved procedures. Defects discovered between passes shall be repaired before additional weld material is deposited. Wherever a defect is removed and repair by welding is not required, the affected area shall be blended into the surrounding surface to eliminate sharp notches, crevices, or corners. After a defect is thought to have been removed, and before rewelding, the area shall be examined by suitable methods to insure that the defect has been eliminated. Repair welds shall meet the inspection requirements for the original welds. Any indication of a defect shall be regarded as a defect, unless reevaluation by nondestructive methods or by surface conditioning shows that no unacceptable defect is present.

SECTION 05120

STRUCTURAL STEEL

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC FCD (1995a) Quality Certification Program Description

AISC ASD Manual (1989) Manual of Steel Construction Allowable Stress Design

AISC ASD/LRFD Vol II (1992) Manual of Steel Construction Vol II: Connections

AISC Design Guide No. 10 (1989) Erection Bracing of Low-Rise Structural Steel Frames

AISC LRFD Vol I (1995) Manual of Steel Construction Load & Resistance Factor Design, Vol I: Structural Members, Specifications & Codes

AISC LRFD Vol II (1995) Manual of Steel Construction Load & Resistance Factor Design, Vol II: Structural Members, Specifications & Codes

AISC Pub No. S303 (1992) Code of Standard Practice for Steel Buildings and Bridges

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 6/A 6M (1998a) General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

ASTM A 36/A 36M (1997a) Carbon Structural Steel

ASTM A 53 (1999) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A 242/A 242M (1998) High-Strength Low-Alloy Structural Steel

ASTM A 307 (1997) Carbon Steel Bolts and Studs, 60000 PSI Tensile Strength

ASTM A 325 (1997) Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

ASTM A 325M (1997) High-Strength Bolts for Structural Steel Joints (Metric)

ASTM A 490 (1997) Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength

ASTM A 490M (1993) High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric)

ASTM A 500 (1999) Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A 501 (1999) Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

ASTM A 502 (1993) Steel Structural Rivets

ASTM A 514/A 514M (1994a) High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding

ASTM A 529/A 529M (1996) High-Strength Carbon-Manganese Steel of Structural Quality

ASTM A 563 (1997) Carbon and Alloy Steel Nuts

ASTM A 563M (1997) Carbon and Alloy Steel Nuts (Metric)

ASTM A 572/A 572M (1999) High-Strength Low-Alloy Columbium-Vanadium Structural Steel

ASTM A 588/A 588M (1997) High-Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point to 4 in. (100 mm) Thick

ASTM A 618 (1999) Hot-Formed Welded and Seamless High-Strength Low-Alloy Structural Tubing

ASTM A 709/A 709M	(1997a) Carbon and High-Strength Low-Alloy Structural Steel Shapes, Plates, and Bars and Quenched-and-Tempered Alloy Structural Steel Plates for Bridges
ASTM A 852/A 852M	(1997) Quenched and Tempered Low-Alloy Structural Steel Plate with 70 ksi (485 MPa) Minimum Yield Strength to 4 in. (100 mm) Thick
ASTM A 992/A 992M	(1998e1) Steel for Structural Shapes For Use in Building Framing
ASTM F 436	(1993) Hardened Steel Washers
ASTM F 436M	(1993) Hardened Steel Washers (Metric)
ASTM F 844	(1998) Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM F 959	(1999) Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B18.21.1	(1994) Lock Washers (Inch Series)
ASME B46.1	(1995) Surface Texture (Surface Roughness, Waviness and Lay)

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(1998) Standard Symbols for Welding, Brazing and Nondestructive Examination
AWS D1.1	(1998) Structural Welding Code – Steel STEEL STRUCTURES PAINTING COUNCIL (SSPC)

STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SSPC Paint 25	(1991) Red Iron Oxide, Zinc Oxide, Raw Linseed Oil and Alkyd Primer (without Lead and Chromate Pigments)

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1002	(1986) Hexagon Head Bolts and Hexagon Head Screws
KS B 1010	(1981) Sets of High Strength Hexagon Bolt, Hexagon Nut and Plain Washers for Friction Grip Joints
KS B 1012	(1986) Hexagon Nuts and Hexagon Thin Nuts
KS B 1013	(1990) Square Nuts
KS B 1014	(1993) Wing Nuts
KS B 1102	(1996) Hot Head Rivets
KS B 1326	(1980) Plain Washers

KS D 3503 (1993) Rolled Steel for General Structure

KS D 3515 (1997) Rolled Steel for Welded Structures

KS D 3566 (1994) Carbon Steel Tubes for General Structural Purpose

1.2 GENERAL REQUIREMENTS

Structural steel fabrication and erection shall be performed by an organization experienced in structural steel work of equivalent magnitude. The Contractor shall be responsible for correctness of detailing, fabrication, and for the correct fitting of structural members. Connections, for any part of the structure not shown on the contract drawings, shall be considered simple shear connections and shall be designed and detailed in accordance with pertinent provisions of AISC ASD Manual and AISC LRFD Vol II. Substitution of sections or modification of connection details will not be accepted unless approved by the Contracting Officer. AISC ASD Manual and AISC ASD/LRFD Vol II, or AISC LRFD Vol I and AISC LRFD Vol II shall govern the work. Welding shall be in accordance with AWS D1.1; except that welding for critical applications shall be in accordance with Section 05090 WELDING, STRUCTURAL or paragraph WELDING. High-strength bolting shall be in accordance with AISC ASD Manual or AISC LRFD Vol I.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Structural Steel System; G. Structural Connections; G.

Shop and erection details including members (with their connections) not shown on the contract drawings. Welds shall be indicated by standard welding symbols in accordance with AWS A2.4.

SD-03 Product Data

Erection; G.

Prior to erection, erection plan of the structural steel framing describing all necessary temporary supports, including the sequence of installation and removal.

Welding;

WPS, prequalified and not prequalified.

SD-04 Samples

High Strength Bolts and Nuts; G. Carbon Steel Bolts and Nuts; G. Nuts Dimensional Style; G. Washers; G.

Random samples of bolts, nuts, and washers as delivered to the job site if requested, taken in the presence of the Contracting Officer and provided to the Contracting Officer for testing to establish compliance with specified requirements.

SD-07 Certificates

Mill Test Reports; G.

Certified copies of mill test reports for structural steel, structural bolts, nuts, washers and other related structural steel items, including attesting that the structural steel furnished contains no less than 25 percent recycled scrap steel and meets the requirements specified, prior to the installation.

Welder Qualifications; G.

Certified copies of welder qualifications test records showing qualification in accordance with AWS D1.1.

Welding Inspector; G.

Welding Inspector qualifications.

Fabrication; G.

A copy of the AISC certificate indicating that the fabrication plant meets the specified structural steelwork category.

1.4 STORAGE

Material shall be stored out of contact with the ground in such manner and location as will minimize deterioration.

1.5 WELDING INSPECTOR

Welding Inspector qualifications shall be in accordance with AWS D1.1

PART 2 PRODUCTS

2.1 STRUCTURAL STEEL

2.1.1 Carbon Grade Steel

Carbon grade steel shall conform to ASTM A 36/A 36M, ASTM A 529/A 529M, KS D 3503 or KS D 3515.

2.1.2 High-Strength Low-Alloy Steel

High-strength low-alloy steel shall conform to ASTM A 572/A 572M, Grade 42 or above.

2.1.3 Corrosion-Resistant High-Strength Low-Alloy Steel

Corrosion-resistant steel shall conform to ASTM A 242/A 242M or ASTM A 588/A 588M.

2.1.4 Quenched and Tempered Alloy Steel

Tempered alloy steel shall conform to ASTM A 514/A 514M.

2.1.5 Carbon and High-Strength Low-Alloy Steel

Carbon and high-strength low-alloy steel shall conform to ASTM A 709/A 709M.

2.1.6 Quenched and Tempered Low-Alloy Steel

Quenched and tempered low-alloy steel shall conform to ASTM A 852/A 852M, 485 MPa (70 ksi).

2.1.7 Structural Shapes for Use in Building Framing

Wide flange shapes in accordance with ASTM A 992/A 992M shall be used where indicated on the drawings.

2.2 STRUCTURAL TUBING

Structural tubing shall conform to ASTM A 500, Grade B or above, ASTM A 501, ASTM A 618, Grade Ia or Ib, or KS D 3566.

2.3 STEEL PIPE

Steel pipe shall conform to ASTM A 53, Type E or Type S, Grade B.

2.4 RIVETS

Rivets shall conform to ASTM A 502, Grade 2 or KS B 1102.

2.5 HIGH STRENGTH BOLTS AND NUTS

High strength bolts shall conform to ASTM A 325M, Type 1 with carbon steel nuts conforming to ASTM A 563M, Grade C or DH, or ASTM A 490M ASTM A 490, Type 1 or 2 with carbon steel nuts conforming to ASTM A 563M ASTM A 563, Grade DH, or KS B 1010, Class 1 or 2, as indicated on drawings.

2.6 CARBON STEEL BOLTS

Carbon steel bolts shall conform to ASTM A 307, Grade A with carbon steel nuts conforming to ASTM A 563M, Grade A, or KS B 1002.

2.7 NUTS DIMENSIONAL STYLE

Carbon steel nuts shall be Square or Hex Style when used with ASTM A 307 bolts or Heavy Hex style when used with ASTM A 325M, ASTM A 490M bolts, or shall conform to KS B 1012, KS B 1013, or KS B 1014.

2.8 WASHERS

Plain washers shall conform to ASTM F 844 or KS B 1326. Other types, when required, shall conform to ASME B18.21.1, ASTM F 436 or ASTM F 959.

2.9 PAINT

Paint shall conform to SSPC Paint 25.

PART 3 EXECUTION

3.1 FABRICATION

Fabrication shall be in accordance with the applicable provisions of AISC ASD Manual. Fabrication and assembly shall be done in the shop to the greatest extent possible. The fabricating plant shall be certified under the AISC FCD. Compression joints depending on contact bearing shall have a surface roughness not in excess of 13 micrometer (500 micro inches) as determined by ASME B46.1, and ends shall be square within the tolerances for milled ends specified in ASTM A 6/A 6M. Structural steelwork, except surfaces of steel to be encased in concrete, surfaces to be field welded, surfaces to be fireproofed, and contact surfaces of friction-type high-strength bolted connections shall be prepared for painting in accordance with endorsement "P" of AISC FCD and primed with the specified paint.

3.2 ERECTION

a: Erection of structural steel, except as indicated in item b. below, shall be in accordance with the applicable provisions of AISC ASD Manual, AISC LRFD Vol I, or endorsement F of AISC FCD. Erection plan shall be reviewed, stamped and sealed by a structural engineer.

b. For low-rise structural steel buildings (18 m 60 feet tall or less and a maximum of 2 stories), the erection plan shall conform to AISC Pub No. S303 and the structure shall be erected in accordance with AISC Design Guide No. 10.

3.2.1 Structural Connections

Anchor bolts and other connections between the structural steel and foundations shall be provided and shall be properly located and built into connecting work. Field welded structural connections shall be completed before load is applied.

3.2.2 Base Plates and Bearing Plates

Column base plates for columns and bearing plates for beams, girders, and similar members shall be provided. Base plates and bearing plates shall be provided with full bearing after the supported members have been plumbed and properly positioned, but prior to placing superimposed loads. Separate setting plates under column base plates will not be permitted. The area under the plate shall be damp-packed solidly with bedding mortar, except where non-shrink grout is indicated on the drawings. Bedding mortar and grout shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.2.3 Field Priming

After erection, the field bolt heads and nuts, field welds, and any abrasions in the shop coat shall be cleaned and primed with paint of the same quality as that used for the shop coat.

3.3 WELDING

The contractor shall develop and submit the Welding Procedure Specifications (WPS) for all welding, including welding done using prequalified procedures. Prequaliried procedures may be submitted for information only; however, procedures that are not prequalified shall be submitted for approval.

SECTION 05210

STEEL JOISTS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

STEEL JOIST INSTITUTE (SJI)

SJI Specs & Tables (1994) Standard Specifications Load Tables and Weight Tables for Steel Joists and Joist Girders

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Drawings

Steel Joists; G.

Detail drawings shall include fabrication and erection details, specifications for shop painting, and identification markings of joists and joist girders.

SD-7 Certificates

Steel Joists; G.

Certificates stating that the steel joists and joist girders have been designed and manufactured in accordance with SJI Specs & Tables. Complete engineering design computations may be submitted in lieu of the certification.

1.3 GENERAL REQUIREMENTS

Steel joists and joist girders are designated on the drawings in accordance with the standard designations of the Steel Joist Institute. Joists of other standard designations or joists with properties other than those shown may be substituted for the joists designated provided the structural properties are equal to or greater than those of the joists shown and provided all other specified requirements are met.

1.4 DELIVERY AND STORAGE

Materials shall be delivered to the site in undamaged condition and stored off the ground in a well drained location, protected from damage, and easily accessible for inspection and handling.

PART 2 PRODUCTS

2.1 OPEN WEB STEEL JOISTS

Open web steel joists shall conform to SJI Specs & Tables, K-Series. Joists shall be designed to support the loads given in the standard load tables of SJI Specs & Tables.

2.2 LONGSPAN STEEL JOISTS

Longspan steel joists and deep longspan steel joists shall conform to SJI Specs & Tables, LH-Series or DLH-Series. Joists designated LH and DLH shall be designed to support the loads given in the applicable standard load tables of SJI Specs & Tables.

2.3 JOIST GIRDERS

Joist girders shall conform to SJI Specs & Tables.

2.4 ACCESSORIES AND FITTINGS

Accessories and fittings, including end supports and bridging, shall be in accordance with the standard specifications under which the members were designed.

2.5 SHOP PAINTING

Joists, joist girders and accessories shall be shop painted with a rust-inhibiting primer paint. For joists and joist girders which will be finish painted under Section 09900 PAINTING, GENERAL, the primer paint shall be limited to a primer which is compatible with the specified finish paint.

PART 3 EXECUTION

3.1 ERECTION

Installation of joists and joist girders shall be in accordance with the standard specification under which the member was produced. Joists and joist girders shall be handled in a manner to avoid damage. Damaged joists and joist girders shall be removed from the site, except when field repair is approved and such repairs are satisfactorily made in accordance with the manufacturer's recommendations. Joists and joist girders shall be accurately set, and end anchorage shall be in accordance with the standard specification under which the joists and joist girders were produced. For spans over 12 m (40 ft) through 18 m (60 ft) one row of bridging nearest midspan shall be bolted diagonal bridging; for spans over 18 m (60 ft) bolted diagonal bridging shall be used instead of welded horizontal bridging. Joist bridging and anchoring shall be secured in place prior to the application of any construction loads. Any temporary loads shall be distributed so that the carrying capacity of any joist is not exceeded. Loads shall not be applied to bridging during construction or in the completed work. Abraded, corroded, and field welded areas shall be cleaned and touched up with the same type of paint used in the shop painting.

3.2 BEARING PLATES

Bearing plates shall be provided with full bearing after the supporting members have been plumbed and properly positioned, but prior to placing superimposed loads. The area under the plate shall be damp-packed solidly with bedding mortar, except where nonshrink grout is indicated on the drawings. Bedding mortar and grout shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

SECTION 05300

STEEL DECKING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 335 (1989) Specification for Structural Steel Buildings - Allowable Stress Design and Plastic Design

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI SG-973 (1996) Cold-Formed Steel Design Manual

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 108 (1995) Steel Bars, Carbon, Cold Finished, Standard Quality

ASTM A 570/A 570M (1996) Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality

ASTM A 611 (1997) Structural Steel (SS), Sheet, Carbon, Cold-Rolled

ASTM A 653/A 653M (2000) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A 780 (2000) Repair of Damaged and Uncoated Areas of Hot-Dipped

Galvanized Coatings

ASTM A 792/A 792M (1999) Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process

ASTM C 423 (1990a) Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method

ASTM E 795 (2000) Mounting Test Specimens During Sound Absorption Tests

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2000) Structural Welding Code - Steel

AWS D1.3 (1998) Structural Welding Code – Sheet Steel

STEEL DECK INSTITUTE (SDI)

SDI DDM01 (1991) Diaphragm Design Manual

SDI 30 (1995) Design Manual for Composite Decks, Form Decks, Roof Decks, and Cellular Metal Floor Deck with Electrical Distribution

STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SSPC Paint 20 (1991) Zinc-Rich Primers (Type I - Inorganic and Type II - Organic)

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506 (1995) Hot-dip Zinc-coated Steel Sheet and Coil

KS D 3512 (1996) Cold Rolled Carbon Steel Sheets and Strip

KS D 3555 (1991) Hot-Rolled Carbon Steel Strip for Pipes and Tubes

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Deck Units; G. Accessories; G. Attachments; G. Holes and Openings; G.

Drawings shall include type, configuration, structural properties, location, and necessary details of deck units, accessories, and supporting members; size and location of holes to be cut and reinforcement to be provided; location and sequence of welded or fastener connections; and the manufacturer's erection instructions.

SD-03 Product Data

Deck Units; G.

Design computations for the structural properties of the deck units or SDI certification that the units are designed in accordance with SDI specifications.

Attachments; G.

Prior to welding operations, copies of qualified procedures and lists of names and identification symbols of qualified welders and welding operators.

SD-04 Samples

Deck Units; G. Accessories; G.

A 0.19 sq meter sample of the decking material to be used, along with a sample of each of the accessories used. A sample of acoustical material to be used shall be included.

SD-07 Certificates

Deck Units; Attachments;

Manufacturer's certificates attesting that the decking material meets the specified requirements. Manufacturer's certificate attesting that the operators are authorized to use the low-velocity piston tool.

1.3 DELIVERY, STORAGE, AND HANDLING

Deck units shall be delivered to the site in a dry and undamaged condition, stored off the ground with one end elevated, and stored under a weathertight covering permitting good air circulation. Finish of deck units shall be maintained at all times by using touch-up paint whenever necessary to prevent the formation of rust.

PART 2 PRODUCTS

2.1 DECK UNITS

Deck units shall conform to SDI Pub No 29. Panels of maximum possible lengths shall be used to minimize end laps. Deck units shall be fabricated in lengths to span 3 or more supports with flush, telescoped, or nested 50 mm (2 inch) laps at ends, and interlocking, or nested side laps, unless otherwise indicated. Deck with cross-sectional configuration differing from the units indicated may be used, provided that the properties of the proposed units, determined in accordance with AISI Cold-Formed Mnl, are equal to or greater than the properties of the units indicated and that the material will fit the space provided without requiring revisions to adjacent materials or systems.

2.1.1 Roof Deck

Steel deck used in conjunction with insulation and built-up roofing shall conform to ASTM A 792/A 792M, ASTM A 611 or ASTM A 792/A 792M. Roof deck units shall be fabricated of 0.75 mm (0.0295 inch) design thickness or the steel design thickness required by the design drawings and shall be painted with an epoxy coating or equivalent applied to prime-coating in accordance with manufacturer's standard or zinc-coated in conformance with ASTM A 653/A

653M, G90 coating class or aluminum-zinc coated in accordance with ASTM A 792 A 792M Coating Designation AZ55.

2.1.2 Acoustical Deck Units

Deck shall have a noise reduction coefficient of 0.70 when measured in accordance with ASTM C 423 using ASTM E 795 Mounting Type F-25. Sound absorbing materials shall be either glass fiber in roll or premolded form for acoustical steel deck (noncellular) or glass fiber rigid strip for acoustical steel deck (cellular) in accordance with manufacturer's standards.

2.1.3 Composite Deck

Deck to receive concrete as a filler or for composite deck assembly shall conform to ASTM A 653/A 653M or ASTM A 611. Deck used as the tension reinforcing in composite deck shall be fabricated of 0.75 mm (0.0295 inch) design thickness or thicker steel, or the steel design thickness required by the design drawings, and shall be zinc-coated in conformance with ASTM A 653/A 653M, G60 or G90 coating class. Deck units used in composite deck shall have adequate embossment to develop mechanical shear bond to provide composite action between the deck and the concrete.

2.1.4 Form Deck

Deck used as a permanent form for concrete shall conform to ASTM A 653/A 653M or ASTM A 611. Deck used as a form for concrete shall be fabricated of 0.38 mm (0.015 inch) design thickness or thicker steel or the steel design thickness required by the design drawings, and shall be painted with one coat of manufacturer's standard paint or zinc-coated in conformance with ASTM A 653/A 653M, G60 or G90 coating class.

2.1.5 Sump Pans

Sump pans shall be provided for roof drains and shall be minimum 2 mm (0.075 inch) thick steel, flat or recessed type. Sump pans shall be shaped to meet roof slope by the supplier or by a sheet metal specialist. Bearing flanges of sump pans shall overlap steel deck a minimum of 75 mm (3 inches). Opening in bottom of pan shall be shaped, sized, and reinforced to receive roof drain.

2.1.6 Shear Connectors

Shear connectors shall be headed stud type, ASTM A 108, Grade 1015 or 1020, cold finished carbon steel with dimensions complying with AISC ASD Specification or strap type, ASTM A 570/A 570M, Grade D, hot-rolled carbon steel.

2.2 TOUCH-UP PAINT

Touch-up paint for shop-painted units shall be of the same type used for the shop painting, and touch-up paint for zinc-coated units shall be an approved galvanizing repair paint with a high-zinc dust content. Welds shall be touched-up with paint conforming to SSPC Paint 20 in accordance with ASTM A 780. Finish of deck units and accessories shall be maintained by using touch-up paint whenever necessary to prevent the formation of rust.

2.3 ADJUSTING PLATES

Adjusting plates or segments of deck units shall be provided in locations too narrow to accommodate full-size units. As far as practical, the plates shall be the same thickness and configuration as the deck units.

2.4 CLOSURE PLATES

2.4.1 Closure Plates for Roof Deck

Voids above interior walls shall be closed with sheet metal where shown. Open deck cells at parapets, end walls, eaves, and openings through roofs shall be closed with sheet metal. Sheet metal shall be same thickness as deck units.

2.4.2 Closure Plates for Composite Deck

The concrete shall be supported and retained at each floor level. Provide edge closures at all edges of the slab of sufficient strength and stiffness to support the wet concrete. Metal closures shall be provided for all openings in composite steel deck 6 mm (1/4 inch) and over, including but not limited to:

2.4.2.1 Cover Plates to Close Panels

Cover plates to close panel edge and end conditions and where panels change direction or abut. Butt joints in composite steel deck may receive a tape joint cover.

2.4.2.2 Column Closures to Close Openings

Column closures to close openings between steel deck and structural steel columns.

2.4.2.3 Sheet Metal

Where deck is cut for passage of pipes, ducts, columns, etc., and deck is to remain exposed, provide a neatly cut sheet metal collar to cover edges of deck. Do not cut deck until after installation of supplemental supports.

2.5 ACCESSORIES

The manufacturer's standard accessories shall be furnished as necessary to complete the deck installation. Metal accessories shall be of the same material as the deck and have minimum design thickness as follows: saddles, 1.204 mm (0.0474 inch); welding washers, 1.519 mm (0.0598 inch); cant strip, 0.749 mm (0.0295 inch); other metal accessories, 0.909 mm (0.0358 inch); unless otherwise indicated. Accessories shall include but not be limited to saddles, welding washers, cant strips, butt cover plates, underlapping sleeves, and ridge and valley plates.

PART 3 EXECUTION

3.1 ERECTION

Erection of deck and accessories shall be in accordance with SDI Pub No 29 or SDI Diaphram Mnl and the approved detail drawings. Damaged deck and accessories including material which is permanently stained or contaminated, with burned holes or deformed shall not be installed. The deck units shall be placed on secure supports, properly adjusted, and aligned at right angles to supports before being permanently secured in place. The deck shall not be filled with concrete, used for storage or as a working platform until the units have been secured in position. Shoring shall be in position before concrete placement begins in composite or form deck. Loads shall be distributed by appropriate means to prevent damage during construction and to the completed assembly. The maximum uniform distributed storage load shall not exceed the design live load. There shall be no loads suspended directly from the steel deck. Acoustical material shall be neatly fitted into the rib voids.

3.2 SHORING

Shoring requirements for placing and curing of concrete in the composite floor and roof deck assemblies shall be as shown.

3.3 ATTACHMENTS

All fasteners shall be installed in accordance with the manufacturer's recommended procedure, except as otherwise specified. The deck units shall be welded with nominal 16 mm (5/8 inch) diameter puddle welds, or fastened with screws, powder-actuated fasteners or pneumatically driven fasteners to supports as indicated on the design drawings and in accordance with requirements of SDI Pub No 29. All welding of steel deck shall be in accordance with AWS D1.3 using methods and electrodes as recommended by the manufacturer of the steel deck being used. Welds shall be made only by operators previously qualified by tests prescribed in AWS D1.3 to perform the type of work required. Welding washers shall not be used at the connections of the deck to supports. Welding washers shall not be used at sidelaps. Holes and similar defects will not be acceptable. Deck ends shall be lapped 50 mm (2 inches) or butted. All partial or segments of deck units shall be attached to structural supports in accordance with Section 2.5 of SDI Diaphram Mnl. Powder-actuated fasteners shall be driven with a low-velocity piston tool by an operator authorized by the manufacturer of the piston tool. Pneumatically driven fasteners shall be driven with a low-velocity fastening tool and shall comply with the manufacturer's recommendations. Shear connectors shall be attached as shown and shall be welded as per AWS D1.1 through the steel deck to the steel member or directly to the steel member.

3.4 HOLES AND OPENINGS

All holes and openings required shall be coordinated with the drawings, specifications, and other trades. Holes and openings shall be drilled or cut, reinforced and framed as indicated on the drawings or described in the specifications and as required for rigidity and load capacity. Holes and openings less than 150 mm (6 inches) across require no reinforcement. Holes and openings 150 to 300 mm (6 to 12 inches) across shall be reinforced by 1.204 mm (0.0474-inch) thick steel sheet at least 300 mm (12 inches) wider and longer than the opening and be fastened to the steel deck at each corner of the sheet and at a maximum of 150 mm (6 inches) on center. Holes and openings larger than 300 mm (12 inches) shall be reinforced by steel angles installed perpendicular to the steel joists and supported by the adjacent steel joists. Steel angles shall be installed perpendicular to the deck ribs and shall be fastened to the angles perpendicular to the steel joists. Openings must not interfere with seismic members such as chords and drag struts.

3.5 PREPARATION OF FIRE-PROOFED SURFACES

Deck surfaces, both composite and noncomposite, which are to receive sprayed-on fireproofing, shall be galvanized and shall be free of all grease, mill oil, paraffin, dirt, salt, and other contaminants which impair adhesion of the fireproofing. Any required cleaning shall be done prior to steel deck installation using a cleaning method that is compatible with the sprayed-on fireproofing.

SECTION 05500

MISCELLANEOUS METAL

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF-45 (1997) Designation System for Aluminum Finishes

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A14.3 (1992) Ladders - Fixed - Safety Requirements

ANSI MH28.1 (1982) Design, Testing, Utilization, an Application of Industrial Grade Steel Shelving

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36/A 36M (2002a) Carbon Structural Steel

ASTM A 123/A 123M (2001) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 283/A 283M (2000) Low and Intermediate Tensile Strength Carbon Steel Plates

ASTM A 36/A 36M (2000a) Carbon Structural Steel

ASTM A 467/A 467M (1998) Machine and Coil Chain

ASTM A 475 (1998) Zinc-Coated Steel Wire Strand

ASTM A 500 (1999) Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A 53/A 53M (2001) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A 653/A 653M (2000) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A 924/A 924M (1999) General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

ASTM B 221 (2000) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

ASTM B 221M (2000) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)

ASTM B 26/B 26M	(1999) Aluminum-Alloy Sand Castings
ASTM B 429	(2000) Aluminum-Alloy Extruded Structural Pipe and Tube
ASTM D 2047	(1999) Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine
ASTM E 814	(2000) Fire Tests of Through-Penetration Fire Stops
ASTM F 1267	(1991; R 1997) Metal, Expanded, Steel

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7	(1998) Minimum Design Loads for Buildings and Other Structures

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1	(2000) Structural Welding Code - Steel

COMMERCIAL ITEM DESCRIPTIONS (CID)

CID A-A-344	(Rev B) Lacquer, Clear Gloss, Exterior, Interior

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM MBG 531	(1994) Metal Bar Grating Manual
NAAMM MBG 532	(1994) Heavy Duty Metal Bar Grating Manual

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 10	(1998; Errata 10-98-1) Portable Fire Extinguishers
NFPA 211	(2000) Chimneys, Fireplaces, Vents and Solid Fuel-Burning Appliances

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-344 (Rev B) Lacquer, Clear Gloss, Exterior, Interior

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3503	(1993) Rolled Steel for General Structure
KS D 3506	(1995) Hot-dip Zinc-coated Steel Sheet and Coil
KS D 3515	(1997) Rolled Steel for Welded Structures
KS D 3566	(1991) Carbon Steel Tubes for General Structural Purpose
KS D 6761	(1998) Aluminum and Aluminum Alloy Seamless Pipes and Tubes
KS D 7007	(1996) Zinc Coated Steel Wire Strands
KS D 7018	(1997) Chain Link Wire Netting
KS D 8308	(1986) Zinc Hot Dip Galvanizings

KS D 9521 (1988) Recommended Practice for Zinc Coating (Hot Dipped)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Miscellaneous Metal Items; G.

Detail drawings indicating material thickness, type, grade, and class; dimensions; and construction details. Drawings shall include catalog cuts, erection details, manufacturer's descriptive data and installation instructions, and templates.

SD-04 Samples

Miscellaneous Metal Items; G.

Samples shall be full size, taken from manufacturer's stock, and shall be complete as required for installation in the structure. Samples may be installed in the work, provided each sample is clearly identified and its location recorded.

1.3 GENERAL REQUIREMENTS

The Contractor shall verify all measurements and shall take all field measurements necessary before fabrication. Welding to or on structural steel shall be in accordance with AWS D1.1. Items specified to be galvanized, when practicable and not indicated otherwise, shall be hot-dip galvanized after fabrication. Galvanizing shall be in accordance with ASTM A 123, ASTM A 653, ASTM A 924 or KS D 3506, as applicable. Exposed fastenings shall be compatible materials, shall generally match in color and finish, and shall harmonize with the material to which fastenings are applied. Materials and parts necessary to complete each item, even though such work is not definitely shown or specified, shall be included. Poor matching of holes for fasteners shall be cause for rejection. Fastenings shall be concealed where practicable. Thickness of metal and details of assembly and supports shall provide strength and stiffness. Joints exposed to the weather shall be formed to exclude water.

1.4 DISSIMILAR MATERIALS

Where dissimilar metals are in contact, or where aluminum is in contact with concrete, mortar, masonry, wet or pressure-treated wood, or absorptive materials subject to wetting, the surfaces shall be protected with a coat of bituminous paint or asphalt varnish.

1.5 WORKMANSHIP

Miscellaneous metalwork shall be well formed to shape and size, with sharp lines and angles and true curves. Drilling and punching shall produce clean true lines and surfaces. Welding shall be continuous along the entire area of contact except where tack welding is permitted. Exposed connections of work in place shall not be tack welded. Exposed welds shall be ground smooth. Exposed surfaces of work in place shall have a smooth finish, and unless otherwise approved, exposed riveting shall be flush. Where tight fits are required, joints shall be milled. Corner joints shall be coped or mitered, well formed, and in true alignment. Work shall be accurately set to established lines and elevations and securely fastened in place. Installation shall be in accordance with manufacturer's installation instructions and approved drawings, cuts, and details.

1.6 ANCHORAGE

Anchorage shall be provided where necessary for fastening miscellaneous metal items securely in place. Anchorage not otherwise specified or indicated shall include slotted inserts made to engage with the anchors, expansion shields, and power-driven fasteners when approved for concrete; toggle bolts and through bolts for masonry; machine and carriage bolts for steel; and lag bolts and screws for wood.

1.7 ALUMINUM FINISHES

Unless otherwise specified, aluminum items shall have standard mill finish or anodized finish. The thickness of the coating shall be not less than that specified for protective and decorative type finishes for items used in interior locations or architectural Class I type finish for items used in exterior locations in AA DAF-45. Items to be anodized shall receive a polished satin finish. Aluminum surfaces to be in contact with plaster or concrete during construction shall be protected with a field coat conforming to CID A-A-344, for protection from plaster or concrete during construction.

1.8 SHOP PAINTING

Surfaces of ferrous metal except galvanized surfaces, shall be cleaned and shop coated with the manufacturer's standard protective coating unless otherwise specified. Surfaces of items to be embedded in concrete shall not be painted. Items to be finish painted shall be prepared according to manufacturer's recommendations or as specified.

PART 2 PRODUCTS

2.1 ACCESS DOORS AND PANELS

Doors and panels shall be flush type unless otherwise indicated. Frames for access doors shall be fabricated of not lighter than 1.52 mm (16 gauge) steel with welded joints and finished with anchorage for securing into construction. Access doors shall be a minimum of 350 by 500 mm (14 by 20 inches) and of not lighter than 1.9 mm (14 gauge) steel, with stiffened edges, complete with attachments. Access doors shall be hinged to frame and provided with a flush face, screw driver operated latch. Access doors in fire-rated walls and ceilings shall be of equivalent fire ratings. Exposed metal surfaces shall have a baked enamel finish.

2.2 CHIMNEYS, VENTS, AND SMOKESTACKS

Chimneys and vents shall be designed and constructed in accordance with NFPA 211. Chimney connectors shall be formed of not lighter than 1.01 mm (20 gauge) galvanized steel. Stacks shall be designed and constructed to withstand the local maximum wind velocity of the projected area. Unlined stacks shall be constructed of black-steel plates not less than 5 mm (3/16 inch) thick conforming to ASTM A 36/A 36M. Seams and joints shall be welded, except that an angle flange shall be provided for connection to the boiler, other equipment, and stack support.

2.3 CLEANOUT DOORS

Cleanout doors shall be galvanized or cast iron, shall be provided with frames, and unless otherwise indicated, shall be sized to match flues. The frames shall have a continuous flange and anchors for securing into masonry. The doors shall be smokeproof, hinged, and shall have fastening devices to hold the door closed.

2.4 COAL-HOPPER DOORS

Coal-hopper doors shall be constructed of galvanized steel plates and shapes and shall be complete with frame, stops, wall box, hinges, and hasp or locktype latch. Joints and attachments shall be welded.

2.5 CORNER GUARDS AND SHIELDS

Corner guards and shields for jambs and sills of openings and edges of platforms shall be steel shapes and plates anchored in masonry or concrete with welded steel straps or end weld stud anchors. Corner guards for use with glazed or ceramic tile finish on walls shall be formed of 1.6 mm (0.0625 inch) thick corrosion-resisting steel with polished or satin finish, shall extend 1.5 m (5 feet) above the top of cove base or to the top of the wainscot, whichever is less, and shall be securely anchored to the supporting wall. Corner guards on exterior shall be galvanized.

2.6 DOOR GUARDS

Door guards shall be constructed of woven steel wire or expanded metal framed with structural steel shapes. Expanded metal guards shall be of 38 mm (1-1/2 inch) No. 10 mesh, welded to 25 by 25 by 3 mm (1 by 1 by 1/8 inch) angle frame. Woven-wire panel shall be of 10 gauge, 38 mm (1-1/2 inch) mesh secured through weaving to 25 mm (1 inch) channel frame or around a 10 mm (3/8 inch) round bar frame. Corners of frames shall be mitered and welded. Guards shall be sized as indicated.

2.7 PIPE GUARDS

Pipe guards shall be heavy duty steel pipe conforming to ASTM A 53/A 53M, Type E or S, weight STD, black finish, or KS D 3566, STK 400 or above.

2.8 DOWNSPOUT BOOTS

Downspout boots shall be cast iron with receiving bells sized to fit downspouts.

2.9 EXPANSION JOINT COVERS

Expansion joint covers shall be constructed of extruded aluminum with anodized satin finish for walls and ceilings and with standard mill finish for floor covers and exterior covers. Plates, backup angles, expansion filler strip and anchors shall be designed as indicated.

2.10 FIRE ESCAPES

Fire escapes shall be fabricated of steel shapes, shall have treads, platforms and railings as specified for steel stairs, and shall be complete with required fastenings and accessories. Fire escapes and accessories shall be galvanized.

2.11 FLOOR GRATINGS AND FRAMES

Carbon steel, Aluminum or Stainless steel grating shall be designed in accordance with NAAMM MBG 531 and NAAMM MBG 532 to meet the indicated load requirements. Edges shall be banded with bars 6 mm (1/4 inch) less in height than bearing bars for grating sizes above 19 mm (3/4 inch). Banding bars shall be flush with the top of bearing grating. Frames shall be of welded steel construction finished to match the grating. Floor gratings and frames shall be galvanized after fabrication.

2.12 FLOOR PLATES

Floor plates shall be 6 mm (1/4 inch) thick, galvanized or slip-resistant, carbon steel conforming with ASTM A 283 having a minimum static coefficient of friction of 0.50 when tested in accordance with ASTM D 2047. Wearing surface shall be aluminum oxide or silicon carbide.

2.13 HANDRAILS

Handrails shall be designed to resist a concentrated load of 890 N (200 pounds) in any direction at any point of the top of the rail or 292 Newtons per meter (20 pounds per foot) applied horizontally to top of the rail, whichever is more severe.

2.13.1 Steel Handrails, Including Carbon Steel Inserts

Steel handrails, including inserts in concrete, shall be steel pipe conforming to ASTM A 53/A 53M or KS D 3566 or structural tubing conforming to ASTM A 500, Grade A or B of equivalent strength. Steel railings shall be 40 mm (1-1/2 inch) or 50 mm (2 inch) nominal size. Railings shall be hot-dip galvanized and shop painted. Pipe collars shall be hot-dip galvanized steel.

a. Joint posts, rail, and corners shall be fabricated by one of the following methods:

(1) Flush type rail fittings of commercial standard, welded and ground smooth with railing splice locks secured with 10 mm (3/8 inch) hexagonal recessed-head setscrews.

(2) Mitered and welded joints by fitting post to top rail and intermediate rail to post, mitering corners, groove welding joints, and grinding smooth. Railing splices shall be butted and reinforced by a tight fitting interior sleeve not less than 150 mm (6 inches) long.

(3) Railings may be bent at corners in lieu of jointing, provided bends are made in suitable jigs and the pipe is not crushed.

b. Removable sections, toe-boards, and brackets shall be provided as indicated.

2.13.2 Aluminum Handrails

Handrails shall consist of 40 mm (1-1/2 inch) or 50 mm (2 inch) nominal Schedule 40 pipe ASTM B 429 or KS D 6761. Railings and pipe collars shall be mill finish or anodized. All fasteners shall be Series 300 stainless steel.

a. Jointing shall be by one of the following methods:

(1) Flush type rail fittings, welded and ground smooth with splice locks secured with 10 mm (3/8 inch) recessed head setscrews.

(2) Mitered and welded joints, made by fitting post to top rail and intermediate rail to post and corners, shall be groove welded and ground smooth. Splices, where allowed by the Contracting Officer, shall be butted and reinforced by a tight fitting dowel or sleeve not less than 150 mm (6 inches) in length. Dowel or sleeve shall be connected to one side of the splice by tack welding or by using epoxy cement.

(3) Railings shall be assembled using slip-on aluminum-magnesium alloy fittings for joints. Fittings shall be fastened to pipe or tube with 6 mm (1/4 inch) or 10 mm (3/8 inch) stainless steel recessed head setscrews. Assembled railings shall be provided with fittings only at vertical supports or at rail terminations attached to walls. Expansion joints shall be at the midpoint of panels. A setscrew shall be provided in only one side of the slip-on sleeve. Alloy fittings shall conform to ASTM B 26/B 26M.

b. Removable sections, toe-boards and brackets shall be provided where indicated, using flange castings as appropriate.

2.14 GUY CABLES

Guy cables shall be prestretched, galvanized wire rope of the sizes indicated. Wire rope shall conform to ASTM A 475 or KS D 7007, high strength grade with Class A coating. Guys shall have a factory attached clevis top-end fitting; guys shall have a factory attached open-bridge strand socket bottom-end fitting; guys shall be complete with oval eye, threaded anchor rods. Fittings and accessories shall be hot-dip galvanized.

2.15 LADDERS

Ladders shall be galvanized steel or aluminum, fixed rail type in accordance with ANSI A14.3.

2.16 METAL GRID WALKWAYS

Metal grid walkways shall be designed to protect rooftops from pedestrian traffic and shall be 2.0 mm (14 gauge) minimum galvanized steel or 2.0 mm (12 gauge) minimum aluminum. The walkway shall consist of metal planks, 610 by 3050 or 3650 mm (2 by 10 or 12 feet), bolted or welded to support stands. Other sizes may be furnished if approved. In addition to end supports, a midspan support shall be provided when required to limit deflection. End supports shall be located to avoid uplift and to provide continuous runs.

2.17 MIRROR FRAMES

Frames for plate glass mirrors larger than 450 by 750 mm (18 by 30 inches) shall be fabricated from extruded aluminum with anodized finish or corrosion-resisting steel with satin finish. Frames shall be provided with concealed fittings and tamperproof mountings.

2.18 MISCELLANEOUS

Miscellaneous plates and shapes for items that do not form a part of the structural steel framework, such as lintels, sill angles, miscellaneous mountings, and frames, shall be provided to complete the work.

2.19 PARTITIONS, DIAMOND MESH TYPE

Partitions shall be constructed of metal fabric attached to structural steel framing members. Fabric shall be 10 gauge steel wires woven into 38 mm (1-1/2 inch) diamond mesh with wire secured through weaving channels, or expanded metal of 38 mm (1-1/2 inch), No. 10 diamond mesh secured to channel frame by welding, or 8 gauge steel wires woven into 50 mm (2 inch) diamond mesh with wire secured through weaving channels. Framing members shall be channels 38 by 3 mm (1-1/2 by 1/8 inch) minimum size. Channel frames shall be mortised and tenoned at intersections. Steel frames, posts, and intermediate members shall be of the sizes and shapes indicated. Cast-iron floor shoes and caps shall have setscrew adjustment. Doors and grilles shall be provided as indicated, complete with hardware and accessories including sliding mechanisms, locks, guard plates, sill shelves and brackets, and fixed pin butts. Doors and grilles shall have cover plates as indicated. Dutch doors shall have a lock for each leaf. A continuous rubber bumper shall be provided at bottom of grille frame. Locks shall be bronze, cylinder, mortise type. Keying shall be coordinated with Section 08700 BUILDERS' HARDWARE. Ferrous metal portions of partitions and accessories shall be galvanized.

2.20 ROOF SCUTTLES

Roof scuttles shall be of aluminum or galvanized steel not less than 2.0 mm (14 gauge) with 75 mm (3 inch) beaded flange welded and ground at corners. Scuttle shall be sized to provide minimum clear opening of 940 by 760 mm (37 by 30 inches). Cover and curb shall be insulated with 25 mm (1 inch) thick rigid insulation covered and protected by aluminum sheet or galvanized steel liner not less than 0.55 mm (26 gauge). The curb shall be equipped with an integral metal cap flashing of the same gauge and metal as the curb, full welded and ground at corners for weathertightness. Scuttle shall be completely assembled with heavy hinges, compression spring operators enclosed in telescopic tubes, positive snap latch with turn handles on inside and outside and neoprene draft seal. Fasteners shall be provided for padlocking on the inside. The cover shall be equipped with an automatic hold-open arm complete with handle to permit one hand release.

2.21 SAFETY CHAINS

Safety chains shall be galvanized welded steel, proof coil chain tested in accordance with ASTM A 467/A 467M, Class CS. Safety chains shall be straight link style, 5 mm (3/16 inch) diameter, minimum 39 links per meter (12 links per foot) and with bolt type snap hooks on each end. Eye bolts for attachment of chains shall be galvanized 10 mm (3/8 inch) bolt with 19 mm (3/4 inch) eye, anchored as indicated. Two chains shall be furnished for each guarded opening.

2.22 SAFETY NOSING

Safety nosings shall be of cast iron or cast aluminum with cross-hatched or plain, abrasive surface. Nosing shall be 75 mm (3 inches) wide and terminating at not more than 150 mm (6 inches) from the ends of treads, except nosing for metal pan cement-filled treads shall extend the full length of the tread. Safety nosings shall be provided with anchors not less than 19 mm (3/4 inch) long. Integrally cast mushroom anchors are not acceptable.

2.23 SHELVING

Shelving shall conform to ANSI MH28.1. Minimum dimensions and number of shelves shall be as indicated.

2.24 STEEL STAIRS

Steel stairs shall be complete with structural or formed channel stringers, steel plate treads and risers, metal pan cement-filled treads, grating treads, or slip-resistant metallic treads, and landings, columns, handrails, and necessary bolts and other fastenings as indicated. Structural steel shall conform to ASTM A 36/A 36M or KS D 3503. Stairs and accessories shall be galvanized. Risers on stairs with metal pan treads shall be deformed to form a sanitary cove to retain the tread concrete. Integral nosings shall have braces extended into the concrete fill. Gratings for treads and landings shall conform to NAAMM MBG 531. Grating treads shall have slip-resistant nosings.

2.25 STEEL DOOR FRAMES

Steel door frames built from structural shapes shall be neatly mitered and securely welded at the corners with all welds ground smooth. Jambs shall be provided with 50 by 6 by 300 mm (2 by 1/4 by 12 inch) bent, adjustable metal anchors spaced not over 760 mm (2 feet 6 inches) on centers. Provision shall be made to stiffen the top member for all spans over 900 mm (3 feet). Continuous door stops shall be made of 38 by 16 mm (1-1/2 by 5/8 inch) bars.

2.26 TRENCH COVERS, FRAMES, AND LINERS

Trench frames and anchors shall be all welded steel construction designed to match cover. Covers shall be secured to frame or have flush drop handles formed of 6 mm (1/4 inch) round stock, and shall be raised-tread, or steel floor plate, or cast-iron grating. Grating opening widths shall not exceed 25 mm (1 inch). Trench liners shall be cast iron with integral frame for cover.

2.27 WHEELGUARDS

Wheelguards shall be hollow, heavy duty, cast iron half round or three quarters round, at least 450 mm (18 inches) high designed to provide a minimum of 150 mm (6 inches) of protection.

2.28 WINDOW GUARDS, BAR GRILLE TYPE

Bar grill window guards shall be of 19 mm (3/4 inch) round bars, spaced not over 100 mm (4 inches) on centers vertically, and 50 by 13 mm (2 by 1/2 inch) horizontal bars spaced not over 300 mm (12 inches) on centers. Vertical bars shall be extended through and securely welded to the cross bars. Horizontal bars shall be extended, bent, and drilled as shown for anchorage at jambs of window openings.

2.29 WINDOW GUARDS, DIAMOND MESH TYPE

Diamond mesh window guards shall be constructed of woven steel wire or expanded metal frames with hot-rolled or cold-formed steel shapes. Expanded metal conforming to ASTM F 1267 shall be of 38 mm (1-1/2 inch), No. 10 mesh, welded to 25 by 25 by 3 mm (1 by 1 by 1/8 inch) angle frame. Woven-wire panels shall be of 10 gauge, 38 mm (1-1/2 inch) mesh secured through weaving bar to 10 mm (3/8 inch) round or 25 mm (1 inch) channel frame. Corners of frames shall be mitered and welded or mortised and tenoned. One tamperproof hasp and padlock, with access from the interior, shall be provided for each butt used.

2.30 FIRE EXTINGUISHER CABINETS

Cabinets to be located in fire-rated walls shall be fire-rated type, fabricated in accordance with ASTM E 814, and shall be listed by an approved testing agency for 1- and 2-hour combustible and non-combustible wall systems. The testing agency's seal shall be affixed to each fire-rated cabinet. Cabinets shall be of the recessed type suitable for extinguishers. Box and trim shall be of heavy gage rolled steel. Door shall be a rigid frame with full length piano type hinge and double strength (DSA) glass panel. Door and panel shall be prime-coated inside and out or have the manufacturer's standard white baked enamel finish inside and out.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

All items shall be installed at the locations shown and according to the manufacturer's recommendations. Items listed below require additional procedures as specified.

3.2 REMOVABLE ACCESS PANELS

A removable access panel not less than 300 by 300 mm (12 by 12 inches) shall be installed directly below each valve, flow indicator, damper, or air splitter that is located above the ceiling, other than an acoustical ceiling, and that would otherwise not be accessible.

3.3 INSTALLATION OF CHIMNEYS, VENTS, AND SMOKESTACKS

Chimneys and vents shall be installed in accordance with NFPA 211. A cleanout opening with a tight-fitting, hinged, cast-iron door and frame shall be provided at the base of each smokestack. A top band shall be provided on stacks for attachment of painter's rigging. Roof housing, rain cap, downdraft diverter, fire damper, and other accessories required for a complete installation shall be provided. Sections of prefabricated lined stacks shall be joined with acid-resisting high-temperature cement and steel draw bands. Means to prevent accumulation of water in the smokestack shall be provided.

3.4 DOOR GUARD FRAME

Door guard frame shall be mounted over the glazed opening using 6 mm (1/4 inch) lag bolts on the interior of wood doors or tamperproof through bolts on the interior of metal doors.

3.5 INSTALLATION OF PIPE GUARDS

Pipe guards shall be set vertically in concrete piers. Piers shall be constructed of, and the hollow cores of the pipe filled with, concrete specified in SECTION 03300 CAST-IN-PLACE STRUCTURAL CONCRETE or having a compressive strength of 21 MPa (3000 psi).

3.6 INSTALLATION OF DOWNSPOUT BOOTS

Downspouts shall be secured to building through integral lips with appropriate fasteners.

3.7 ATTACHMENT OF HANDRAILS

Toeboards and brackets shall be installed where indicated. Splices, where required, shall be made at expansion joints. Removable sections shall be installed as indicated.

3.7.1 Installation of Steel Handrails

Installation shall be one of the followings: in pipe sleeves embedded in concrete and filled with molten lead or sulphur with anchorage covered with standard pipe collar pinned to post; by means of pipe sleeves secured to wood with screws or masonry with expansion shields and bolts or toggle bolts, or base plates bolted to stringers or structural steel framework. Rail ends shall be secured by steel pipe flanges anchored by expansion shields and bolts, or through-bolted to a back plate or by 6 mm (1/4 inch) lag bolts to studs or solid backing.

3.7.2 Installation of Aluminum Handrails

Installation shall be by means of one of the followings: flanges anchored to concrete or masonry by expansion shields; base plates or flanges bolted to stringers or structural steel framework; flanges through-bolted to a back plate or by 6 mm (1/4 inch) lag bolts to studs or other structural members. Bolts used to anchor aluminum alloy flanges shall be stainless steel of a size appropriate to the standard product of the manufacturer. Where aluminum or alloy fittings or extrusions are to be in contact with dissimilar metals or portland cement concrete, the contact surface shall be given a heavy coating of bituminous paint or asphalt varnish.

3.8 ERECTION OF GUY CABLES

Guy cables shall be erected as indicated. Anchor rods shall be cast in concrete located and reinforced as shown.

3.9 INSTALLATION OF METAL GRID WALKWAYS

Walkways shall be installed after final flood coat and aggregate surfacing. Each stand shall be set on a protective pad; the pad may be adhesively attached to the bottom of the stand or set loose under the stand. The area where the supports are to be located shall be swept clear of loose aggregate. Protective pad shall be placed on the roof membrane except on inverted roofs where the protective pad shall be set on the rigid insulation.

3.10 PARTITION POSTS AND OPENINGS

Posts shall be set in shoes bolted to the floor and in caps tap-screwed to clip angles in overhead construction, as indicated. Openings shall be formed using channels similar to the partition frames at ducts, pipes, and other obstructions.

3.11 RECESSED FLOOR MATS

Contractor shall verify field measurements prior to releasing materials for fabrication by the manufacturer. A mat frame shall be used to ensure recess accuracy in size, shape and depth. Drain pit shall be formed by blocking out concrete when frames are installed. Pit shall be dampproofed after concrete has set. Frames shall be assembled onsite and installed so that upper edge will be level with finished floor surface. A cement base shall be screeded inside the mat recess frame area using the edge provided by the frame as a guide. The frame shall be anchored into the cement with anchor pins a minimum of 610 mm (24 inches) on centers.

3.12 MOUNTING OF SAFETY CHAINS

Safety chains shall be mounted 1070 mm (3 feet 6 inches) and 610 mm (2 feet) above the floor.

3.13 INSTALLATION OF SAFETY NOSINGS

Nosing shall be completely embedded in concrete before the initial set of the concrete occurs and shall finish flush with the top of the concrete surface.

3.14 DOOR FRAMES

Door frames shall be secured to the floor slab by means of angle clips and expansion bolts. Continuous door stops shall be welded to the frame or tap screwed with countersunk screws at no more than 450 mm (18 inch) centers, assuring in either case full contact with the frame. Any necessary reinforcements shall be made and the frames shall be drilled and tapped as required for hardware.

3.15 TRENCH FRAMES AND COVERS

Trench frames and covers shall finish flush with the floor.

3.16 INSTALLATION OF WHEEL GUARDS

Wheel guards shall be filled with concrete and anchored to the floor or the building according to the manufacturer's recommendations.

3.17 BAR-GRILLE WINDOW GUARDS

Bar-grille window guards shall be securely anchored to masonry with 13 mm (1/2 inch) diameter prison-type screws or bolts and expansion shields, or other type of fastenings if the ends of such fastenings are welded to the adjoining metal grilles or otherwise made tamperproof in a satisfactory manner. Spanner-head screws or bolts are not considered prison-type fasteners.

3.18 DIAMOND MESH WINDOW GUARDS

Diamond mesh window guards shall be mounted on interior window frame with not less than two tamperproof hinged butts mounted on wood jambs, or exterior of window frame with not less than two tamperproof hinged butts mounted on 25 by 300 by 3 mm (1 by 12 by 1/8 inch) jamb channel attached as indicated to 50 by 6 mm (2 by 1/4 inch) plate anchored to wood jamb with 6 mm (1/4 inch) lag bolt, to masonry jamb with toggle bolts, or to concrete jambs and solid masonry jambs with expansion shields and bolts. One additional butt shall be provided for each 900 mm (3 foot) internal length of guard over 1500 mm (5 feet). Hasp and padlock shall be installed on the jamb opposite to that hinged.

3.19 INSTALLATION OF FIRE EXTINGUISHER CABINETS

Metal fire extinguisher cabinets shall be furnished and installed where shown on the drawings or specified.

DIVISION 06 WOOD & PLASTICS

SECTION 06100

ROUGH CARPENTRY

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN FOREST & PAPER ASSOCIATION (AF&PA)

AF&PA T01 (1991; Supple 1993; Addenda Apr 1997; Supple T02) National Design Specification for Wood Construction

AF&PA T11 (1988) Manual for Wood Frame Construction

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.4 (1995) Basic Hardboard

AHA A194.1 (1985) Cellulosic Fiber Board

AMERICAN INSTITUTE OF TIMBER CONSTRUCTION (AITC)

AITC TC Manual (1994) Timber Construction Manual

AITC 109 (1990) Standard for Preservative Treatment of Structural Glued Laminated Timber

AITC 111	(1979) Recommended Practice for Protection of Structural Glued Laminated Timber During Transit, Storage and Erection
AITC 190.1	(1992) Wood Products - Structural Glued Laminated Timber

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A208.1	(1999) Particleboard Mat Formed Woods

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 307	(2000) Carbon Steel Bolts and Studs, 60000 PSI Tensile Strength
ASTM C 79/C 79M	(1997) Treated Core and Nontreated Core Gypsum Sheathing Board
ASTM C 208	(1995) Cellulosic Fiber Insulating Board
ASTM C 516	(1980; R 1996el) Vermiculite Loose Fill Thermal Insulation
ASTM C 518	(1998) Steady-State Heat Flux Measurements and Thermal Transmission Properties By Means of the Heat Flow Meter Apparatus
ASTM C 549	(1981; R 1995e1) Perlite Loose Fill Insulation
ASTM C 552	(2000) Cellular Glass Thermal Insulation
ASTM C 553	(1992) Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C 578	(1995) Rigid, Cellular Polystyrene Thermal Insulation
ASTM C 591	(1994) Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C 612	(2000) Mineral Fiber Block and Board Thermal Insulation
ASTM C 665	(1998) Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing
ASTM C 726	(2000) Mineral Fiber Roof Insulation Board
ASTM C 739	(2000) Cellulosic Fiber (Wood-Base) Loose-Fill Thermal Insulation
ASTM C 764	(1998) Mineral Fiber Loose-Fill Thermal Insulation
ASTM C 1136	(1995) Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C 1177/C 1177M	(1996) Glass Mat Gypsum Substrate for Use as Sheathing
ASTM C 1289	(1998) Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board
ASTM D 2898	(1999) Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing

ASTM D 3498 (1999) Standard Specification for Adhesives for Field-Gluing Plywood to Lumber Framing for Floor Systems

ASTM E 84 (2000a) Surface Burning Characteristics of Building Materials

ASTM E 96 (2000) Water Vapor Transmission of Materials

ASTM E 154 (1988; R 1999) Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover

ASTM F 547 (1977; R 1995) Definitions of Terms Relating to Nails for Use with Wood and Wood-Base Materials

AMERICAN WOOD-PRESERVERS' ASSOCIATION (AWPA)

AWPA C2 (2000) Lumber, Timber, Bridge Ties and Mine Ties - Preservative Treatment by Pressure Processes

AWPA C9 (1997) Plywood - Preservative Treatment by Pressure Processes

AWPA C20 (1996) Structural Lumber Fire-Retardant Pressure Treatment

AWPA C27 (1996) Plywood - Fire-Retardant Pressure Treatment

AWPA M4 (1996) Standard for the Care of Preservative-Treated Wood Products

AWPA P5 (2000) Standards for Waterborne Preservatives

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA EWS R540C (1996) Builder Tips Proper Storage and Handling of Glulam Beams

APA EWS T300C (1997) Technical Note Glulam Connection Details

APA PRP-108 (1980; Rev Jan 1996) Performance Standards and Policies for Structural-Use Panels

CALIFORNIA REDWOOD ASSOCIATION (CRA)

CRA RIS-01-SS (1997) Standard Specifications for Grades of California Redwood Lumber

CODE OF FEDERAL REGULATIONS (CFR)

16 CFR 1209 Interim Safety Standard for Cellulose Insulation

DEPARTMENT OF COMMERCE (DOC)

DOC PS 1 (1996) Voluntary Product Standard - Construction and Industrial Plywood

DOC PS 2 (1992) Performance Standards for Wood-Based Structural-Use Panels

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM LPD 1-49 (1995) Loss Prevention Data Sheet - Perimeter Flashing

NATIONAL HARDWOOD LUMBER ASSOCIATION (NHLA)

NHLA Rules (1994) Rules for the Measurement & Inspection of Hardwood & Cypress

NORTHEASTERN LUMBER MANUFACTURERS ASSOCIATION (NELMA)

NELMA Grading Rules (1997) Standard Grading Rules for Northeastern Lumber

SOUTHERN CYPRESS MANUFACTURERS ASSOCIATION (SCMA)

SCMA Specs (1986; Supple No. 1, Aug 1993) Standard Specifications for Grades of Southern Cypress

SOUTHERN PINE INSPECTION BUREAU (SPIB)

SPIB Rules (1994; Supple 8 thru 11) Standard Grading Rules for Southern Pine Lumber

TRUSS PLATE INSTITUTE (TPI)

TPI 1 (1995; Errata) National Design Standard for Metal Plate-Connected Wood Truss Construction and Commentary; and Apendix 1

TPI Bklet HIB (1991) Handling, Installing & Bracing Metal Plate Connected Wood Trusses

WEST COAST LUMBER INSPECTION BUREAU (WCLIB)

WCLIB Std 17 (1996; Supples VII(A-E), VIII(A-C)) Grading Rules for West Coast Lumber

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA Grading Rules (1999) Western Lumber Grading Rules 95

KOREA INDUSTRIAL STANDARDS (KS)

KS D 3553 (1990) Round Wire Nails

KS F 3101 (1997) Ordinary Plywood

KS F 3104 (1997) Particle Board

KS F 3113 (1999) Plywood for Structures

KS F 3114 (1994) Plywood for Floor

KS F 3504 (1996) Gypsum Boards

KS F 3701 (1991) Perlite

KS F 3702 (1997) Vermiculite

KS L 9102 (1995) Glass Fiber Insulating Material

KS M 3808	(1997) Foam Polystyrene Thermal Insulation Material
KS M 3809	(1997) Thermal Insulation Material Made of Rigid Urethane Foam

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Structural Wood Members; G. Installation of Framing; G.

Drawings of structural laminated members, fabricated wood trusses, engineered wood joists and rafters, and other fabricated structural members indicating materials, shop fabrication, and field erection details; including methods of fastening.

Nailers and Nailing Strips; G.

Drawings of field erection details, including materials and methods of fastening nailers in conformance with Factory Mutual wind uplift rated systems specified in other Sections of these specifications.

SD-03 Product Data

Structural Wood Members; G.

Design analysis and calculations of structural laminated members, fabricated wood trusses, and other fabricated structural members showing design criteria used to accomplish the applicable analysis.

Product Installations; G.

List containing name and location of successful installation of similar type of fabricated structural members specified herein.

SD-07 Certificates

Grading and Marking; G.

Manufacturer's certificates (approved by an American Lumber Standards approved agency) attesting that lumber and material not normally grade marked meet the specified requirements. Certificate of Inspection for grade marked material by an American Lumber Standards Committee (ALSC) recognized inspection agency prior to shipment.

Insulation; G.

Certificate attesting that the cellulose, perlite, glass and mineral fiber,glass mat gypsum roof board, polyurethane, or polyisocyanurate insulation furnished for the project contains recovered material, and showing an estimated percent of such recovered material.

1.3 DELIVERY AND STORAGE

Materials shall be delivered to the site in undamaged condition, stored off ground in fully covered, well ventilated areas, and protected from extreme changes in temperature and humidity. Laminated timber shall be handled and stored in accordance with AITC 111 or EWS R540.

PART 2 PRODUCTS

2.1 LUMBER AND SHEATHING

2.1.1 Grading and Marking

2.1.1.1 Lumber Products

Solid sawn and finger-jointed lumber shall bear an authorized gradestamp or grademark recongnized by ALSC, or an ALSC recognized certification stamp, mark, or hammerbrand. Surfaces that are to be exposed to view shall not bear grademarks, stamps, or any type of identifying mark. Hammer marking will be permitted on timbers when all surfaces will be exposed to view.

2.1.1.2 Fabricated Structural Members

Wood trusses shall be fabricated in accordance with TPI 1. Laminated timbers shall be marked with a quality mark indicating conformance to AITC A190.1. Engineered wood joists and rafters shall be fabricated using an approved quality control system to meet specified requirements.

2.1.1.3 Plywood and other Sheathing Products

Materials shall bear the grademark or other identifying marks indicating grades of material and rules or standards under which produced, including requirements for qualifications and authority of the inspection organization. Except for plywood and wood structural panels, bundle marking will be permitted in lieu of marking each individual piece. Surfaces that are to be exposed to view shall not bear grademarks or other types of identifying marks.

2.1.2 Sizes

Lumber and material sizes shall conform to requirements of the rules or standards under which produced. Unless otherwise specified, lumber shall be surfaced on four sides. Unless otherwise specified, sizes indicated are nominal sizes, and actual sizes shall be within manufacturing tolerances allowed by the standard under which the product is produced.

2.1.3 Treatment

Exposed areas of treated wood that are cut of drilled after treatment shall receive a field treatment in accordance with AWPA M4. Items of all-heart material of cedar, cypress, or redwood will not require preservative treatment, except when in direct contact with soil. Except as specified for all-heart material of the previously mentioned species, the following items shall be treated:

a. Wood members in contact with or within 455 mm (18 inches) of soil.

b. Wood members in contact with water.

c. Wood members exposed to the weather including those used in built-up roofing systems or as nailing strips or nailers over fiberboard or gypsum-board wall sheathing as a base for wood siding.

d. Wood members set into concrete regardless of location, including flush-with-deck wood nailers for roofs.

e. Wood members in contact with concrete that is in contact with soil or water or that is exposed to weather.

2.1.3.1 Lumber and Timbers

Lumber and timbers shall be treated in accordance with AWPA C2 with waterborne preservatives listed in AWPA P5 to a retention level as follows:

a. 4 kg per cubic meter (0.25 pcf) intended for above ground use.

b. 6.4 kg per cubic meter (0.40 pcf) intended for ground contact and fresh water use.

2.1.3.2 Plywood

Plywood shall be treated in accordance with AWPA C9 or KS F 3101, Class 1 with waterborne preservatives listed in AWPA P5 to a retention level as follows:

a. 4 kg per cubic meter (0.25 pcf) intended for above ground use.

b. 6.4 kg per cubic meter (0.40 pcf) intended for ground contact and fresh water use.

2.1.4 Moisture Content

At the time lumber and other materials are delivered and when installed in the work their moisture content shall be as follows:

a. Treated and Untreated Lumber Except Roof Planking: 100 mm (4 inches) or less, nominal thickness, 19 percent maximum. 125 mm (5 inches) or more, nominal thickness, 23 percent maximum in a 75 mm (3 inch) perimeter of the timber cross-section.

b. Roof Planking: 15 percent maximum.

c. Materials Other Than Lumber: In accordance with standard under which product is produced.

2.1.5 Fire-Retardant Treatment

Fire-retardant treated wood shall be pressure treated in accordance with AWPA C20 for lumber and AWPA C27 for plywood. Material use shall be defined in AWPA C20 and AWPA C27 for Interior Type A and B and Exterior Type. Treatment and performance inspection shall be by an independent and qualified testing agency that establishes performance ratings. Each piece or bundle of treated material shall bear identification of the testing agency to indicate performance in accordance with such rating. Treated materials to be exposed to rain wetting shall be subjected to an accelerated weathering technique in accordance with ASTM D 2898 prior to being tested for compliance with AWPA C20 or AWPA C27. Fire-retardant treated plywood shall be used only for nonstructural applications which are not subject to elevated temperature or high humidity. Fire-retardant treated plywood shall not be used in any part of the roof or roofing system.

2.1.6 Structural Wood Members

Species and grades shall be as listed in AF&PA T01. Structural lumber used in fabrication of bolted trusses and other fabricated structural members for engineered uses, except laminated members, shall have allowable design values of 7.2 MPa (1,050 psi) in bending for single member use; 8.3 MPa (1200 psi) in bending for repetitive member use; 4.8 MPa (700 psi) in tension parallel to the grain; 2.1 MPa (300 psi) in compression perpendicular to the grain; 2.1 MPa (300 psi) in compression parallel to the grain; 0.4 MPa (60 psi) in horizontal shear; and a modulus of elasticity of 8,275 Mpa (1,200,000 psi). Joists, rafters including trussed type, decking, and headers shall have design values of 8.275 MPa (1,200 psi) in bending for repetitive member uses. Design of members and fastenings shall conform to AITC TC Manual. Other stress graded or dimensioned items such as blocking, carriages, and studs shall be standard or No. 2 grade except that studs may be Stud grade.

2.1.6.1 Trussed Rafters

As an option to standard rafters, trussed rafters may be provided. The design shall be as indicated. Connections shall be made with light-metal plate-connectors. Light-metal-plate-connected wood trusses shall be designed and fabricated in conformance with TPI 1. When new plate configuration is proposed, load testing of trusses is required and shall conform to Appendix D of TPI 1.

2.1.6.2 Engineered Wood Joists and Rafters

As an option to standard rafters, engineered wood joists and rafters may be provided. Engineered wood rafters shall be wood I-joists manufactured in accordance with a nationally recognized code and installed in accordance with the manufacturer's recommendations.

2.1.7 Sheathing

Sheathing shall be fiberboard, gypsum board, plywood, structural-use panels, or wood for wall sheathing; and plywood, structural-use panels, or wood for roof sheathing.

2.1.7.1 Fiberboard

Fiberboard shall conform to ASTM C 208, Type IV, Grade 2, Structural Grade, or AHA A194.1, Type IV, Grade 2 asphalt impregnated or asphalt coated to be water-resistant but vapor permeable.

2.1.7.2 Gypsum Board

Gypsum board shall conform to ASTM C 79/C 79M or KS F 3504, 13 mm thick (1/2 inch thick), 1200 mm (4 feet) wide with straight edges for supports 400 mm (16 inches) on center without corner bracing of framing or for supports 600 mm (24 inches) on center with corner bracing of framing; 600 mm wide (2 feet wide) with V-tongue and groove edges for supports 400 or 600 mm (16 or 24 inches) on center with corner bracing of framing.

2.1.7.3 Plywood

Plywood shall conform to DOC PS 1, APA PRP-108 or DOC PS 2, Grade C-D with exterior glue with exterior glue, or KS F 3113, Class 1. Sheathing for roof and walls without corner bracing of framing shall have a span rating of 16/0 or greater for supports 400 mm (16 inches) on center and a span rating of 24/0 or greater for supports 600 mm (24 inches) on center.

2.1.7.4 Wood Structural Panels

Panels shall meet the qualification requirements of APA PRP-108 or DOC PS 2 for rated sheathing, Exposure 1 or Structural I rated sheathing, Exposure 1.

Sheathing for roofs or walls without corner bracing of framing shall have a span rating of 16/0 or greater for supports 400 mm (16 inches) on center and shall have a span rating of 24/0 or greater for supports 600 mm (24 inches) on center.

2.1.7.5 Wood

Species and grade shall be in accordance with TABLE I at the end of this section. Wall sheathing shall be 25 mm (1 inch) thick for supports 400 or 600 mm (16 or 24 inches) on center without corner bracing of framing provided sheathing is applied diagonally. Roof sheathing shall be 25 mm (1-inch) thick for supports 400 or 600 mm (16 or 24 inches) on center.

2.1.8 Subflooring

2.1.8.1 Plywood

Plywood shall conform to DOC PS 1, APA PRP-108 or DOC PS 2; Grade C-D or Sheathing grade with exterior glue or KS F 3114, Class 1 for uses not otherwise specified; Grade C-D or sheathing grade with exterior glue for reception of underlayment or wood flooring; underlayment grade with exterior glue, or C-C (plugged) exterior grade for use as a combination subfloor-underlayment under resilient flooring. Minimum span rating for subflooring shall be 24/16 for supports 400 mm (16 inches) on center, and 48/24 for supports 600 mm (24 inches) on center. Minimum span rating for combination subfloor-underlayment shall be 16/0 for supports 400 mm (16 inches) on center and 24/0 for supports at 600 mm (24 inches) on center.

2.1.8.2 Structural-Use Panels

Rated structural-use panels shall be qualified for subflooring or combination subfloor-underlayment under APA PRP-108 or DOC PS 2. Subflooring shall be rated sheathing with a span rating of 24/16 or greater for supports 400 mm (16 inches) on center and shall have span rating of 48/24 or greater for supports 600 mm (24 inches) on center. Combination subfloor-underlayment shall have a span rating of 16/O or greater for supports 400 mm (16 inches) on center and shall have span rating for 24/O or greater for supports 600 mm (24 inches) on center.

2.1.8.3 Wood

Species and grade shall be in accordance with TABLE I at the end of this section, 25 mm (1 inch) thick, center-matched, shiplapped, or square edge.

2.1.9 Underlayment

Underlayment shall conform to one of the following:

2.1.9.1 Hardboard

AHA A135.4 service class, sanded one side, 6.4 mm (1/4 inch) thick, 1200 mm (4 feet) wide.

2.1.9.2 Particleboard

ANSI A208.1, Grade 1-M-1, 6.4 mm (1/4 inch) thick, 1200 x 1200 mm (4 x 4 feet) or KS F 3104.

2.1.9.3 Plywood

Plywood shall conform to DOC PS 1, underlayment grade with exterior glue, or C-C (Plugged) exterior grade 9 mm (11/32 inch) thick, 1200 mm (4 feet) wide, or KS F 3114, Class 1.

2.1.10 Shear Wall Panels

Panels used in shear wall construction shall be of the span rating and thickness shown and shall be plywood conforming to DOC PS 1 or DOC PS 2, Grade C-D with exterior glue or Grade C-D, Structural I; or wood structural panels conforming to APA PRP-108 or DOC PS 2, rated sheathing, Exposure I or Structural I rated sheathing, Exposure 1.

2.1.11 Roof Decking

Exposed roof decking shall be commercial grade with minimum design value of 7.6 MPa (1100 psi) in bending. Decking shall be 50 mm (2 inches) thick with single tongue and groove or 100 mm (4 inches) thick with double tongue and groove; V-jointed, matched and dressed. As an option, fabricated laminated lumber decking with interlocking tongue and groove joints may be provided.

2.1.12 Miscellaneous Wood Members

2.1.12.1 Nonstress Graded Members

Members shall include bridging, corner bracing, furring, grounds, and nailing strips. Members shall be in accordance with TABLE I for the species used. Sizes shall be as follows unless otherwise shown:

Member	Size [mm(inch)]
Bridging	25 by 75 (1 by 3) or 25 by 100 (1 by 4) for use between members 50 by 300 (2 by 12) and smaller; 50 by 100 (2 by 4) for use between members larger than 50 by 300 (2 by 12).
Corner bracing	25 by 100 (1 by 4).
Furring	25 (1) by 50 (2) or 75 (3).
Grounds	Plaster thickness by 38 (1-1/2).
Nailing strips	25 by 75 (1 by 3) or 25 by 100 (1 by 4) when used as shingle base or interior finish, otherwise 50 mm (2 inch) stock.

2.1.12.2 Wood Bumpers

Bumpers shall be of the species and grade in accordance with TABLE II in paragraph 3.11 TABLES, size as shown.

2.1.12.3 Sill Plates

Sill plates shall be standard or number 2 grade.

2.1.12.4 Blocking

Blocking shall be standard or number 2 grade.

2.1.12.5 Rough Bucks and Frames

Rough bucks and frames shall be straight standard or number 2 grade.

2.2 ACCESSORIES AND NAILS

Markings shall identify both the strength grade and the manufacturer. Accessories and nails shall conform to the following:

2.2.1 Anchor Bolts

ASTM A 307, size as indicated, complete with nuts and washers.

2.2.2 Bolts: Lag, Toggle, and Miscellaneous Bolts and Screws

Type, size, and finish best suited for intended use. Finish options include zinc compounds, cadmium, and aluminum paint impregnated finishes.

2.2.3 Clip Angles

Steel, 5 mm (3/16 inch) thick, size best suited for intended use; or zinc-coated steel or iron commercial clips designed for connecting wood members.

2.2.4 Expansion Shields

Type and size best suited for intended use.

2.2.5 Joist Hangers

Steel or iron, zinc-coated, size to fit members where used, sufficient strength to develop the full strength of supported member, complete with any special nails required.

2.2.6 Metal Bridging

Optional to wood bridging; zinc-coated steel, size and design to provide rigidity equivalent to specified wood bridging.

2.2.7 Nails and Staples

ASTM F 547 or KS D 3553, size and type best suited for purpose; staples shall be as recommended by the manufacturer of the materials to be joined. For sheathing and subflooring, length of nails shall be sufficient to extend 25 mm (1 inch) into supports. In general, 8-penny or larger nails shall be used for nailing through 25 mm (1 inch) thick lumber and for toe nailing 50 mm (2 inch) thick lumber; 16-penny or larger nails shall be used for nailing through 50 mm (2 inch) thick lumber. Nails used with treated lumber and sheathing shall be galvanized. Nailing shall be in accordance with the recommended nailing schedule contained in AF&PA T11. Where detailed nailing requirements are not specified, nail size and spacing shall be sufficient to develop an adequate strength for the connection. The connection's strength shall be verified against the nail capacity tables in AF&PA T01. Reasonable judgement backed by experience shall ensure that the designed connection will not cause the wood to split. If a load situation exceeds a reasonable limit for nails, a specialized connector shall be used.

2.2.8 Timber Connectors

Unless otherwise specified, timber connectors shall be in accordance with TPI 1, APA EWS T300C or AITC TC Manual.

2.3 INSULATION

Thermal resistance of insulation shall be not less than the R-values shown. R-values shall be determined at 24 degrees C (75 degrees F) in accordance with ASTM C 518. Insulation shall contain the highest practicable percentage of recovered material which has been recovered or diverted from solid waste, but not including material reused in a manufacturing process. Where two materials have the same price and performance, the one containing the higher recovered material content shall be provided. Insulation shall be the standard product of a manufacturer and factory marked or identified with manufacturer's name or trademark and R-value. Identification shall be on individual pieces or individual packages. Materials containing more than one percent asbestos will not be allowed.

2.3.1 Batt or Blanket

2.3.1.1 Glass Fiber Batts and Rolls

Glass fiber batts and rolls shall conform to ASTM C 665, Type I unfaced insulation, Type II kraft faced insulation or Type III foil faced insulation, Class A, having a UL rating of 25 and a smoke developed rating of 150 or less when tested in accordance with ASTM E 84; or KS L 9102. Insulation shall have a 0.25 mm (10 mil) thick, white, puncture resistant woven-glass cloth with vinyl facing on one side. Width and length shall suit construction conditions.

2.3.1.2 Mineral Fiber Batt

Mineral fiber batt shall conform to ASTM C 665, Type I unfaced insulation, Type II kraft faced insulation, Class C or Type III foil faced insulation, Class C, or KS L 9102.

2.3.1.3 Mineral Fiber Blanket

Mineral fiber blanket shall conform to ASTM C 553, Type I, Class 6. Blankets shall be sized to suit construction conditions, resilient type for use below and above ambient temperature to 195 degrees C (350 degrees F). Blankets shall have a factory applied vapor-barrier facing on one side with 50 mm (2 inch) nailing tabs on both edges. Vapor barriers shall be fire retardant, high vapor transmission, and aluminum foil laminated to crepe paper type conforming to ASTM C 1136, Type II. Nominal density shall be 12 kg per cubic meter (0.75 pcf).

2.3.2 Loose Fill or Granular Fill

2.3.2.1 Vermiculite

Vermiculite shall conform to ASTM C 516, Type II or KS F 3702.

2.3.2.2 Perlite

Perlite shall conform to ASTM C 549, Type II or KS F 3701 with minimum recovered material content of 23 percent by weight of core material.

2.3.2.3 Mineral Fiber

Mineral fiber shall conform to ASTM C 764, Type I or II. Blown-in mineral fiber insulation shall conform to ASTM C 764, Type I, Category 1, one percent or less loss on ignition or Category 2, 12 percent or less loss on ignition. Blown-in insulation shall be used in attics or floors directly over ceilings, in wall spaces where mineral fiber flexible blankets cannot be used.

2.3.2.4 Cellulosic or Wood Fiber

Cellulosic or wood fiber shall conform to ASTM C 739 or 16 CFR 1209 with minimum recovered material content of 75 percent by weight of core material. Cellulosic or wood fiber insulation shall not be used for family housing construction. The use of cellulosic or wood fiber insulation should be limited to dry areas and areas treated with non-corrosive fire retardant.

2.3.3 Sill Sealer

Mineral wool, 25 mm (1 inch) thick and compressible to 0.8 mm (1/32 inch), width of sill, designed to perform as an air, dirt, and insect seal in conformance with ASTM C 665, Type I.

2.3.4 Rigid Insulation

2.3.4.1 Polystyrene Board

Polystyrene board shall be extruded and conform to ASTM C 578, Type IV, or KS M 3808.

2.3.4.2 Polyurethane or Polyisocyanurate Board

Polyurethane or polyisocyanurate board shall have a minimum recovered material content of 9 percent by weight of core material in the polyurethane or polyisocyanurate portion. Unfaced preformed polyurethane shall conform to ASTM C 591 or KS M 3809. Faced polyisocyanurate shall conform to ASTM C 1289.

2.3.4.3 Glass Fiber or Insulation Board

Glass mat gypsum roof board shall conform to ASTM C 1177/C 1177M, flame spread 0, smoke developed 0, psi 500, water resistant. Glass fiber or insulation board shall conform to ASTM C 612, Type 1A with a minimum recovered material content of 6 percent by weight of glass fiber core material, or KS L 9102.

2.3.4.4 Mineral Fiber Block and Board

Mineral fiber block and board shall conform to ASTM C 612 or ASTM C 726 with a minimum recovered material content of 5 percent by weight of mineral fiber core material.

Mineral fiber block and board shall conform to ASTM C 612 or ASTM C 726 with a minimum recovered material content of 5 percent by weight of mineral fiber core material.

2.3.4.5 Cellular Glass

Cellular glass shall conform to ASTM C 552.

2.4 VAPOR RETARDER

Vapor retarder shall be polyethylene sheeting conforming to ASTM E 154 or other equivalent material. Vapor retarder shall have a maximum vapor permeance rating of 29 ng per Pa per second per square meter (0.5 perms) as determined in accordance with ASTM E 96, unless otherwise specified.

2.5 AIR INFILTRATION BARRIER

Air infiltration barrier shall be building paper meeting the requirements of ASTM C 1136, Type IV, style optional or a tear and puncture resistant olefin building wrap (polyethylene or polypropylene) with a moisture vapor transmission rate of 125 g per square meter per 24 hours in accordance with ASTM E 96, Desiccant Method at 23 degrees C or with a moisture vapor transmission rate of 670 g per square meter per 24 hours in accordance with ASTM E 96, Water Method at 23 degrees C.

PART 3 EXECUTION

3.1 INSTALLATION OF FRAMING

3.1.1 General

General framing shall be in accordance with AF&PA T11. Members shall be closely fitted, accurately set to required lines and levels, and rigidly secured in place. Members shall be framed for passage of ducts. Members shall be cut, notched, or bored in accordance with applicable requirements of AF&PA T01 for the passage of pipes, wires, or conduits. Rafters, purlins, and joists shall be set with crown edge up. Framing shall be kept at least 50 mm (2 inches) away from chimneys and 100 mm (4 inches) away from fireplace backwalls. When joists, beams, and girders are placed on masonry or concrete, a wood base plate shall be positioned and leveled with grout. The joist, beam, or girder shall then be placed on the plate. When joists, beams, and girders are set into masonry or concrete, a pocket shall be formed into the wall. The joist, beam, or girder shall then be placed into the pocket and leveled with a steel shim.

3.1.2 Structural Members

Members shall be adequately braced before erection. Members shall be aligned and all connections completed before removal of bracing. Individually wrapped members shall be unwrapped only after adequate protection by a roof or other cover has been provided. Scratches and abrasions of factory-applied sealer shall be treated with two brush coats of the same sealer used at the factory.

3.1.3 Partition and Wall Framing

Unless otherwise shown, studs shall be spaced 400 or 600 mm (16 or 24 inches) on centers. Studs shall be doubled at openings. Unless otherwise indicated, headers for openings shall be made of two pieces of stud material set on edge or solid lumber of equivalent size, and corners shall be constructed of not less than three full members. End studs of partitions abutting concrete or masonry shall be anchored thereto with expansion bolts, one near each end of each stud and at intermediate intervals of not more than 1200 mm (4 feet). Plates of partitions resting on concrete floors shall be anchored in place with expansion bolts, one near each end of each piece and at intermediate intervals of not more than 1800 mm (6 feet) between bolts. In lieu of expansion bolts, anchoring into concrete may be accomplished with powder-driven threaded studs of suitable type and size and spaced at 900 mm (3 feet) on center. Walls and load bearing partitions shall be provided with double top plates with members lapped at least 600 mm (2 feet) and well spiked together.

3.1.4 Floor (Ceiling) Framing

Except where otherwise indicated joists shall have bearings not less than 100 mm (4 inches) on concrete or masonry and 40 mm (1-1/2 inches) on wood or metal. Joists, trimmers, headers, and beams framing into carrying members at the same relative levels shall be carried on joist hangers. Joists shall be lapped and spiked together at bearings or butted end-to-end with scab ties at joint and spiked to plates. Openings in floors shall be framed with headers and trimmers. Headers carrying more than two tail joists and trimmers supporting headers carrying more than one tail joist shall be doubled, unless otherwise indicated. Joists shall be doubled under partitions parallel with floor joists. Joists built into masonry shall be provided with a beveled fire cut so that the top of the joist does not enter the wall more than 25 mm (1 inch) or standard steel wall bearing boxes. Engineered wood joists shall be installed in accordance with distributor's instructions.

3.1.5 Roof Framing or Rafters

Tops of supports or rafters shall form a true plane. Valley, ridge, and hip members shall be of depth equal to cut on rafters where practicable, but in no case less than depth of rafters. Valleys, hips, and ridges shall be straight and true intersections of roof planes. Necessary crickets and watersheds shall be formed. Rafters, except hip and valley rafters, shall be spiked to wall plate and to ceiling joists with no less than three 8-penny nails or bolted by angles. Rafters shall be toe-nailed to ridge, valley, or hip members with at least three 8-penny nails. Rafters shall be braced to prevent movement until permanent bracing, decking or sheathing is installed. Hip and valley rafters shall be secured to wall plates by clip angles. Openings in roof shall be framed with headers and trimmers. Unless otherwise indicated, headers carrying more than two rafters and trimmers supporting headers carrying more than one rafter shall be double. Hip rafters longer than the available lumber shall be butt jointed and scabbed. Valley rafters longer than the available lumber shall be double, with pieces lapped not less than 1200 mm (4 feet) and well spiked together. Trussed rafters shall be installed in accordance with TPI Bklet HIB. Engineered wood joists shall be installed in accordance with distributor's instructions.

3.1.6 Stair Framing

Stair framing members shall be well spiked together. Normally a minimum of three rough carriages will be required. Rough carriages shall be cut to exact shape required to receive finish treads and risers. Risers shall be of uniform height, and treads shall be of uniform width except as otherwise shown. Trimmers, blocking, and other framing necessary for support of finish treads, risers, newels, and railing shall be provided.

3.2 INSTALLATION OF SHEATHING

3.2.1 Fiberboard

Sheathing shall be applied with edges 3 mm (1/8 inch) apart at joints, fitted snugly at abutting frames of openings, and nailed or stapled in accordance with the manufacturer's approved instructions. Sheets shall be applied vertically, extended over top and bottom plates, and with all vertical and horizontal joints over supports.

3.2.2 Gypsum Board

Sheathing shall be applied with edges in light contact at joints and nailed in accordance with the manufacturer's approved instructions. Sheets 600 mm (2 feet) wide shall be applied horizontally with tongued edge up, with vertical joints over supports, and with vertical joints staggered. Sheets 1200 mm (4 feet) wide shall be applied vertically, extended over top and bottom plates, and with all vertical and horizontal joints over supports.

3.2.3 Plywood and Structural-Use Panels

Sheathing shall be applied with edges 3 mm (1/8 inch) apart at side and end joints, and nailed at supported edges at 150 mm (6 inches) on center and at intermediate supports 300 mm (12 inches) on center unless otherwise shown. Nailing of edges shall be 10 mm (3/8 inch) from the edges. Wall sheathing shall extend over top and bottom plates, and if applied horizontally the vertical joints shall be made over supports and staggered. Wall sheathing over which wood shingles are to be applied shall be applied horizontally. Roof sheathing shall be applied with long dimension at right angles to supports, end joints made over supports, and end joints staggered.

3.2.4 Wood

Sheathing end joints shall be made over framing members and so alternated that there will be at least two boards between joints on the same support. Each board shall bear on at least three supports. Boards shall be nailed at each support using two nails for boards 150 mm (6 inches) and less in width and three nails for boards more than 150 mm (6 inches) in width. Roof sheathing shall not be installed where roof decking is installed.

3.3 INSTALLATION OF SUBFLOORING

3.3.1 Plywood and Structural-Use Panel

Subflooring shall be applied with long dimension at right angles to the supports, with edges 3 mm (1/8 inch) apart at side and end joints, and nailed at supported edges 150 mm (6 inches) on center and at intermediate supports 300 mm (12 inches) on center unless otherwise shown. Subflooring may be installed with adhesive conforming to ASTM D 3498 and nails spaced at 300 mm (12 inches) on center unless otherwise shown. Installation of subflooring with adhesives shall be in accordance with APA E30. Each panel shall have end joints made over supports and end joints staggered. Where finish flooring of different thicknesses is used in adjoining areas, wood strips of the thickness required to bring the finish flooring surfaces into the same plane shall be used under the plywood subfloor.

3.3.2 Wood

Subflooring shall be applied diagonally with end joints made over supports. Each board shall bear on at least three supports and shall be nailed at each support using two nails for boards 150 mm (6 inches) and less in width and three nails for boards more than 150 mm (6 inches) in width.

3.4 INSTALLATION OF UNDERLAYMENT

3.4.1 Hardboard

Underlayment shall be applied with edges 0.8 mm (1/32 inch) apart at joints and nailed at edges 150 mm (6 inches) on center and at 150 mm (6 inches) on center throughout remainder of panel. Nailing at edges shall be 10 mm (3/8 inch) from edges. A clearance of 6 mm (1/4 inch) shall be provided at walls. Joints of underlayment shall not be located directly over parallel joints of subflooring. Power-driven wire staples of lengths recommended by the underlayment manufacturer may be used in lieu of nails. Any surface roughness at nail heads or joints shall be lightly sanded to blend with the undisturbed surface.

3.4.2 Particleboard

Underlayment shall be applied with edges 0.8 mm (1/32 inch) apart at joints and nailed at edges 150 mm (6 inches) on center and at 250 mm (10 inches) on center throughout remainder of panel. Nailing at edges shall be 10 mm (3/8 inch) from edges. A clearance of 6 mm (1/4 inch) shall be provided at walls. Joints of underlayment shall not be located directly over parallel joints of subflooring. Power-driven wire staples of lengths recommended by the underlayment manufacturer may be used in lieu of nails. Any surface roughness at nail heads or joints shall be lightly sanded to blend with the undisturbed surface.

3.4.3 Plywood

Underlayment shall be applied with edges 0.8 mm (1/32 inch) apart at joints and nailed at edges 150 mm (6 inches) on center and at 200 mm (8 inches) on center throughout remainder of panel for panels 9 mm (11/32 inch) and thicker. Thinner panels shall be nailed at edges 75 mm (3 inches) on center and at 150 mm (6 inches) on center throughout remainder of panel. Nailing at edges shall be 10 mm (3/8 inch) from edges. A clearance of 6 mm (1/4 inch) shall be provided at walls. Joints of underlayment shall not be located directly over parallel joints of subflooring. Power-driven wire staples of lengths recommended by the underlayment manufacturer may be used in lieu of nails. When plywood combination subfloor-underlayment is used in lieu of separate layers, it shall be installed as specified for plywood subfloor, except all joints shall be made over supports with edge and joints spaced 3 mm (1/8 inch) apart. When plywood combination subfloor-underlayment is tongued and grooved, only end joints shall require support. Tongued and grooved combination subfloor-underlayment shall be applied with joints spaced 3 mm (1/8 inch) apart. Any surface roughness at nail heads or joints shall be lightly sanded to blend with the undisturbed surface. For floors receiving a vinyl finish flooring, a separate layer of fully-sanded underlayment shall be installed as provided for above over combination subfloor-underlayment panels.

3.5 INSTALLATION OF SHEAR WALLS

Plywood or structural-use panels shall be installed with the long dimension parallel or perpendicular to the supports. Blocking shall be provided behind edges not located over supports. Shear wall construction, nailing, and top and bottom anchorage shall be as shown.

3.6 INSTALLATION OF MISCELLANEOUS WOOD MEMBERS

3.6.1 Bridging

Wood bridging shall have ends accurately bevel-cut to afford firm contact and shall be nailed at each end with two nails. Metal bridging shall be installed as recommended by the manufacturer. The lower ends of bridging shall be driven up tight and secured after subflooring or roof sheathing has been laid and partition framing installed.

3.6.2 Corner Bracing

Corner bracing shall be installed when required by type of sheathing used or when siding, other than panel siding, is applied directly to studs. Corner bracing shall be let into the exterior surfaces of the studs at an angle of approximately 45 degrees, shall extend completely over wall plates, and shall be secured at each bearing with two nails.

3.6.3 Blocking

Blocking shall be provided as necessary for application of siding, sheathing, subflooring, wallboard, and other materials or building items, and to provide firestopping. Blocking for firestopping shall ensure a maximum dimension of 2400 mm (8 feet) for any concealed space. Blocking shall be cut to fit between framing members and rigidly nailed thereto.

3.6.4 Nailers and Nailing Strips

Nailers and nailing strips shall be provided as necessary for the attachment of finish materials. Nailers used in conjunction with roof deck installation shall be installed flush with the roof deck system. Stacked nailers shall be assembled with spikes or nails spaced not more than 450 mm (18 inches) on center and staggered. Beginning and ending nails shall not be more than 150 mm (6 inches) for nailer end. Ends of stacked nailers shall be offset approximately 300 mm (12 inches) in long runs and alternated at corners. Anchors shall extend through the entire thickness of the nailer. Strips shall be run in lengths as long as practicable, butt jointed, cut into wood framing members when necessary, and rigidly secured in place. Nailers and nailer installation for Factory Mutual wind uplift rated roof systems specified in other Sections of these specifications shall conform to the recommendations contained in FM LPD 1-49.

3.6.5 Wood Grounds

Wood grounds shall be provided as necessary for attachment of trim, finish, and other work to plaster. Grounds shall be run in lengths as long as practicable, butt jointed, and rigidly secured in place.

3.6.6 Furring Strips

Furring strips shall be provided at the locations shown. Furring strips shall be installed at 400 mm (16 inches) on center unless otherwise shown, run in lengths as long as practicable, butt jointed and rigidly secured in place.

3.6.7 Rough Bucks and Frames

Rough bucks shall be set straight, true, and plumb, and secured with anchors near top and bottom of each wood member and at intermediate intervals of not more than 900 mm (3 feet). Anchors for concrete shall be expansion bolts, and anchors for masonry shall be 5 by 32 mm (3/16 by 1-1/4 inch) steel straps extending not less than 200 mm (8 inches) into the masonry and turned down 50 mm (2 inches) into the masonry.

3.6.8 Wood Bumpers

Wood bumpers shall be bored, countersunk and securely bolted in place.

3.6.9 Sill Plates

Sill plates shall be set level and square and anchor bolted at not more than 1800 mm (6 feet) on centers and not more than 300 mm (12 inches) from end of each piece. A minimum of two anchors shall be used for each piece.

3.7 INSTALLATION OF TIMBER CONNECTORS

Installation of timber connectors shall conform to applicable requirements of AF&PA T01.

3.8 INSTALLATION OF INSULATION

Insulation shall be installed after construction has advanced to a point that the installed insulation will not be damaged by remaining work. For thermal insulation the actual installed thickness shall provide the thermal resistance (R-values) shown. For acoustical insulation the installed thickness shall be as shown. Insulation shall be installed on the weather side of such items as electrical boxes and water lines. Unless otherwise specified, installation shall be in accordance with the manufacturer's recommendation.

3.9 INSTALLATION OF VAPOR RETARDER

Vapor retarder shall be applied to provide a continuous barrier at window and door frames, and at all penetrations such as electrical outlets and switches, plumbing connections, and utility service penetrations. Joints in the vapor retarder shall be lapped and sealed according to the manufacturer's recommendations.

3.10 INSTALLATION OF AIR INFILTRATION BARRIER

Air infiltration barrier shall be installed in accordance with the manufacturer's recommendations.

3.11 TABLES

TABLE I. SPECIES AND GRADE

Subflooring, Roof Sheathing, Wall Sheathing, Furring

Grading Rules	Species	Const Standard	No. 2 Comm	No. 2 Board Comm	No. 3 Comm
NHLA Rules	Cypress			X	
NELMA Grading Rules					
	Northern White Cedar				X
	Eastern White Pine	X			
	Northern Pine	X			
	Balsam Fir				X
	Eastern Hemlock - Tamarack				X
CRA RIS-01-SS					
	Redwood		X		
SCMA Specs	Cypress			X	
SPIB Rules	Southern Pine		X		
WCLIB Std 17	Douglas Fir-Larch	X			
	Hem-Fir	X			
	Sitka Spruce	X			
	Mountain Hemlock	X			
	Western Cedar	X			
WWPA Grading Rules					
	Douglas Fir-Larch	X			
	Hem-Fir	X			
	Idaho White Pine	X			
	Lodgepole Pine			X	
	Ponderosa Pine			X	
	Sugar Pine			X	
	Englemann Spruce			X	
	Douglas Fir South			X	
	Mountain Hemlock			X	
	Subalpine Fir			X	
	Western Cedar			X	

TABLE II. SPECIES AND GRADE

Wood Bumpers

Grading Rules	Species	No. 1	No. 2

NHLA Rules	Red Oak	X	
NELMA Grading Rules			
	Northern Pine		X
	Eastern Hemlock - Tamarack		X
SPIB Rules	Southern Pine	X	
WCLIB Std 17	Douglas Fir-Larch		X
	Hem-Fir		X
WWPA Grading Rules			
	Douglas Fir-Larch		X
	Hem-Fir		X
	Douglas Fir-south		X

SECTION 06200

FINISH CARPENTRY

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.6 (1998) Hardboard Siding

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA PRP-108 (1980; Rev Jan 1996) Performance Standards and Policies for Structural-Use Panels

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 1435 (1994) Outdoor Weathering of Plastics

ASTM D 2898 (1999) Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing

ASTM D 3679 (1996a) Rigid Poly(Vinyl Chloride) (PVC) Siding

ASTM F 547 (1977; R 1995) Definitions of Terms Relating to Nails for Use with Wood and Wood-Base Materials

AMERICAN WOOD-PRESERVERS' ASSOCIATION (AWPA)

AWPA C9 (1997) Plywood - Preservative Treatment by Pressure Processes

AWPA C20	(1996) Structural Lumber Fire-Retardant Pressure Treatment
AWPA C27	(1996) Plywood - Fire-Retardant Pressure Treatment
AWPA M4	(1996) Standard for the Care of Preservative-Treated Wood Products
AWPA P5	(1997) Standards for Waterborne Preservatives

ARCHITECTURAL WOODWORK INSTITUTE (AWI)

AWI Qual Stds	(1997) Architectural Woodwork Quality Standards

CALIFORNIA REDWOOD ASSOCIATION (CRA)

CRA RIS-01-SS	(1997) Standard Specifications for Grades of California Redwood Lumber

DEPARTMENT OF COMMERCE (DOC)

DOC PS 1	(1996) Voluntary Product Standard - Construction and Industrial Plywood
DOC PS 2	(1992) Performance Standards for Wood-Based Structural-Use Panels

NORTHEASTERN LUMBER MANUFACTURERS ASSOCIATION (NELMA)

NELMA Grading Rules	(1997) Standard Grading Rules for Northeastern Lumber

SOUTHERN CYPRESS MANUFACTURERS ASSOCIATION (SCMA)

SCMA Specs	(1986; Supple No. 1, Aug 1993) Standard Specifications for Grades of Southern Cypress

SOUTHERN PINE INSPECTION BUREAU (SPIB)

SPIB Rules	(1994;Supple 8 thru 11) Standard Grading Rules for Southern Pine Lumber

WEST COAST LUMBER INSPECTION BUREAU (WCLIB)

WCLIB Std 17	(1996; Supples VII(A-E), VIII(A-C)) Grading Rules For West Coast Lumber

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA Grading Rules	(1999)Western Lumber Grading Rules 95

WOOD MOULDING AND MILLWORK PRODUCERS ASSOCIATION (WMMPA)

WMMPA WM 6	(1987) Industry Standard for Non-Pressure Treating of Wood Millwork

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 7051	(1993) Thick Round Nails
KS D 7052	(1993) Stainless Steel Nails

KS F 3113 (1999) Structural Plywood

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Finish Carpentry; G.

Drawings showing fabricated items and special mill and woodwork items. Drawings shall indicate materials and details of construction, methods of fastening, erection, and installation.

SD-03 Product Data

Siding; G. Epoxy-Aggregate Panels; G.

Manufacturer's printed data, showing texture, density, catalog cuts, and installation instructions.

Wood Items, Siding, and Trim; G.

Manufacturer's printed data indicating the usage of engineered or recycled wood products, and environmentally safe preservatives.

SD-04 Samples

Siding; G. Wood Shingles; G. Moldings; G. Fascias and Trim; G.

Samples shall be of sufficient size to show patterns, color ranges, and types, as applicable, of the material proposed to be used.

1.3 DELIVERY AND STORAGE

Materials shall be delivered to the site in undamaged condition, stored off ground in fully covered, well-ventilated areas, and protected from extreme changes in temperature and humidity.

PART 2 PRODUCTS

2.1 WOOD ITEMS, SIDING, AND TRIM

The Contractor shall furnish products which optimize design by reducing the amount of wood used (engineered wood), or recycled wood products, and preservatives without arsenic or chromium when the products and methods are competitive in price or directed by the Contracting Officer.

2.1.1 Grading and Marking

Materials shall bear the grademark, stamp or other identifying marks indicating grades of material and rules or standards under which produced. Such identifying marks on a material shall be in accordance with the rule or standard under which the material is produced, including requirements for qualifications and authority of the inspection organization, usage of authorized identification, and information included in the identification.

The inspection agency for lumber shall be certified by the Board of Review, American Lumber Standards Committee, to grade the species used. Except for plywood, structural-use panels, and lumber, bundle marking will be permitted in lieu of marking each individual piece. Surfaces that are to be architecturally exposed to view shall not bear grademarks, stamps, or other types of identifying marks.

2.1.2 Sizes and Patterns

Lumber sizes and patterns shall conform to rules or standards under which produced. Unless otherwise specified, lumber shall be surfaced on four sides. Sizes and patterns for materials other than lumber shall conform to requirements of the rules or standards under which produced. Size references, unless otherwise specified, are nominal sizes, and actual sizes shall be within manufacturing tolerances allowed by the standard under which the product is produced.

2.1.3 Moisture Content

The maximum moisture content of untreated trim and wood siding shall be 15 percent at the time of delivery to the jobsite and when installed. Moisture content of all other material shall be in accordance with the standard under which the product is produced.

2.1.4 Preservative Treatment

2.1.4.1 Plywood

Plywood shall be treated in accordance with AWPA C9 with waterborne preservatives listed in AWPA P5 to a retention level as follows:

a. 4 kg per cubic meter (0.25 pcf) intended for above ground use.

b. 6.4 kg per cubic meter (0.4 pcf) intended for ground contact and fresh water use.

2.1.4.2 Exterior Wood Molding and Millwork

Exterior wood molding and millwork within 455 mm (18-inches) of soil, in contact with water or concrete shall be preservative-treated in accordance with WMMPA WM 6. Exposed areas of treated wood that are cut or drilled after treatment shall receive a field treatment in accordance with AWPA M4. Items of all-heart material of cedar, cypress, or redwood will not require preservative treatment, except when in direct contact with soil.

2.1.5 Fire-Retardant Treatment

Fire-retardant treated lumber shall be pressure treated in accordance with AWPA C20. Fire-retardant treated plywood shall be pressure treated in accordance with AWPA C27. Material use shall be defined in AWPA C20 and AWPA C27 for Interior Type A and B, and Exterior Type. Treatment and performance inspection shall be by a qualified independent testing agency that establishes performance ratings. Each piece or bundle of treated material shall bear identification of the testing agency to indicate performance with such rating. Treated materials to be exposed to rain wetting shall be subjected to an accelerated weathering technique in accordance with ASTM D 2898, Method A, prior to being tested for compliance with AWPA C20 or AWPA C27. Fire-retardant treated plywood shall be used only for nonstructural applications which are not subject to elevated temperature or high humidity. Fire-retardant treated plywood shall not be used in any part of the roof or roofing system.

2.1.6 Siding

Horizontal siding shall be hardboard, plywood, structural-use panel, wood or vinyl. Panel siding shall be hardboard, structural-use panel, or plywood.

2.1.6.1 Horizontal Plywood Siding

Horizontal plywood siding shall conform to DOC PS 1, exterior, medium-density overlay lap type, 150, 200 or 300 mm (6, 8 or 12 inches) wide, maximum practicable lengths, 10, 11, 12 or 13 mm (3/8, 7/16, 15/32 or 1/2 inch) thick, smooth, rough-sawn texture or embossed face.

2.1.6.2 Wood Siding

Wood siding shall be of the species and grades listed in TABLE I at the end of this section. Siding shall be horizontal bevel type, minimum 5 mm (3/16 inch) thin edge by minimum 11 mm (7/16 inch) thick edge, or vertical board, tongue and groove or shiplap on long edges, 25 mm (1 inch) thick, 150, 200 or 250 mm (6, 8 or 10 inches) wide, maximum practicable lengths, smooth or rough-sawn texture face.

2.1.6.3 Panel Plywood Siding

Panel plywood siding shall conform to DOC PS 1, exterior medium-density overlay, 1200 mm (4 feet) wide, maximum practicable lengths, span rating of 400 mm or 600 mm on centers (16 inch or 24 inch on centers), smooth, embossed, rough-sawn texture or striated face, and grooved as selected from manufacturer's standard patterns.

2.1.7 Soffits

2.1.7.1 Hardboard and Plywood

Hardboard and plywood soffits shall be siding grade hardboard, 10 mm (3/8 inch) or 11 mm (7/16 inch) thick; plywood, DOC PS 1 or KS F 3113, exterior type, Grade A-C plywood panel siding, 9 mm (11/32-inch) thick for 600 mm (24 inch) on centers, 12 mm (15/32-inch) thick for 800 mm (32 inch) on centers, and 15 mm (19/21-inch) thick for 1200 mm (48 inch) on centers maximum span with all edges supported.

2.1.8 Fascias and Trim

2.1.8.1 Wood

Fascias and trim, including exterior door and window casing, shall be species and grade listed in TABLE I at the end of this section. Sizes shall be as indicated. Metal corners may be furnished in lieu of wood cornerboards for horizontal siding; and if furnished, shall be galvanized steel and primed or aluminum and primed.

2.1.9 Moldings

Moldings shall be of the pattern indicated and shall be of a grade compatible with the finish specified.

2.1.10 Woodwork Items

2.1.10.1 Bulletin Boards

Bulletin boards shall have a hardwood or aluminum frame, 6 mm (1/4 inch) thick plywood or hardboard back; and a 6 mm (1/4 inch) thick, dense, smooth faced corkboard face securely cemented to the back.

2.1.10.2 Chalkboards

Chalkboards shall have a hardwood or aluminum frame and 6 mm (1/4 inch) thick writing surface of selected chalkboard slate with surface ground to a true plane, cast acrylic plastic plate glass with color fused to surface or porcelain enamel laminated to plywood. Color shall be black or green.

2.1.10.3 Utility Shelving

Utility shelving shall be a suitable species equal to or exceeding requirements of No. 3 Common white fir under WWPA-01, 25 mm (1 inch) thick; or plywood, interior type, Grade A-B, 13 mm (1/2 inch) thick, any species group.

2.1.10.4 Workbench

Workbench shall have a work surface of 6 mm (1/4 inch) tempered hardboard, 6 mm (1/4 inch) particle board or 6 mm (1/4 inch) solid core plywood with sanded face or 1.3 mm (18 gauge) steel with gray enamel finish over 50 mm (2 inch) thick lumber backing. Base shall be 2 mm (14 gauge) steel with legs adjustable to 25 mm (1 inch) increments to adjust the work surface from 760 to 915 mm (30 to 36 inches).

2.2 NAILS

Nails shall be the size and type best suited for the purpose and shall conform to ASTM F 547, KS D 7051 or KS D 7052. Nails shall be hot-dip galvanized or aluminum when used on exterior work. For siding, length of nails shall be sufficient to extend 40 mm (1-1/2 inches) into supports, including wood sheathing over framing. Screws for use where nailing is impractical shall be size best suited for purpose.

PART 3 EXECUTION

3.1 GENERAL

3.1.1 Installation of Siding

Siding shall be accurately fitted and positioned without springing or otherwise forcing siding in place. Siding to have a stain finish shall have nails set and stopped with nonstaining putty to match finished siding, or siding to have a paint finish shall have nails driven flush.

3.1.2 Horizontal Siding

End joints shall be made over framing members and be so alternated that at least two boards will be between joints on the same support. Shorter pieces shall be uniformly distributed throughout each area. Starter strips shall be provided as necessary to establish proper slant for siding. Ends of siding shall be predrilled if necessary to prevent splitting when nailed. Horizontal bevel or plain lap siding shall be overlapped and nailed into each support in accordance with approved recommendations of the siding manufacturer, Horizontal drop siding shall have each course fully worked into the top edge of the previous course, and shall be nailed into each support with two nails, one near the lower edge to clear top of previous course, and one just above mid-height of course.

3.2 SOFFITS

3.2.1 Wood

Panels shall be applied with edges at joints spaced in accordance with manufacturer's instructions and with all edges backed with framing members. Panels shall be nailed 10 mm (3/8 inch) from edges at 150 mm (6 inches) on center and at intermediate supports at 300 mm (12 inches) on center. Panels shall be installed using the maximum practical lengths.

3.3 FASCIAS AND EXTERIOR TRIM

Exposed surfaces and square edges shall be machine sanded, caulked, and constructed to exclude water. Joints of built-up items, in addition to nailing, shall be glued as necessary for weather-resistant construction. End joints in built-up members shall be well distributed. Joints in flat work shall be shouldered. Backs of wide-faced miters shall be held together with metal rings and glue. Fascias and other flat members shall be in maximum practicable lengths. Cornices shall be braced, blocked, and rigidly anchored for support and protection of vertical joints.

3.4 MOLDING AND INTERIOR TRIM

Molding and interior trim shall be installed straight, plumb, level and with closely fitted joints. Exposed surfaces shall be machine sanded at the mill. Molded work shall be coped at returns and interior angles and mitered at external corners. Intersections of flatwork shall be shouldered to ease any inherent changes in plane. Window and door trim shall be provided in single lengths. Blind nailing shall be used to the extent practicable, and face nailing shall be set and stopped with a nonstaining putty to match the finish applied. Screws shall be used for attachment to metal; setting and stopping of screws shall be of the same quality as required where nails are used.

3.5 FINISH STAIRWORK

Finish stairwork shall conform to AWI Qual Stds, Premium Grade for transparent or Custom Grade for opaque finish. Stairwork shall be erected to form a strong, rigid structure without squeaks or vibrations. Railings shall be secured with concealed fasteners. Wall rails shall be supported on metal brackets spaced near ends and not over 1.5 m (5 feet) on centers.

3.6 WOODWORK ITEMS

3.6.1 Bulletin Boards and Chalkboards

Items shall be installed in accordance with the manufacturer's recommendation.

3.6.2 Shelving

Shelving shall be anchored to supporting construction. Unless otherwise indicated, shelves shall be supported by wall-supported brackets not more than 600 mm (24 inches) on center or as required to limit deflection to 6 mm (1/4 inch) between supports with a load of 525 N per meter (35 lb per lineal foot). Adjustable shelf hardware shall be steel standards, channel shaped, with 25 mm (1 inch) adjustment slots and brackets designed for attachment to standards.

3.6.3 Clothes Hanger Rods

Rods shall be provided where indicated and in all closets having hook strips. Rods shall be hardwood 38.1 mm (1-1/2 inches) in diameter, or aluminum pipe/ tubing 25.4 mm (1 inch) in diameter, or zinc-coated steel pipe 25 mm (1 inch) in diameter. Rods shall be set parallel with the front edges of the shelving, and shall be supported at each end by suitable sockets, and by intermediate brackets spaced at not more than 1200 mm (4 feet) centers.

3.6.4 Workbenches

Items shall be anchored in place as indicated.

3.7 TABLE

TABLE I. SPECIES AND GRADE TABLES

Grading Rules	Species	Choice	Clear	C Select	C & Better
NELMA Grading Rules					
	Eastern Cedar				X
	Eastern Hemlock		X		
	Tamarack				X
	Eastern W. Pine				X
	Northern Pine				X
	Eastern Spruce			X	
	Balsam Fir		X		
CRA-RIS-01-SS	Redwood		X		
SCMA Specs	Cypress			X	
SPIB Rules	Southern Pine				X
WCLIB Std 17	Douglas Fir				X
	Larch				X
	Hemlock Fir				X
	Mountain Hemlock				X
	Sitka Spruce				X
WWPA Grading Rules					
	Douglas Fir				X
	Larch				X
	Hemlock Fir		X		
	Mountain Hemlock				X
	Western Larch		X		
	Idaho White Pine	X			
	Lodgepole Pine		X		
	Ponderosa Pine		X		
	Sugar Pine		X		
	Englemann Spruce		X		
	Douglas Fir South		X		
	Subalpine Fir		X		

NOTE 1: Western Cedar under WCLIB Std 17 shall be Grade B; and under WWPA Grading Rules, Western Cedar shall be Grade B bevel for siding and Grade A for trim.

NOTE 2: Except as specified in NOTE 3 below, siding and exterior trim shall be any of the species listed above. Interior trim shall be any one of the species listed above and the highest grade of the species for stain or natural finish and one grade below highest grade of species for paint finish.

NOTE 3: Southern Yellow Pine, Douglas Fir, Larch, Western Larch, and Tamarack shall not be used where painting is required and may be used on exterior work only when approved and stained with a preservative type stain.

DIVISION 07 THERMAL & MOISTURE PROTECTION

SECTION 07110

BITUMINOUS DAMPPROOFING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 41	(1994) Asphalt Primer Used in Roofing, Dampproofing and Waterproofing
ASTM D 1187	(1997) Asphalt-Base Emulsions for Use as Protective Coatings for Metal
ASTM D 1227	(1995) Emulsified Asphalt Used as a Protective Coating for Roofing
ASTM D 4479	(1993) Asphalt Roof Coatings - Asbestos Free

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-07 Certificates

Materials; G.

Certificates attesting that the materials meet the requirements specified.

1.3 QUALIFICATIONS

Work shall be performed by skilled laborers thoroughly experienced in the type of bituminous dampproofing work specified to meet the requirements of the contract.

1.4 DELIVERY, STORAGE AND HANDLING

Dampproofing materials shall be delivered to the project site in the original sealed containers bearing the name of manufacturer, contents and brand name, and stored in a weathertight enclosure to prevent moisture damage and absorption. Dampproofing materials shall be protected from freezing. Asphalt shall be stored off the ground on pallets, and covered on top and all sides with breathable-type canvas tarpaulins. Plastic sheets cause condensation buildup and therefore shall not be used to cover dampproofing materials. Care shall be taken during storage to avoid separation or settlement of the emulsion components. Damaged or deteriorated materials shall be removed from the project site.

PART 2 PRODUCTS

2.1 EMULSION-BASED ASPHALT DAMPPROOFING

2.1.1 Fibrated Emulsion-Based Asphalt

Type IV fibrated emulsion-based asphalt is typically used as a protective coating against dampness on interior surfaces above grade and exterior surfaces of concrete, metal and wood above or below grade. Type IV is also used as a vapor barrier when applied to interior surfaces. Fibrated emulsion-based asphalt dampproofing shall be cold-applied type conforming to ASTM D 1227 Type IV, asbestos-free, manufactured of refined asphalt, emulsifiers and selected clay, fibrated with mineral fibers. For spray or brush application, emulsion shall contain a minimum of 59 percent solids by weight, 56 percent solids by volume. For trowel application, emulsion shall contain a minimum of 58 percent solids by weight, 55 percent solids by volume.

2.1.2 Non-Fibrated Emulsion-Based Asphalt

Non-fibrated emulsion-based asphalt shall be used as a protective coating against dampness on interior surfaces of concrete, metal and wood above or below grade. Non-fibrated emulsion-based asphalt dampproofing shall be cold-applied type conforming to ASTM D 1187 Type II or ASTM D 1227 Type III, manufactured of refined asphalt, emulsifiers and selected clay. Asphalt shall contain a minimum 58 percent solids by weight, 55 percent solids by volume.

2.2 SOLVENT-BASED ASPHALT DAMPPROOFING

2.2.1 Asphaltic Primer

Primer for cold-applied solvent-based asphalt dampproofing shall conform to ASTM D 41, asbestos-free, non-fibrated, manufactured with highly ductile soft asphalts and selected hydrocarbons.

2.2.2 Fibrated Asphalt

Fibrated solvent-based asphalt shall be used to dampproof masonry and concrete exterior surfaces below grade and interior surfaces above grade. Fibrated asphalt shall be also used as a general protective coating for wood, steel and backup materials for masonry walls such as stone, brick and concrete. Fibrated solvent-based asphalt dampproofing shall be cold-applied type conforming to ASTM D 4479 Type I, asbestos-free, manufactured with selected asphalts, stabilizers, mineral spirits and fibrated with mineral fibers. Solvent-based asphalt shall contain 72 percent solids by weight, 65 percent solids by volume.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Surfaces scheduled for bituminous dampproofing shall be prepared in accordance with dampproofing manufacturer's recommendations. Surface preparation shall be approved prior to dampproofing application.

3.1.1 Protection of Surrounding Areas

Before starting the dampproofing work, the surrounding areas and surfaces shall be protected from spillage and migration of asphalt onto other work. Drains and conductors shall be protected from clogging with asphalt.

3.1.2 Masonry Surfaces

Surfaces shall be free of oil, grease, dirt, laitance, loose material, frost, debris and other contaminants. Mortar joints shall be flush and free of extraneous mortar and chipped or broken masonry.

3.1.3 Concrete Surfaces

Surfaces shall be properly cured, free of form release agents, oil, grease, dirt, laitance, loose material, frost, debris and other contaminants. Form ties shall be cut flush with surface. Sharp protrusions and form match lines shall be removed. Holes, voids, spalled areas and cracks which can damage the dampproofing materials and impair performance shall be repaired. Rough surfaces shall be parged with a well-adhering coat of cement mortar.

3.1.4 Metal Surfaces

Metal surfaces shall be dry and be free of rust, scale, loose paint, oil, grease, dirt, frost and debris.

3.2 APPLICATION OF BITUMINOUS DAMPPROOFING

3.2.1 Emulsion-Based Asphalt

Emulsion-based asphalt dampproofing work shall not be performed in temperatures below 4 degrees C (40 degrees F). Emulsions shall have a smooth and uniform consistency at time of application. Dampproofing materials shall be applied in accordance with manufacturer's published instructions to produce a smooth uniform dry film of not less than 0.3 mm (12 mils) thick without voids or defects. Dull or porous spots shall be recoated. Dampproofing materials shall seal tightly around pipes and other items projecting through dampproofing. Rates of application shall be as follows:

a. Primer: 0.2 liters per square meter (1/2 gallon per 100 square feet), cold-applied.

b. Fibrated Dampproofing: 0.8 liters per square meter (2 gallons per 100 square feet), cold-applied with spray, brush or trowel.

c. Non-fibrated Dampproofing: 0.8 liters per square meter (2 gallons per 100 square feet), cold-applied with spray, brush or trowel.

3.2.2 Solvent-Based Asphalt

Solvent-based asphalt dampproofing work shall not be performed in temperatures below 4 degrees C (40 degrees F). Dampproofing materials shall be applied in accordance with manufacturer's published instructions to produce a smooth uniform dry film not less than 0.3 mm (12 mils) thick without voids or defects. Dull or porous spots shall be recoated. Dampproofing materials shall seal tightly around pipes and other items projecting through dampproofing. Rates of application shall be as follows:

a. Primer: 0.4 liters per square meter (1/2 gallon per 200 square feet), cold-applied.

b. Dampproofing Coat: 0.8 liters per square meter (2 gallons per 100 square feet), cold-applied with spray, brush or trowel.

3.3 CLEAN-UP

Surfaces of other work which are stained with dampproofing materials shall be cleaned with a cleaner recommended by dampproofing manufacturer.

3.4 PROTECTION

The completed dampproofing work shall be protected from damage during and after construction.

SECTION 07132

BITUMINOUS WATERPROOFING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 208	(1995) Cellulosic Fiber Insulating Board
ASTM D 41	(1994) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
ASTM D 173	(1997b) Bitumen-Saturated Cotton Fabrics Used in Roofing and Waterproofing
ASTM D 449	(1989; R 1999el) Asphalt Used in Dampproofing and Waterproofing
ASTM D 1327	(1997a) Bitumen-Saturated Woven Burlap Fabrics Used in Roofing and Waterproofing
ASTM D 1668	(1997a) Glass Fabrics (Woven and Treated) for Roofing and Waterproofing
ASTM D 4586	(1993; R 1999) Asphalt Roof Cement, Asbestos Free

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 4052	(1999) Waterproofing Asphalts for Building Constructions
KS F 4913	(2001) Woven Fabrics Asphalt Roofings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Reinforcing Fabric; G. Protection Board; G.

Manufacturer's data including technical information which indicates full compliance with this section.

Applications; G.

Manufacturer's installation instructions, before delivery of materials to the site. Instructions shall specify acceptable range of asphalt application temperatures and the maximum temperature for holding asphalt in a heated condition.

SD-07 Certificates

Materials; G.

Certificates from manufacturer attesting that asphalt manufactured and shipped to jobsite meets the specified requirements.

1.3 QUALIFICATIONS

Work shall be performed by skilled laborers thoroughly experienced in the type of bituminous waterproofing work specified to meet the requirements of the contract.

1.4 DELIVERY, STORAGE AND HANDLING

Waterproofing materials shall be delivered to the project site in the original sealed containers bearing the name of the manufacturer, contents and brand name. Asphalt shall be protected from freezing in a weathertight enclosure. Reinforcement fabrics shall be protected from moisture damage and moisture absorption in a weathertight enclosure or shall be stored off the ground on pallets, and covered on top and all sides with breathable-type canvas tarpaulins. Plastic sheets cause condensation buildup and therefore shall not be used to cover waterproofing materials. Damaged or deteriorated materials shall be removed from project site.

PART 2 PRODUCTS

2.1 ASPHALT WATERPROOFING

2.1.1 Primer

Primer for hot-applied asphalt waterproofing shall conform to ASTM D 41, asbestos-free, non-fibrated, manufactured with highly ductile soft asphalts and selected hydrocarbons.

2.1.2 Above-Grade Hot-Applied Asphalt

For above-grade applications where asphalt shall not be exposed to temperatures exceeding 50 degrees C (122 degrees F), hot-applied asphalt for membrane waterproofing system shall conform to ASTM D 449, Type II, or KS F 4052, Type II. For above-grade applications where asphalt shall be exposed to sunlight and temperatures exceeding 50 degrees C (122 degrees F), hot-applied asphalt shall conform to ASTM D 449, Type III, or KS F 4052, Type III.

2.1.3 Below-Grade Hot-Applied Asphalt

Hot-applied asphalt for below-grade applications shall conform to ASTM D 449, Type I, or KS F 4052, Type I, asbestos-free, manufactured from crude petroleum, suitable for use with membrane waterproofing systems.

2.1.4 Reinforcement Fabrics

2.1.4.1 Cotton Fabrics

Cotton fabrics shall be woven entirely of cotton conforming to ASTM D 173 or KS F 4913, thoroughly and uniformly saturated with asphalt.

2.1.4.2 Woven Burlap Fabrics

Woven burlap fabrics shall be composed of 100 percent jute fiber and two cotton threads at each selvage conforming with ASTM D 1327 or KS F 4913, thoroughly and uniformly saturated with asphalt. The fabric mesh shall not be completely closed or sealed by the process of saturation. Sufficient porosity shall be maintained to allow successive moppings of the plying asphalt to seep through. The surface shall not be coated or covered with talc or any other substances that will interfere with the adhesion between fabric and plying asphalt. The fabric surface shall be uniformly smooth and free of irregularities, folds and knots. The finished woven burlap fabrics shall be free of ragged edges, untrue edges, breaks or cracks, and other visible external defects.

2.1.4.3 Glass Fabrics

Glass fabrics shall conform to ASTM D 1668, Type I, asphalt-treated woven glass waterproofing fabrics coated with asphalt.

2.1.5 Flashing Cement

Flashing cement shall conform to ASTM D 4586, Type I, trowel grade, asbestos free, manufactured from asphalts characterized as adhesive, healing and ductile.

2.2 INSULATION BOARDS

Insulation boards shall conform to ASTM C 208 cellulosic fiber boards, construction grade, 13 mm (1/2-inch) thick, fibrous-felted homogeneous panel. Insulation boards shall be manufactured from ligno-cellulosic fibers (wood or cane) by a felting or molding process, asphalt-saturated or coated, with a density of 49 to 151 kg per square meter (10 to 31 lbs. per square foot). Surfaces of insulation boards shall be free of cracks, lumps, excessive departure from planeness, or other defects that adversely affect performance.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Surfaces scheduled for bituminous waterproofing shall be prepared in accordance with waterproofing manufacturer's recommendations. Surface preparation shall be approved prior to waterproofing application.

3.1.1 Protection of Surrounding Areas

Before starting the waterproofing work, the surrounding areas and surfaces shall be protected from spillage and migration of asphalt onto other work. Drains and conductors shall be protected from clogging with asphalt.

3.1.2 Masonry Surfaces

Surfaces shall be free of oil, grease, dirt, laitance, loose material, frost, debris and other contaminants. Mortar joints shall be flush and free of extraneous mortar and chipped or broken masonry.

3.1.3 Concrete Surfaces

Surfaces shall be properly cured, free of form release agents, oil, grease, dirt, laitance, loose material, frost, debris and other contaminants. Form ties shall be cut flush with surface. Sharp protrusions and form match lines shall be removed. Holes, voids, spalled areas and cracks which can damage waterproofing materials shall be repaired. Rough surfaces shall be parged with a well-adhering coat of cement mortar.

3.1.4 Metal Surfaces

Surfaces shall be dry and be free of rust, scale, loose paint, oil, grease, dirt, frost and debris.

3.2 HOT-APPLIED ASPHALT WATERPROOFING

Asphalt waterproofing shall be applied when the ambient temperature is 4 degrees C (40 degrees F) or above. Heating kettles and tanks shall be provided with automatic thermostatic control capable of maintaining asphalt temperature. Controls shall be calibrated and maintained in working order for duration of work. At time of application, asphalt shall not be heated above the equiviscous temperature (EVT) recommended by manufacturer. Immediately before use, temperature shall be measured with a portable thermometer at the point of application. EVT and flashpoint temperatures of asphalt in kettle shall be conspicuously posted on kettle. Asphalt with a temperature not conforming to the manufacturer's recommendations shall be returned to the kettle. Asphalt overheated by more than 10 degrees C (50 degrees F) for more than 1 hour shall be removed from site.

3.2.1 Below-Grade Wall Waterproofing

Waterproofing for foundation walls shall consist of a 2-ply hot-applied asphalt membrane system. Fabrics shall be installed using the "shingle" method. Joints shall be caulked prior to primer applications. Primer shall be applied at a rate of 0.2 liters per square meter (1/2 gallon per 100 square feet). Fabrics shall be overlapped at ends and staggered a minimum 480 mm (19 inch) for 2-ply system. End-to-end taping is not acceptable. Each fabric shall be firmly embedded into a solid uniform coating of hot asphalt at a rate of 0.98 kg per square meter (20 lbs. per 100 square feet) by pressing with broom. Fabrics shall not touch fabrics. Hot asphalt shall penetrate each fabric to provide the required adhesion. Asphalt between fabrics shall not be excessive to prevent slippage. Waterproofing system consisting of two or more fabrics shall be provided with fabric reinforcement at corners, angles, over construction joints, and in locations where waterproofing fabrics are subject to unusual stress.

3.2.2 Floor Waterproofing

Primer shall be applied at a rate of 0.2 liters per square meter (1/2 gallon per 100 square feet). Primer shall not be left in puddles. Primer shall be dry to the touch before application of asphalt. Where slab abuts walls, first reinforcing fabric shall extend 150 mm (6 inches) minimum on slab and 200 mm (8 inches) on wall. At vertical corners, first fabric shall extend minimum 125 mm (5 inches) from corner on each side. Second fabric shall lap the first fabric 50 mm (2 inches) minimum. At floor drains, and elsewhere as indicated, the fabric shall extend into a clamping device, set in a heavy coating of flashing cement, and securely clamped.

3.3 FLOOD TESTING

Prior to concealment, waterproofed floors over occupied spaces shall be tested for watertightness. Drains shall be plugged and floors shall be submerged with 75 mm (3 inches) of clean water. Water shall be permitted to stand for a minimum of 24 hours. If leaks occur, water shall be drained and repairs made. Upon completion of repairs, floors shall be flooded with 75 mm (3 inches) of clean water and flood testing shall be repeated for minimum of 24 hours from the time each leak is repaired. Waterproofing system shall be completely watertight, and shall be approved in writing before covering up with other materials. Additional coats of asphalt are not an acceptable method for repairing leaks.

3.4 CLEAN-UP

Surfaces of other work which are stained with waterproofing materials shall be cleaned with a cleaner recommended by waterproofing manufacturer.

3.5 PROTECTION OF COMPLETED WORK

3.5.1 Floor Waterproofing

The completed waterproofing work shall be protected from damage during and after construction. Protective covering shall be placed immediately before proceeding with the work which will conceal the waterproofing.

3.5.2 Wall Waterproofing

Waterproofing against which backfill is to be placed shall be protected with a single layer of insulation board. Insulation boards shall be pressed into the final mopping while the asphalt is still hot, with edges of boards placed into moderate contact and joints staggered. For two-layer installation, joints in second layer shall be staggered over joints in first layer. Where surfaced insulation board is used, the surfaced side shall face outward. Boards shall be carefully and neatly fitted around projections, and shall cover the entire surface of the waterproofing materials. Waterproofing system not covered with protection boards shall be protected to prevent damage from subsequent building operations. Installed boards shall not remain exposed at the end of a work day.

SECTION 07141

ACRYLIC FLUID-APPLIED WATERPROOFING

TABLE OF CONTENTS

PART 1 GENERAL

This specification covers a liquid-applied water-dispersed 100 percent acrylic elastomeric latex coating used for roof waterproofing. This specification also covers a water-repellent coating applied to concrete or masonry wall surfaces.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 117	(1997) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C 794	(1993) Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
ASTM D 471	(1998) Standard Test Method for Rubber Property - Effect of Liquids E1-1999
ASTM D 522 Rev A	(1993) Standard Test Method for Mandrel Bend Test of Attached Organic Coatings
ASTM D 523	(1989) Standard Test Method for Specular Gloss
ASTM D 562	(2001) Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer
ASTM D 624	(2000) Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer

ASTM D 722	(1993) Standard Test Method for Grease Resistance of Paper
ASTM D 903	(1998) Standard Test Method for Peel or Stripping Strength of Adhesive Bonds
ASTM D 1475	(1998) Standard Test Method for Density of Liquid Coatings, Inks, and Related Products
ASTM D 1640	(1995) Standard Test Method for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature
ASTM D 1644	(2001) Standard Test Method for Nonvolatile Content of Varnishes
ASTM D 1653	(1993) Standard Test Method for Water Vapor Transmission of Organic Coated Films E1-1999 R(1999)
ASTM D 1712	(1996) Standard Practice for Resistance of Plastics to Sulfide Staining
ASTM D 1729	(1996) Standard Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
ASTM D 2196	(1999) Standard Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield) Viscometer
ASTM D 2244	(1993) Standard Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates
ASTM D 2370	(1998) Standard Test Method for Tensile Properties of Organic Coatings
ASTM D 2697	(1986) Standard Test Method for Volume Nonvolatile Matter in Clear of Pigmented Coatings R(1998)
ASTM D 3359	(1997) Standard Test Method for Measuring Adhesion by Tape Test
ASTM D 3776	(1996) Standard Test Method for Mass Per Unit Area (Weight) of Fabric
ASTM D 3786	(1987) Hydraulic Bursting Strength of Knitted Goods
ASTM D 4214	(1998) Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D 4798	(2000) Standard Test Method for Accelerated Weathering Test Conditions and Procedures for Bitumen Materials (Xenon-Arc Method)
ASTM D 5035	(1995) Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
ASTM D 5201	(2001) Standard Practice for Calculating Formulation Physical Constants of Paints and Coatings
ASTM D 5733	(1999) Standard Test Method for Tearing Strength of Nonwoven Fabrics by the Trapezoid Procedure

ASTM D 6083	(1997a) Standard Specification for Liquid Applied Acrylic Coating Used in Roofing
ASTM E 96	(2000) Standard Test Method for Water Vapor Transmission of Materials
ASTM E 108	(2000) Standard Test Methods for Fire Tests of Roof Coverings
ASTM E 514	(1996) Standard Test Method for Water Penetration and Leakage Through Masonry.
ASTM G 7	(1997) Standard Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials
ASTM G 21	(1996) Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi
ASTM G 154	(2000) Standard Practice for Operating Florescent Light Apparatus for UV Exposure of Nonmetallic Materials

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Roofing System; G.

Drawings showing details, flashing details, fastening patterns where applicable for insulation, and expansion joint details.

Detail showing construction of water cutoffs to be used at membrane terminations at the end of a day's work to seal the roofing system from water intrusion.

SD-03 Product Data

Application; G.

Manufacturer's instructions for preparing and applying the membrane, flashings, seams, insulation, nailers and other accessories.

Protection of Finished Roofing; G.

Protection plan showing areas to be protected, type of material used; a plan to protect the membrane from damage until completion of work by other trades, and a description of the method of repairing the roofing.

Inspection; G.

The inspection procedure for substrate suitability including decks, curbs and insulation installation, prior to start of the work. Inspection procedures during and after placement of the membrane, and after completion of work by other trades.

Material Safety Data Sheets (MSDS);

All materials required to have MSDS.

SD-06 Test Reports

Test Reports: G.

Report signed by authorized official of a certified independent testing laboratory verifying conformance of properties as per ASTM D 6083 and class A fire rating as per ASTM E 108.

SD-07 Certificates

Applicator's Qualifications; G.

A copy of approved applicator letter and/or certificate as issued by the manufacturer of the elastomeric acrylic coating system.

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver waterproofing materials in manufacturer's original, unopened containers, with labels intact and legible. Containers of materials covered by a referenced specification number shall bear the specification number, type, and class of the contents. Deliver materials in sufficient quantity to continue work without interruption. Store and protect materials in accordance with manufacturer's instructions, and use within their indicated shelf life. Materials shall be stored in an area specifically designated for that purpose, in accordance with manufacturer's recommendations, where temperatures will not be less than 10 degrees C (50 degrees F) or higher than 38 degrees C (100 degrees F). When hazardous materials are involved, adhere to special precautions of the manufacturer, unless precautions conflict with local, state, and federal regulations. Promptly remove from the site materials or incomplete work adversely affected by exposure to moisture or freezing. Store materials on pallets and cover from top to bottom with canvas tarpaulins.

1.4 JOB CONDITIONS

Do not apply elastomeric acrylic coating system components when the ambient and/or surface temperature is below 10 degrees C (50 degrees F) or above 43 degrees C (110 degrees F), if any surface moisture is present, when the dew point is within 3 degrees C (5 degrees F) of the surface temperature, or when there is a possibility of temperatures falling below 0 degrees C (32 degrees F) within a 24 hour period. Do not apply if weather conditions will not permit complete cure before rain, dew, fog or freezing temperatures occur. Do not spray apply if the wind velocity exceeds 16 kilometer per hour (10 MPH) without taking appropriate precautions to eliminate over-spray. Take all measures necessary to protect unrelated surfaces from coating over-sprays or spillage. Furnish all scaffolding and the necessary equipment to complete the work. Scaffolding shall comply with all requirements as to safety. Provide drop cloths and other forms of protection necessary to protect all adjoining surfaces to render them completely free of overspray and splashes. Any surfaces that have been damaged or splattered shall be cleaned, restored, or replaced. If sealant is applied prior to sealer, a test must be conducted prior to installation to verify compatibility of the sealer and sealant. For interior application, provide ventilation or forced air circulation during and after interior application of sealer until any odor is no longer evident.

1.5 WARRANTY

Upon completion of the roof coating system, a final inspection shall take place to determine the dry mil thickness of the fluid applied acrylic membrane and to verify that the system meets the manufacturer's requirements and project specifications for warranty. The contractor shall notify all interested parties in advance of said inspection. Upon acceptance, deliver to the COR a copy of the fully executed 10-year materials and labor warranty.

PART 2 PRODUCTS

2.1 ROOF WATERPROOFING SYSTEM MATERIALS

A seamless, fluid applied 100 percent acrylic membrane system designed for application over asphalt built-up roofing, concrete, metal, roof tile, or composite shingle substrates.

2.1.1 Reinforcement Fabric

Non-woven, stitch bonded polyester fabric for reinforcement of joints, horizontal seams, non-crimped vertical seams, damaged areas, roof terminations and flashings, skylights and other openings, vents, conduits, HVAC equipment and other protrusions. Polyester fabric shall meet or exceed the following physical properties:

A. Fabric Weight (ASTM D 3776): 4 oz per square yard

B. Mullen Bursting Strength (ASTM D 3786): 144 lbs per square inch

C. Tearing Strength (Trapezoid, ASTM D 5733): 16 lbf (length), 24 lbf (width)

D. Breaking Force (1" cut strip, ASTM D 5035): 42 lbf (length), 27 lbf (width)

E. Elongation at Break (1" cut strip, ASTM D 5035): 28 percent (length), 61 percent (width)

2.1.2 Fluid-Applied Base Coat (Primer or Foundation Coat)

100 percent pure acrylic co-polymer internally plasticized to maintain elastomeric properties, designed for adding film build prior to application of the intermediate and finish coats.

2.1.3 Fluid-Applied Intermediate Coat and Finish Coat

100 percent pure acrylic co-polymer in the specified finish color internally plasticized to maintain elastomeric properties, designed to provide a permanently flexible, weather-resistant topcoat. Coating material and coating shall meet or exceed all properties specified in ASTM D 6083, Table 1, Liquid Property Requirements, and Table 2, Film Physical Property Requirements for Acrylic Roof Coatings, as verified by a certified independent testing agency.

TABLE 1
Liquid Property Requirements

Physical Property	ASTM Designation	Requirements
Viscosity	D 562	85 to 141 KU
	D 2196	12,000 to 85,000 cps
Volume Solids	D 2697	greater than 50 percent
Weight Solids	D 1644	greater than 60 percent

TABLE 2
Film Physical Property Requirements for Acrylic Roof Coatings

Physical Property	ASTM Designation	Requirements
Initial Percent Elongation (break)	D 2370	minimum 100 percent @23 degree C (73 degree F)

Initial Tensile Strength (minimum stress)	D 2370	minimum 200 psi (1.38 MPa) @23 degree C (73 degree F)
Final Percent Elongation (break) after accelerated weathering 1000 Hrs.	D 2370	minimum 100 percent @23 degree C (73 degree F)
Permeance	D 1653	maximum 50 perms (17.2 x 10 - 10 $kg/s.m^2.Pa$)
Water Swelling	D 471	maximum 20 percent (mass)
Accelerated Weathering 1000 hours	D 4798	No cracking or checking
Adhesion	C 794 or D 903	minimum 2.0 pli (350 N/m) wet
Fungi Resistance	G 21	Zero Rating
Tear Resistance	D 624	>60 lbf/in. (21 kN/m)
Low Temperature Flexibility after 1000 hours accelerated weathering	D 522	minimum pass 1/2 in. mandrel -18 degree C (-15 degree F)

2.1.4 Fluid-Applied Encapsulation Coat

100 percent pure acrylic co-polymer, low viscosity, designed to saturate through and encapsulate the Reinforcement Fabric on detail areas as well as the body of the roof. It also penetrates into and seals the existing substrate, while blocking asphaltic bleed-through.

2.1.5 Reinforcement Tape for Metal Roof Surface

Self-adhesive, butyl-backed fabric for use as an alternative to reinforcement fabric in reinforcing joints, horizontal seams, non-crimped vertical seams, damaged areas, roof terminations and flashings, skylights and other openings, vents, conduits, HVAC equipment and other protrusions.

2.1.6 Acrylic Mastic

Single package, high tensile acrylic mastic for use in reinforcing crimped vertical seams, and as an alternative to reinforcement fabric or reinforcement tape on other seams and detail areas. Also used for encapsulating and sealing fastener screws of metal roof.

2.1.7 Concrete Repair Material

High strength acrylic polymer concrete renovation and repair material shall be applied, blended with portland cement at the jobsite. It is for use in repairing damaged mortar, filling voids and resurfacing spalled concrete surfaces.

2.1.8 Fluid-Applied Metal Primer

Single package, acrylic metal primer shall be applied to provide corrosion protection, flash rust resistance and enhanced adhesion over steel, aluminum and galvanized metal roof surfaces.

2.2 ROOFING SYSTEM

The roofing system shall have a Class A fire rating on a noncombustible deck when tested according to the procedures outlined in ASTM E 108.

2.3 WATER REPELLENT COATING MATERIALS

2.3.1 Clear Water repellent sealer

Water repellent sealer shall be a water-based, clear blend of reactive silane with a silicone emulsion designed to provide invisible water-repellency and protection from the intrusion of chloride salts, airborne pollution and de-icing chemicals over vertical and horizontal concrete, masonry and brick surfaces. Product is supplied in either a pre-diluted 5 percent solids by volume concentration, or in concentrate form that is diluted at the jobsite to achieve the specified solids, and shall meet the following minimum requirements:

A. Solids by volume: 5 to 10 percent (+/-2) [ASTM D 5201]

B. Viscosity: 1,000 to 1,500 cps at 24 degree C (75 degree F) [ASTM D 2196]

C. Dry time: 15 to 20 minutes at 24 degree C (75 degree F), 50 percent R.H. [ASTM D 1640]

D. Cure time: 1 to 2 hours at 24 degree C (75 degree F), 50 percent R.H. [ASTM D 1640]

E. Temperature Limits for Service Conditions: -56 degree C to 93 degree C (-70 degree F to 200 degree F)

F. Resistance to Accelerated Weathering: Treated specimen shall show no deleterious effects, no surface checking, cracking or delamination after 3,000 hours of testing in accordance with ASTM G 154 in a QUV cabinet.

G. Resistance to Wind Driven Rain: After 40 hours of continuous testing, treated precast concrete panel shall show no apparent moisture penetration into the substrate. Test conducted in a pressurized test chamber producing 12.7 cm (5 inch) of water pressure, equivalent to 100 mph wind pressure (161 km/hr) as per ASTM E 154.

H. Resistance to Salt Spray: Treated sample shall show no deleterious effects, no surface checking, cracking or delamination following 500 hours of continuous exposure. Testing shall be in accordance with ASTM B 117 in a Harshaw Salt Spray Cabinet. Test specimens shall be treated cement asbestos board or equal.

I. Resistance to Sulfide Staining: No discoloration after 15 minutes immersion in saturated hydrogen sulfide gas solution when tested in accordance with ASTM D 1712. Compare with control specimen not exposed to hydrogen sulfide gas solution.

J. Resistance to Chemical Reagents: Specimen shall exhibit none or slight color change and no softening or deterioration after 7 days immersion in the following chemicals: ammonium hydroxide - 10 percent; sodium hydroxide - 10 percent; mineral spirits, KB value 38. Inspection is compared to specimen not exposed to chemical reagents.

K. Verification of Minimum 5-Year Exposure to Appropriate Climate: Sealer shall have been in use in a similar climatic region 5 years or more and show no sign of fading, peeling or flaking. Supply project locations exceeding 5 years of service.

L. Moisture Vapor Transmission: Must allow moisture from building interior to pass through the substrate and stain with a perm rating of greater than 5.00 when tested in accordance with ASTM E 96.

2.3.2 Water repellent stain

Water repellent stain shall be an water-based, modified acrylic, penetrating stain designed to provide long term color uniformity, ultraviolet resistance, alkali and pollution resistance, plus water repellency without disturbing the natural texture of the substrate. It shall be for use over vertical, above-grade, smooth or textured concrete, exposed aggregate concrete, glass reinforced concrete, brick, stone, stucco and other masonry surfaces. Water repellent stain shall meet the following minimum requirements:

A. Solids by volume shall be a maximum of 30 percent (+/-2) [ASTM D 2697]

B. Weight per gallon shall be a minimum of 9.2 (+/-.2) lbs. [ASTM D 1475]

C. Dry time shall be 15 minutes at 24 degree C (75 degree F), 50 percent R.H. [ASTM D 1640]

D. Cure time shall be 1 hour at 24 degree C (75 degree F), 50 percent R.H. [ASTM D 1640]

E. Gloss (Angular Reflectance) shall be 4 at 60 degree Gardner [ASTM D 523]

F. Adhesion to Concrete shall be a minimum of 700 lbs./sq. in. [ASTM D 3359]

G. Temperature Limits for Service Conditions shall range from -56 degree C to 93 degree C (-70 degree F to 200 degree F).

H. Toning pigments shall be inorganic oxides.

I. Resistance to Accelerated Weathering: Color retention and ultraviolet resistance of the treated specimen shall meet the following requirements after 3,000 hours of testing in accordance with ASTM G 154 in a QUV cabinet.

   1. Color Retention: Within five (5) N.B.S. (National Bureau of Standards) units when tested in accordance with ASTM D 2244; or shall show no appreciable change when tested in accordance with ASTM D 1729. Inspection is compared to unweathered specimen.

   2. Ultraviolet Resistance: No chalking or flaking when tested in accordance with ASTM D 4214 and D 722.

J. Resistance to Accelerated Atmospheric Exposure: Specimen shall exhibit no visible change after 12-month exposure in accordance with ASTM G 7.

K. Resistance to Salt Spray: Color retention and degree of efflorescence of the treated specimen shall meet the following requirements after 500 hours of testing in accordance with ASTM B 117 in a Harshaw Salt Spray Cabinet.

   1. Color Retention: Within five (5) N.B.S. (National Bureau of Standards) units when tested in accordance with ASTM D 2244; or shall show no appreciable change when tested in accordance with ASTM D 1729. Inspection is compared to unweathered specimen.

   2. Degree of Efflorescence: Specimen shall exhibit no efflorescence.

L. Resistance to Sulfide Staining: No discoloration after 15 minutes immersion in saturated hydrogen sulfide gas solution when tested in accordance with ASTM D 1712. Compare with control specimen not exposed to hydrogen sulfide gas solution.

M. Resistance to Chemical Reagents: Specimen shall exhibit none or slight color change and no softening or deterioration after 7 days immersion in the following chemicals: ammonium hydroxide - 10 percent; sodium hydroxide - 10 percent; mineral spirits, KB value 38. Inspection is compared to specimen not exposed to chemical reagents.

N. Verification of Minimum 10 Year Exposure to Appropriate Climate: Stain shall have been in use in a similar climatic region 10 years or more and show no sign of fading, peeling or flaking. Supply project locations exceeding 10 years of service.

O. Moisture Vapor Transmission: Must allow moisture from building interior to pass through the substrate and stain with a perm rating of greater than 5.00 when tested in accordance with ASTM E 96.

PART 3 EXECUTION

3.1 PRE-ROOFING MEETING

Not less than 3 days prior to the start of the roofing work, contractor shall schedule a pre-roofing meeting. This meeting shall include the Contracting Officer's Representative, government inspector, designer, and coating manufacturer's representative. Items that shall be prepared to discuss are schedule of the work, material storage areas, safety measures, protection of building components not to receive roofing materials, inspection methods, method of installation and points of contact in emergencies.

3.2 SURFACE EXAMINATION

Verify that all surfaces are ready to receive work. Roof surfaces shall be clean, dry, structurally sound, stable and well secured. The roof surface shall be free of excessive ponding water. A roof surface that allows standing water 48 hours after a rain shall be considered unacceptable. All water shall be allowed positive drainage from the roof. Inspect condition of flashing details adjacent to protrusions, penetrations, roof mounted equipment, curbs, walls, parapets, drains and roof edge to ensure that details are acceptable and will maintain a weather-tight installation after being properly detailed and coated. Inspect parapets to ensure that concrete, masonry or metal caps are sound. Caulk, reinforce or replace as necessary in order to bring parapet and parapet cap into a weathertight condition. Determine moisture content of existing substrate, insulation and deck. A moisture content of 15 percent or greater indicates a potential problem. Work shall not proceed until the cause of high moisture content is verified and condition is corrected.

3.3 SURFACE PREPARATION

3.3.1 BUILT-UP ROOFING SUBSTRATE

3.3.1.1 All loose gravel, dirt and debris shall be removed by vacuuming and/or power sweeping. Roofs exhibiting heavily embedded gravel must be made smooth for acceptance of the fluid-applied roof coating system using one of the following methods:

A. Removal of the protruding gravel by spudding, scraping or scarifying the surface as necessary to create a smooth, acceptable surface. Take care to preserve the integrity of the existing asphalt membrane whenever possible.

B. Application of a flood-coat of asphaltic emulsion in sufficient quantity so as to encapsulate and bury the protruding gravel, creating a smooth, acceptable surface.

C. Application of an approved roof recovery board, as per manufacturer's instruction, so as to create a smooth, acceptable surface.

3.3.1.2 Roof deck areas shall have positive slope-to-drain. Tapered insulation, cant strips, spray-applied polyurethane foam or other similar materials shall be used to build up affected roof surfaces as necessary to provide adequate slope-to-drain.

3.3.1.3 Inspect parapets to ensure that concrete, masonry, wood or metal caps are sound. Caulk, reinforce or replace as necessary in order to bring parapet and parapet cap into a weathertight condition using an approved single-component urethane sealant.

3.3.1.4 Severely deteriorated flashings shall be removed and either replaced, or repaired utilizing spray-applied polyurethane foam. Seal reglet conterflashings with single-component urethane sealant.

3.3.1.5 Any unsound areas in the roof deck or insulation, including blisters, delamination, deterioration, excessive moisture content, etc. shall be repaired or replaced. All blisters, delaminations, wrinkles and loose areas shall both be cut away and removed, or cut open and nailed flat to the deck.

3.3.1.6 All built-up roofing surfaces shall be cleaned using an approved, biodegradable cleaner, following manufacturer's instructions. Rinse thoroughly with fresh water under high pressure to remove the solution from the roof and achieve a "jet black" clean surface. Heavy deposits of dirt or contamination may require agitation with a stiff-bristle broom or similar mechanical scrubber. Allow the roof to dry thoroughly.

3.3.1.7 If the roof has been previously coated with aluminized asphalt of any kind, a penetrating primer must be applied to prevent potential "leafing" of the surface. Consult coatings manufacturer prior to application of the acrylic coating system over aluminized asphalt surfaces.

3.3.1.8 Reinforce repaired areas by encapsulating reinforcement fabric into the encapsulation coat over the repair. Cut a strip of reinforcement fabric (width depending on the size of the detail) to the desired length, and center it over the detail area. Apply encapsulation coat liberally from the top side using a brush or roller, working the encapsulation coat into the fabric so as to eliminate air pockets, wrinkles and gaps. Ensure that the reinforcement fabric is thoroughly saturated, encapsulated and fully adhered to the substrate.

3.3.1.9 All cracks, splits, voids or holes larger than 3 mm (1/8 inch) in width shall be filled and leveled using an approved single-component urethane caulk or acrylic mastic. Heavy alligatoring or rough texture in the existing built-up roofing shall be leveled by applying a flood-coat of approved asphalt emulsion, in sufficient quantity so as to achieve a smooth surface.

3.3.1.10 Reinforce all split seams, roof termination points, openings, around the base of all vents, pipes and other protrusions, as well as HVAC units and other roof mounted equipment with reinforcement fabric and encapsulation coat as described in 3.3.8 above.

3.3.2 CONCRETE ROOFING SUBSTRATE

3.3.2.1 All surfaces shall be clean and dry, and free of any dirt, dust, gravel, oil, surface chemicals or other contaminants that may interfere with optimum adhesion.

3.3.2.2 Any unsound areas in the roof deck, including deterioration, pitted or spalled concrete, excessive moisture content, etc. shall be repaired or replaced.

3.3.2.3 Roof deck areas shall have positive slope-to-drain. Tapered insulation, cant strips, spray-applied polyurethane foam or other similar materials shall be used to build up affected roof surfaces as necessary.

3.3.2.4 Fill any pits or holes in the concrete with concrete repair material so they are flush with the surrounding substrate. Spalled sections of the concrete should be resurfaced using a slurry-coat of concrete repair material, trowelled smooth over the affected area.

3.3.2.5 "Moving cracks" larger than 3 mm (1/8 inch) in diameter shall be routed out and filled using an approved urethane caulk. Cracks larger than 6 mm (1/4 inch) in diameter shall be routed out and fitted with polyethylene backer rod prior to caulking.

3.3.2.6 Inspect parapets to ensure that concrete, masonry, wood or metal caps are sound. Caulk, reinforce or replace as necessary in order to bring parapet and parapet cap into a weathertight condition.

3.3.2.7 All concrete surfaces, whether new or existing, shall be cleaned using an approved biodegradable cleaner, following manufacturer's instructions. Rinse thoroughly with fresh water under high pressure (minimum 2,000 psi - 13,790 Kpa) to remove the solution from the roof. Heavy deposits of dirt or contamination may require agitation with a stiff-bristle broom or similar mechanical scrubber. Allow the roof to dry thoroughly.

3.3.2.8 Prime all concrete surfaces with one coat of concrete prime material at a rate according to manufacturer's instruction to seal and solidify the surface.

3.3.2.9 Reinforce all "moving" cracks and/or seams, control joints, vertical/horizontal interfaces, roof termination points, openings, around the base of all vents pipes and other protrusions, as well as HVAC units and other roof mounted equipment with reinforcement fabric embedded into encapsulation coat. Cut a strip of reinforcement fabric (width depending upon the detail) to the desired length, and center it over the detail area. Apply encapsulation coat liberally from the top side using a brush or roller, working the encapsulation coat into the fabric so as to eliminate air pockets, wrinkles and gaps. Ensure that the reinforcement fabric is thoroughly saturated, encapsulated and fully adhered to the substrate.

3.3.3 METAL ROOFING SUBSTRATE

3.3.3.1 Metal surfaces to be coated shall be clean, dry, sound, and free of dirt, grease, oil, and any other contaminants that might interfere with the adhesion of the elastomeric acrylic coating.

3.3.3.2 All mechanical fasteners shall be checked for integrity. Retighten or replace as necessary. "Stripped out" fasteners shall be replaced using a larger diameter fastener.

3.3.3.3 Unsound rust shall be wire brushed, sandblasted or mechanically abraded to remove all loose rust. Metal panels deteriorated to the point that their structural integrity is compromised shall be replaced.

3.3.3.4 Remove excessive amounts of asphaltic-based or other deteriorated patching/flashing materials if present.

3.3.3.5 Check all seams to ensure that they are tight and flush. Excessive gaps or deflection between panels shall be eliminated by installing additional screws or rivets as necessary to restrict deflection to 6 mm (1/4 inch) or less.

3.3.3.6 All metal surfaces, whether new or existing, shall be cleaned using an approved biodegradable cleaner, following manufacturer's instructions. Rinse thoroughly with fresh water under high pressure (minimum 2,000 psi - 13,790 Kpa) to remove the solution from the roof. Heavy deposits of dirt or contamination may require agitation with a stiff-bristle broom or similar mechanical scrubber. Allow the roof to dry thoroughly.

3.3.3.7 All existing "sound" rusted areas shall be primed with metal primer according to the manufacturer's instructions.

3.3.3.8 If the roof has been previously coated with aluminized asphalt of any kind, a penetrating primer must applied to prevent potential "leafing" of the surface. Consult coatings manufacturer prior to application of the acrylic coating system over aluminized asphalt surfaces.

3.3.3.9 Fill gaps between 6 and 13 mm (1/4 and 1/2 inch) at panel seams, joints and protrusions with an approved single-component urethane caulk. Fill gaps larger than 13 mm (1/2 inch) such as at the ridge cap, roof edge and/or interface of dissimilar materials, using polyethylene backer rod or spray-applied polyurethane foam.

3.3.3.10 All horizontal (end-lap) seams and vertical (side-lap) seams which have not been factory crimped or presealed, roof terminations and flashings, around drains, scuppers and skylights, and the base of all vents, conduits, HVAC equipment and other protrusions shall be reinforced using one or more of the following methods:

A. Apply base coat acrylic elastomer liberally, using a brush or roller, along the area to be detailed. While the base coat is still wet, embed a strip of 15 to 30 cm (6 to 12 inch) reinforcement mesh for end-lap seams. For side-lap seams, use 5 to 10 cm (2 to 4 inch) reinforcement mesh, as per detail requirements, centered over the seam, joint or interface. Work the reinforcement mesh into the base coat, applying additional material as necessary to totally encapsulate the reinforcement fabric.

B. Cut a length of 15 cm (6 inch) reinforcement tape to the desired length, peel off the release backing, center over the end-lap detail area and press firmly into place, removing all wrinkles and bubbles. For side lap seams 5 to 10 cm (2 to 3 inch) reinforcement tape may be used. A wallpaper seam roller is helpful in securing the reinforcement tape to the metal deck.

C. Apply a minimum of two (2) coats of acrylic mastic, using a brush, roller or airless spray, to a total thickness of 60 to 80 dry mils (1,524 to 2,032 microns) over the detail area. Extend the sealant a minimum of 8 cm (3 inch) on either side of seams, joints and interfaces.

3.3.3.11 At the interface of any metal with a dissimilar material, detail the joint using one of the following methods:

A. Apply 15 cm (6 inch) reinforcement mesh embedded into base coat as previously described in 3.3.3.10 a.

D. Apply a strip of 15 cm (6 inch) reinforcement tape as previously described in 3.3.3.10 b.

E. Apply two (2) coats of acrylic mastic to a total thickness of 60 to 80 mils (1,524 to 2,032 microns) as previously described in 3.3.3.10 c.

3.3.4 TILE ROOFING SUBSTRATE

3.3.4.1 All surfaces shall be clean and dry, and free of any dirt, dust, gravel, oil, surface chemicals or other contaminants that may interfere with optimum adhesion.

3.3.4.2 Any unsound areas in the roof deck, including deterioration, pitted or spalled concrete, excessive moisture content, etc. shall be repaired or replaced.

3.3.4.3 Roof deck areas shall have positive slope-to-drain. Tapered insulation, cant strips, spray-applied polyurethane foam or other similar materials shall be used to build up affected roof surfaces as necessary to allow positive drainage.

3.3.4.4 Fill any pits or holes with concrete repair material so they are flush with the surrounding substrate.

3.3.4.5 Inspect parapets to ensure that concrete, masonry, wood or metal caps are sound. Caulk, reinforce or replace as necessary in order to bring parapet and parapet cap into a weathertight condition.

3.3.4.6 Remove excessive amounts of asphaltic-based or other deteriorated patching/flashing materials if present.

3.3.4.7 All concrete roof tile surfaces, whether new or existing, shall be cleaned using an approved biodegradable cleaner, following manufacturer's instructions. Rinse thoroughly with fresh water under high pressure (minimum 2,000 psi - 13,790 Kpa) to remove the solution from the roof. Heavy deposits of dirt or contamination may require agitation with a stiff-bristle broom or similar mechanical scrubber. Allow the roof to dry thoroughly.

3.3.4.8 Prime all tile roof surfaces with one coat of concrete prime material at a rate according to manufacturer's instructions to seal and solidify the surface.

3.3.4.9 Reinforce all cracks, roof termination points with dissimilar materials, openings, around the base of all vents pipes and other protrusions, as well as HVAC units and other roof mounted equipment with reinforcement fabric embedded into base coat. Apply base coat acrylic elastomer liberally, using a brush or roller, along the area to be detailed. While the base coat is still wet, embed a strip of reinforcement mesh, as per detail requirements, centered over the seam, joint or interface. Work the reinforcement mesh into the base coat, applying additional material as necessary to totally encapsulate the reinforcement fabric. Ensure that the reinforcement fabric is thoroughly saturated, encapsulated and fully adhered to the substrate.

3.3.4.10 Check all seams and joints to ensure that they are tight and flush. Excessive gaps or deflection between tiles shall be eliminated by repositioning tiles as necessary to restrict deflection to 6 mm (1/4 inch) or less.

3.3.4.11 Seal all gaps between tiles, as well as other seams, joints and protrusions with acrylic mastic. Apply acrylic mastic using either brush or airless spray, to a thickness of 40 to 60 dry mils (1,016 to 1,524 microns) centered over the detail area. Extend the acrylic mastic a minimum of 1 inch on either side of seam, joint or interface.

3.3.5 COMPOSITE SHINGLE SUBSTRATE

3.3.5.1 All surfaces shall be clean and dry, and free of any dirt, dust, oil, surface chemicals or other contaminants that may interfere with optimum adhesion. Composite Shingles shall be swept clean so as to remove all loose or partially embedded mineral. Care shall be taken to preserve the integrity of the existing shingles whenever possible.

3.3.5.2 Roof deck areas shall have positive slope-to-drain. Tapered insulation, cant strips, spray-applied polyurethane foam or other similar materials shall be used to build up affected roof surfaces as necessary to provide adequate drainage.

3.3.5.3 Inspect parapets to ensure that concrete, masonry, wood or metal caps are sound. Caulk, reinforce or replace as necessary in order to bring parapet and parapet cap into a weathertight condition.

3.3.5.4 Severely deteriorated flashings shall be removed and either replaced or repaired utilizing spray-applied polyurethane foam.

3.3.5.5 Any unsound areas in the roof deck or insulation, including blisters, delamination, deterioration, excessive moisture content, etc. shall be repaired or replaced. All blisters, delaminations and loose areas shall be removed and replaced. Any curled shingles shall be tightly secured using galvanized nails. All severely curled shingles, or any shingles deteriorated to the point that they have lost their integrity, shall be replaced.

3.3.5.6 All Composite Shingle roofing surfaces shall be cleaned using an approved, biodegradable cleaner, following Manufacturer’s instructions. Rinse thoroughly with fresh water under moderate pressure (approximately 500 psi) to remove the solution from the roof, yet not damage the shingles. Heavy deposits of dirt or contamination between shingles may require agitation with a stiff-bristle broom or similar mechanical scrubber.

3.3.5.7 All algae or moss growing on or between the shingles must be removed. If algae or moss is present after cleaning, use a specialized roof formula algae and moss killer. Allow the roof to dry thoroughly.

3.3.5.8 Reinforce all drains, scuppers, around the base of all vents, pipes and other protrusions, as well as HVAC units and other roof mounted equipment by embedding Reinforcement Fabric into the Encapsulation Coat. Cut a strip of 4”, 6” or 12” (10, 15 or 20 cm) Reinforcement Fabric (depending upon the size of the detail) to the desired length, and center it over the detail area. Apply Encapsulation Coat liberally from the top side using a brush or roller, working the Encapsulation Coat into the fabric so as to eliminate air pockets, wrinkles and gaps. Ensure that the Reinforcement Fabric is thoroughly saturated, encapsulated and fully adhered to the substrate.

3.3.6 SURFACE PREPARATION FOR WATER REPELLENT SEALER AND STAIN

Surfaces to receive water-repellent sealer or stain shall be structurally sound, clean, dry, fully cured, and free from dust, efflorescence, scale, or other foreign materials. Methods and materials used for cleaning of substrate shall be as recommended by the manufacturer of the water-repellent sealer or stain. Materials such as curing agents, form release agents, bond breakers and other concrete production materials shall be completely removed in accordance with the particular manufactures printed instructions for removal prior to coating application.

3.4 COATING APPLICATION

3.4.1 BUILT-UP ROOFING SUBSTRATE

3.4.1.1 All roof preparation materials shall be allowed to dry thoroughly prior to application of the acrylic coating.

3.4.1.2 Prior to application of the acrylic coating system, all dust, dirt and other contaminants shall be blown off the roof surfaces to be coated using high pressure compressed air.

3.4.1.3 Apply encapsulation coat to a small section of roof where the fabric reinforcement will begin. Embed and encapsulate the end of the reinforcement fabric roll so that it is anchored at that point. Roll out a 1.2 to 1.8 meter (4 to 6 foot) section of fabric and either spray apply or pour the encapsulation coat evenly over the top side at the rate according to the manufacturer's instructions, allowing the fabric to conform to the surface contours. Work the encapsulation coat evenly throughout the fabric using a soft-bristle broom or roller so that it is totally encapsulated, eliminating any air pockets, wrinkles or gaps. Take extra care to ensure that edges of the fabric are well saturated and adhered. Overlap consecutive passes of reinforcement fabric a minimum of 5 cm (2 inch) on each side. Use encapsulation coat to embed reinforcement fabric in this manner over all built-up roofing surfaces.

3.4.1.4 Substrate porosity and texture will determine the amount of encapsulation coat required to saturate and encapsulate the reinforcement fabric. Allow the encapsulation coat to dry thoroughly prior to applying the intermediate coat to the roof.

3.4.1.5 Apply base coat, using airless spray or roller, at the rate according to the manufacturer's instructions.

3.4.1.6 After allowing base coat to dry thoroughly, apply intermediate coat (in desired color), using airless spray or roller, at the rate according to the manufacturer's instructions. Apply intermediate coat in a perpendicular direction to the base coat.

3.4.1.7 After allowing intermediate coat to dry thoroughly, apply finish coat (in desired color), using airless spray or roller, at the rate according to the manufacturer's instruction. Apply finish coat in a perpendicular direction to the intermediate coat.

3.4.1.8 The total minimum dry film thickness required at any location shall be 40 mils (1,016 microns).

3.4.1.9 The top coat shall extend up and over the top of all parapets, as well as all vent pipes and other protrusions, to terminate a minimum of 7.6 cm (3 inch) above the substrate, creating a self-terminating flashing and so as to provide an aesthetically pleasing appearance. To lock in the system at perimeter walls, wrap the fabric up the parapet and under the counter-flashing, or up and over the parapet, extending down onto the front face.

3.4.2 CONCRETE ROOFING SUBSTRATE

3.4.2.1 All detail work shall be allowed to dry thoroughly prior to application of the acrylic coating.

3.4.2.2 Immediately prior to application of the acrylic coating system, all dust, dirt and other contaminants shall be blown off the roof surfaces to be coated using high pressure compressed air.

3.4.2.3 Apply encapsulation coat to a small section of roof where the fabric reinforcement will begin. Embed and encapsulate the end of the reinforcement fabric roll so that it is anchored at that point. Roll out a 1.2 to 3 meter (4 to 10 foot) section of fabric, and either spray apply or pour encapsulation coat evenly over the top side at the rate according to the manufacturer's instructions, allowing the fabric to conform to the surface contours. Work the encapsulation coat evenly throughout the fabric using a soft-bristle broom or roller so that it is totally encapsulated, eliminating any air pockets, wrinkles or gaps. Take extra care to ensure that edges of the fabric are well saturated and adhered. Overlap consecutive passes of reinforcement fabric a minimum of 5 cm (2 inch) on each side. Use encapsulation coat to embed reinforcement fabric in this manner over all concrete roofing surfaces.

3.4.2.4 Substrate porosity and texture will determine the amount of encapsulation coat required to saturate and encapsulate the reinforcement fabric. Allow the encapsulation coat to dry thoroughly prior to applying the base coat to the roof.

3.4.2.5 Apply base coat, using airless spray or roller, at the rate according to the manufacturer's instructions.

3.4.2.6 After allowing base coat to dry thoroughly, apply intermediate coat (in desired color), using airless spray or roller, at the rate according to the manufacturer's instructions. Apply intermediate coat in a perpendicular direction to the base coat.

3.4.2.7 After allowing intermediate coat to dry thoroughly, apply finish coat (in desired color), using airless spray or roller, at the rate according to the manufacturer's instructions. Apply finish coat in a perpendicular direction to the intermediate coat.

3.4.2.8 The total minimum dry film thickness required at any location shall be 40 mils (1,016 microns).

3.4.2.9 The top coat shall extend up and over the top of all parapets, as well as all vent pipes and other protrusions, to terminate a minimum of 7.6 cm (3 inch) above the substrate, creating a self-terminating flashing and so as to provide an aesthetically pleasing appearance. To lock in the system at perimeter walls, wrap the fabric up the parapet and under the counter-flashing, or up and over the parapet, extending down onto the front face.

3.4.3 METAL ROOFING SUBSTRATE

3.4.3.1 All detail work shall be allowed to dry thoroughly prior to application of the acrylic coating.

3.4.3.2 Immediately prior to application of the acrylic coating system, all dust, dirt and other contaminants shall be blown off the roof surfaces to be coated using high pressure compressed air.

3.4.3.3 Apply base coat, using airless spray or roller, at the rate according to the manufacturer's instructions.

3.4.3.4 After allowing base coat to dry thoroughly, apply intermediate coat (in desired color), using airless spray or roller, at the rate according to the manufacturer's instructions. Apply intermediate coat in a perpendicular direction to the base coat.

3.4.3.5 After allowing intermediate coat to dry thoroughly, apply finish coat (in desired color), using airless spray or roller, at the rate according to the manufacturer's instructions. Apply finish coat in a perpendicular direction to the intermediate coat.

3.4.3.6 The total minimum dry film thickness required at any location shall be 30 mils (762 microns).

3.4.3.7 The top coat shall extend up and over the top of all parapets, as well as all vent pipes and other protrusions, to terminate a minimum of 7.6 cm (3 inch) above the substrate, creating a self-terminating flashing and so as to provide an aesthetically pleasing appearance. To lock in the system at perimeter walls, wrap the fabric up the parapet and under the counter-flashing, or up and over the parapet, extending down onto the front face.

3.4.4 TILE ROOFING SUBSTRATE

3.4.4.1 All detail work shall be allowed to dry thoroughly prior to application of the acrylic coating.

3.4.4.2 Immediately prior to application of the acrylic coating system, all dust, dirt and other contaminants shall be blown off the roof surfaces to be coated using high pressure compressed air.

3.4.4.3 Apply two separate coats of base coat, using airless spray or roller, at the rate according to the manufacturer's instructions. Apply second base coat, after allowing the first to dry thoroughly, in a perpendicular direction to the first base coat.

3.4.4.4 After allowing base coat to dry thoroughly, apply intermediate coat (in desired color), using airless spray or roller, at the rate according to the manufacturer's instructions. Apply intermediate coat in a perpendicular direction to the second base coat.

3.4.4.5 After allowing intermediate coat to dry thoroughly, apply finish coat (in desired color), using airless spray or roller, at the rate according to the manufacturer's instructions. Apply finish coat in a perpendicular direction to the intermediate coat.

3.4.4.6 The total minimum dry film thickness required at any location shall be 40 mils (1,016 microns).

3.4.4.7 The top coat shall extend up and over the top of all parapets, as well as all vent pipes and other protrusions, to terminate a minimum of 7.6 cm (3 inch) above the substrate, creating a self-terminating flashing and so as to provide an aesthetically pleasing appearance. To lock in the system at perimeter walls, wrap the fabric up the parapet and under the counter-flashing, or up and over the parapet, extending down onto the front face.

3.4.5 COMPOSITE SHINGLE SUBSTRATE

3.4.5.1 All roof preparation materials shall be allowed to dry thoroughly prior to application of the acrylic coating.

3.4.5.2 Prior to application of the acrylic coating system, all dust, dirt and other contaminants shall be blown off the roof surfaces to be coated using high pressure compressed air.

3.4.5.3 Apply Encapsulation Coat, using airless spray or a heavy nap roller, at a rate of approximately 100 sq. ft. per gallon (2.4 m^2/l), depending on the surface texture and porosity. Apply liberally at shingle edges to ensure a secure seal and bond. Follow shingles horizontally across the roof surface, working from the peak down. Allow the Encapsulation Coat to dry thoroughly prior to applying the Intermediate Coat to the roof.

3.4.5.4 Apply Intermediate Coat (in desired finish color), using airless spray or roller, at the approximate rate of 1.75 gallons per 100 sq. ft., in a perpendicular direction to the Encapsulation coat.

3.4.5.5 After allowing Intermediate Coat to dry thoroughly, apply Finish Coat (in desired color), using airless spray or roller, at the rate of 1.75 gallons per 100 sq. ft. Apply Finish Coat in a perpendicular direction to the Intermediate Coat.

3.4.5.6 The total minimum dry film thickness required at any location shall be 35 mils (889 microns).

3.4.5.7 The Top Coat shall extend up and over the top of all parapets, as well as all vent pipes and other protrusions, to terminate a minimum of 3" (7.6 cm) above the substrate, creating a self-terminating flashing and so as to provide an aesthetically pleasing appearance. To lock in the system at perimeter walls, extend the coating system up the parapet and under the counter-flashing, or over the top of the parapet, extending down onto the front face.

3.4.6 WATER REPELLENT SEALER AND STAIN APPLICATION

Mixing and application of water-repellent sealer and stain shall be in accordance with manufacturer's printed application instruction. Applicator shall apply a field test on a small inconspicuous area of the actual building surface to determine the best absorption rate to achieve color uniformity, as well as to determine suitability of the application technique.

3.5 CLEANUP

3.5.1 Maintain work and work areas in accordance with clean, safe condition at all times during coating installation. Remove excess materials, trash and debris daily.

3.5.2 At the completion of the project, clean area of any spills and containers, and clean up all roofing debris, leaving jobsite in a clean and orderly condition.

SECTION 07220

ROOF AND DECK INSULATION

TABLE OF CONTENTS

PART 1 GENERAL

This specification covers the requirements for insulation for use beneath built-up, modified bitumen, or single-ply roofing, EPDM or PVC elastomeric sheet membrane roofing. Insulation materials apply to both organic and inorganic materials used for thermal protection as part of roofing assemblies or under decks.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A208.1 HIST (Historical) 1979 Mat-formed Wood Particleboard (Revised 1986)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 208 (1995) Cellulosic Fiber Insulating Board

ASTM C 552 (2000) Cellular Glass Thermal Insulation

ASTM C 578 (2001) Rigid, Cellular Polystyrene Thermal Insulation

ASTM C 726 (2000, Rev A) Mineral Fiber Roof Insulation Board

ASTM C 728 (1997) Perlite Thermal Insulation Board

ASTM C 984 (1994) Perlite Board and Rigid Cellular Polisocyanurate Composite Roof Insulation

ASTM C 1050 (1991) Rigid Cellular Polystyrene-Cellulosic Fiber Composite Roof Insulation

ASTM C 1177/C 1177M (2001) Glass Mat Gypsum Substrate for Use as Sheathing

ASTM C 1289 (2000) Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board

ASTM D 41 (1994) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing

ASTM D 226 (1997a) Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing

ASTM D 312 (2000; Rev. A) Asphalt Used in Roofing

ASTM D 2178 (1997a) Asphalt Glass Felt Used in Roofing and Waterproofing

ASTM D 4586 (2000) Asphalt Roof Cement, Asbestos Free

ASTM D 4897 (1998) Asphalt-Coated Glass-Fiber Venting Base Sheet Used in Roofing

ASTM E 84 (2001) Surface Burning Characteristics of Building Materials

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P9513 (1996) Loss Prevention Data for Roofing Contractors

FM P7825 (2001) Approval Guide Fire Protection, or

FM P7825c (2001) Approval Guide Building Materials

UNDERWRITERS LABORATORIES (UL)

UL Bld Mat Dir (2001) Building Materials Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 4052 (1999) Waterproofing Asphalt for Building Construction

KS F 4901 (2002) Asphalt Felt

KS M 2270 (1997) Asphalt Primer Used in Roofing, Dampproofing and Waterproofing

KS M 3807 (1998) Recycled Foam Polystyrene Thermal Insulation Material

KS M 3808 (1997) Foam Polystyrene Thermal Insulation Material

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Wood Nailers;

Tapered roof insulation system; G

Taper cants and crickets;

Show location and spacing of wood nailers that are required for securing insulation. Show a complete description of the procedures for the installation of each phase of the system indicating the type of materials, thicknesses, identity codes, sequence of laying insulation, location of ridges and valleys, special methods for cutting and fitting of insulation, and special precautions. The drawings shall be based on field measurements.

SD-03 Product Data

Insulation; G.

SD-06 Test Reports

Flame spread and smoke developed ratings;

Submit in accordance with ASTM E 84.

SD-08 Manufacturer¡s Instructions

Nails and fasteners.

Roof insulation, including field of roof and perimeter attachment requirements.

1.3 MANUFACTURER'S CERTIFICATE

Submit certificate from the insulation manufacturer attesting that the installer has the proper qualifications for installing tapered roof insulation systems. Certificate attesting that the expanded perlite or polyisocyanurate insulation contains recovered material and showing estimated percent of recovered material. Certificates of compliance for felt materials.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery

Deliver materials to site in manufacturer's unopened and undamaged standard commercial containers bearing the following legible information:

a. Name of manufacturer;

b. Brand designation;

c. Specification number, type, and class, as applicable, where materials are covered by a referenced specification; and

Deliver materials in sufficient quantity to allow continuity of the work.

1.4.2 Storage and Handling

Store and handle materials in a manner to protect from damage, exposure to open flame or other ignition sources, and from wetting, condensation or moisture absorption. Store in an enclosed building or trailer that provides a dry, adequately ventilated environment. Store felt rolls on ends. For the 24 hours immediately before application of felts, store felts in an area maintained at a temperature no lower than 10 degrees C (50 degrees F) above grade and having ventilation around all sides. Replace damaged material with new material.

1.5 ENVIRONMENTAL CONDITIONS

Do not install roof insulation during inclement weather or when air temperature is below 4 degrees C (40 degrees F) and interior humidity is 45 percent or greater, or when there is visible ice, frost, or moisture on the roof deck.

PART 2 PRODUCTS

2.1 INSULATION

2.1.1 Insulation Types

Insulation shall be a standard product of the manufacturer and shall be factory marked with the manufacturer's name or trade mark, the material specification number, the R-value at 24 degrees C (75 degrees F), and the thickness. Minimum thickness shall be as recommended by the manufacturer. Boards shall be marked individually. The thermal resistance of insulation shall be not less than the R-value shown on the drawings. The insulation manufacturing process shall not include chlorofluoro carbons(CFC). Roof insulation shall be one or an assembly of a maximum of three of the following materials and compatible with attachment methods for the specified insulation and roof membrane:

a. Expanded Perlite Board: ASTM C 728. Minimum 19 mm (3/4 inch) thick when both top and bottom surfaces will be in contact with asphalt.

b. Polyisocyanurate Board: ASTM C 1289 Type I -- foil faced both sides or Type II, fibrous felt or glass mat membrane both sides, except minimum compressive strength shall be 140 kPa (20 psi).

c. Composite Boards: ASTM C 1289, Type III, perlite insulation board faced one side, fibrous felt or glass fiber mat membrane on other side, or Type V, oriented strand board or waferboard on one side and fibrous felt or glass fiber mat membrane or aluminum foil on the other; ASTM C 984 (Polyisocyanurate-perlite); or ASTM C 1050 (Polystyrene-wood fiberboard), Type III, Grade 1, Class A. Don¡t apply polystyrene composite board when insulation will be applied with hot asphalt.

d. Cellular Glass Boards: ASTM C 552, Type IV.

e. Polystyrene Board: Shall be in accordance with ASTM C 578, Type II, IV, or X, or KS M 3808, Type 1, 2, or 3, or KS M 3807, Type 1. Don¡t apply non-composite polystyrene board when insulation will be applied with hot asphalt or used under hot asphalt-applied roofing. This type of insulation is sensitive to hot asphalt, various solvents, and certain single ply roofing membranes. Expanded or extruded polystyrene insulation board is flexible enough for use on arched roofs. For this application, each layer must be thin enough to permit the required bending and each layer must be mechanically fastened. Check individual manufacturer requirement prior to application.

2.1.2 Mineral-Fiber Insulation Board

ASTM C 726.

2.1.3 Insulation Thickness

Thickness shall be based on the "R" value for aged insulation. Insulation over steel decks shall satisfy both specified R value and minimum thickness for width of rib opening recommended in insulation manufacturer's published literature.

2.2 PROTECTION BOARD

For use as a thermal barrier (underlayment), fire barrier (overlayment), or protection board for hot-mopped, torched-down, or adhesively-applied roofing membrane over roof insulation.

2.2.1 Glass Mat Gypsum Roof Board

Glass mat gypsum roof board will be specified as a contractor's option to wood fiberboard, expanded perlite, or other suitable material, when an underlayment or overlayment is required for the roof insulation board. ASTM C 1177/C 1177M, 0 Flame Spread and 0 Smoke Developed when tested in accordance with ASTM E 84, 3450 kPa (500 psi), Class A, non-combustible, 13 mm (1/2 inch) thick, 1220 by 2440 mm (4 by 8 feet) board size.

2.3 BITUMENS

Where insulation is installed under roofing that does not require hot asphalt and vapor retarder is not required, do not apply asphalt, asphalt roof cement, asphalt-saturated felt, asphalt-coated glass felt, and asphalt primers. Always mechanically secure first layer of insulation to steel decks. For installation over steel and other decks not requiring vapor retarders or where asphalt is not used in installing insulation, specify only mechanical fastening of insulation.

2.3.1 Asphalt Primer

ASTM D 41 or KS M 2270.

2.3.2 Asphalt

ASTM D 312, Type III or IV. Asphalt flash point, finished blowing temperature, and equiviscous temperature (EVT) for mop and for mechanical spreader application shall be indicated on bills of lading or on individual containers.

2.3.3 Asphalt Roof Cement

ASTM D 4586, Type I for horizontal surfaces and for surfaces sloped from 0 to 3 inches per foot, Type II for vertical and surfaces sloped more than 3 inches per foot.

2.4 MOISTURE CONTROL

Vapor retarder should be specified only where:

1. Outside, average January temperature is below 4 degrees C 40 degrees F, and expected winter interior relative humidity is 45 percent or greater;

2. Roofing system will be subject to continuing excessively high interior humidity; and

3. Results of detailed analysis indicate potential roofing problem resulting from water-vapor infiltration.

2.4.1 Vapor Retarder

2.4.1.1 Asphalt-Saturated Felt Base Sheet for Single Layer Application

ASTM D 4601, weighing not less than 17.5 kilograms per 10 square meters 35 pounds per 100 square feet.

2.4.1.2 Asphalt-Coated Glass Felt

ASTM D 2178, Type IV or VI.

2.4.2 Ventilating Felt for Concrete Decks

ASTM D 4897, Type II, non-perforated, with spot mopping holes where specified.

2.4.3 Organic Roofing

ASTM D 226, Type I.

2.5 FASTENERS

Flush-driven through flat round or hexagonal steel or plastic plates. Steel plates shall be zinc-coated, flat round not less than 35 mm (1 3/8 inch) diameter or hexagonal not less than 0.4 mm (28 gage). Plastic plates shall be high-density, molded thermoplastic with smooth top surface, reinforcing ribs and not less than 75 mm (3 inches) in diameter. Fastener head shall recess fully into the plastic plate after it is driven. Plates shall be formed to prevent dishing. Do not use bell-or cup-shaped plates. Fasteners shall conform to insulation manufacturer's recommendations except that holding power, when driven, shall be not less than 534 N (120 pounds) each in steel deck. Fasteners for steel or concrete decks shall conform to FM P7825c for Class I roof deck construction, and shall be spaced to withstand an uplift pressure of 4.3 kPa (90 pounds per square foot).

2.5.1 Roofing Nails for Wood Decks

Barbed 3 mm (11 gage), zinc-coated nails with 11 to 16 mm (7/16 to 5/8 inch) diameter heads or annular ring shank, square head, one-piece composite nails. Nails shall be long enough to penetrate wood deck at least 16 mm (5/8 inch) but shall not protrude through underside of decking.

2.5.2 Fasteners for Plywood Decks

Annular ring shank, square head, one-piece composite nails long enough to penetrate into plywood decks approximately 13 mm (1/2 inch) but not protrude through underside of decking.

2.5.3 Fasteners for Steel Decks

Approved hardened penetrating fasteners or screws conforming to FM AS 4470 and listed in FM P7825c for Class I roof deck construction. Quantity and placement to withstand a minimum uplift pressure of 4.31 kPa (90 psf) conforming to FM P7825.

2.5.4 Fasteners for Poured Concrete Decks

Approved hardened fasteners or screws to penetrate deck at least 25 mm one inch but not more than 38 mm 1 (1/2 inches), conforming to FM AS 4470, and listed in FM P7825 for Class I roof deck construction. Quantity and placement to withstand an uplift pressure of 4.31 kPa (90 psf)conforming to FM P7825.

2.6 WOOD NAILERS

Pressure-preservative-treated as specified in Section 06100N, "Rough Carpentry." When roof slope exceeds one in 24 1/2 inch per foot, insulating materials beneath built-up roofing should be both mopped and held in place by treated wood nailers. Non-nailable decks should be provided with surface-applied nailing strips of same thickness as insulation. See built-up bituminous roofing specifications for requirements on nailing of roofing felts. For all insulated roof decks, treated wood nailers should be applied at eave edgings and sides of roofs and around curbs and elsewhere as necessary to provide nailing for gravel stops and flashings. Refer to FM Loss Prevention Data Sheet 1-49 for method of attachment of nailers.

PART 3 EXECUTION

3.1 EXAMINATION AND PREPARATION

3.1.1 Surface Inspection

Surfaces shall be clean, smooth, and dry. Surfaces receiving vapor retarder shall be free of projections which might puncture the vapor retarder. Check roof deck surfaces, including surfaces sloped to roof drains and outlets, for defects before starting work. The Contracting Officer will inspect and approve the surfaces immediately before starting installation. Prior to installing vapor retarder, ventilating felt, and insulation, perform the following:

a. Examine wood decks to ascertain that deck boards have been properly nailed and that exposed nail heads have been set.

b. Examine steel decks to ensure that panels are properly secured to structural members and to each other and that surfaces of top flanges are flat or slightly convex.

3.1.2 Surface Preparation

Correct defects and inaccuracies in roof deck surface to eliminate poor drainage and hollow or low spots and perform the following:

a. Install wood nailers the same thickness as insulation at eaves, edges, curbs, walls, and roof openings for securing cant strips, gravel stops, gutters, and flashing flanges. On decks with slopes of one in 12 one inch per foot or more, install wood nailers perpendicular to slope for securing insulation [and for backnailing of roofing felts. Space nailers in accordance with approved shop drawings.

b. Fill or cover cracks or knot holes larger than 13 mm (1/2 inch) in diameter in wood decks as necessary to form an unyielding surface.

c. Apply the following requirements when a vapor retarder is required over wood deck or when insulation is applied directly to the wood deck with hot asphalt. Cover wood decks with a layer of rosin-sized building paper or unsaturated felt. Lap sides and ends not less than 75 mm (3 inches). Nail sufficiently to prevent tearing or buckling during installation.

d. Cover steel decks with a layer of insulation board of sufficient thickness to span the width of a deck rib opening, and conforming to fire safety requirements. Secure with piercing or self-drilling, self-tapping fasteners of quantity and placement conforming to FM P7825. Insulation joints parallel to ribs of deck shall occur on solid bearing surfaces only, not over open ribs.

e. Solidly apply asphalt primer to concrete decks at the rate of 4 liters per 10 square meters (one gallon per 100 square feet) of roof surface, stopping approximately 100 mm (4 inches) from joints between the precast concrete units. Allow primer to dry thoroughly. Place felt strips, 100 mm (4 inches) or more in width, over joints, 50 mm (2 inches) on each side, between precast concrete units in a heavy coating of cold-applied asphalt roof cement.

3.2 INSTALLATION OF VAPOR RETARDER

Vapor retarder may be specified for heated buildings where the average January temperature is below 5 degrees C (40 degrees F) and the expected interior winter humidity exceeds 45 percent. Vapor retarder will be specified for heated buildings where a high humidity condition is expected, such as indoor swimming pool or laundry.

Where a vapor retarder is to be installed, the designer will make sure that the computations show that the dew point is on the cold side of the vapor retarder. Computations should use recognized methods in agreement with ASHRAE Handbook, Fundamentals.

Install vapor retarder in direct contact with roof deck surface, ventilating felt, or insulation. Vapor retarder shall consist of either two plies of No. 15 asphalt-saturated felt, two plies of asphalt-coated glass felt, or one layer of asphalt-saturated felt base sheet. Lay vapor retarder at right angles to direction of slope. Install first ply of felt or base sheet as specified herein for the specific deck. Apply second ply of 2-ply vapor retarder system using asphalt at rate of 10 to 18 kgs per 10 square meters (20 to 35 lbs per 100 square feet), applied within plus or minus 15 degrees C (25 degrees F) of EVT. Do not heat asphalt above asphalt's FBT or 275 degrees C (525 degrees F), whichever is less. Use thermometers to check temperatures during heating and application. Side and end laps shall be completely sealed. Asphalt shall be visible beyond all edges of each ply as it is being installed. Plies shall be laid free of wrinkles, buckles, creases or fishmouths. Workers shall not walk on mopped surfaces when the asphalt is sticky. Press out air bubbles to obtain complete adhesion between surfaces. At walls, eaves and rakes, and other vertical surfaces, the vapor retarder organic felts shall be extended 225 Mm

(9 inches), or separate organic felt plies shall be extended 225 mm (9 inches), with not less than 225 mm (9 inches) on the substrate, and the extended portion turned back and mopped in over the top of the insulation. At roof penetrations other than walls, eaves and rakes, and vertical surfaces, the vapor retarder or separate plies shall be extended 225 mm (9 inches) to form a lap which shall later be folded back over the edge of the insulation. Asphalt roof cement shall be used under the vapor retarder for at least 225 mm (9 inches) from walls, eaves, rakes and other penetrations.

3.2.1 Vapor Retarder on Poured Concrete Decks

Solidly mop primed substrate with asphalt at rate of 10 to 18 kgs per 10 square meters (20 to 35 lbs per 100 square feet) before installing vapor retarder. Lay first ply of 2 ply system with each sheet lapping 480 mm (19 inches) over the preceding sheet. Lap ends not less than 100 mm (4 inches). Stagger laps a minimum of 300 mm (12 inches). For a vapor retarder consisting of one layer of asphalt base sheet, provide side and end laps not less than 100 mm 4 inches. Stagger laps a minimum of 300 mm (12 inches). Cement base sheets together with a solid mopping of asphalt.

3.2.2 Vapor Retarder on Precast Concrete Decks

Solidly mop primed substrate with asphalt at rate of 10 to 18 kgs per square meters (20 to 35 lbs per 100 square feet) before installing vapor retarder. Lay first ply of 2 ply system with each sheet lapping 480 mm (19 inches) over preceding sheet. Lap ends not less than 100 mm (4 inches). Stagger laps a minimum of 300 mm (12 inches). For vapor retarder consisting of one layer of asphalt base sheet, provide side and end laps not less than 100 mm (4 inches) and stagger laps a minimum of 300 mm (12 inches). Cement base sheets together with a solid mopping of asphalt.

3.2.3 Vapor Retarder on Wood Decks

Lay first ply of 2 ply system dry with each sheet lapping 50 mm (2 inches) over the preceding sheet. Lap ends not less than 100 mm (4 inches). Stagger laps a minimum of 300 mm (12 inches). Nail felt at 150 mm (6 inch) intervals along side laps and install two rows of nails approximately 275 mm (11 inches) apart down longitudinal center of each sheet, with nails staggered at 450 mm (18 inches) O.C. For vapor retarder consisting of one layer of asphalt base sheet, lap each sheet 100 mm (4 inches) over the preceding sheet. Provide end laps not less than 100 mm (4 inches) and stagger laps a minimum of 300 mm (12 inches). Cement side and end laps together with solid mopping of asphalt or heavy coat of asphalt roof cement. Nail side laps at 150 mm (6 inch) intervals. Apply asphalt mopping at rate of 10 to 18 kgs per 10 square meters (20 to 35 lbs per 100 square feet). Install two rows of nails approximately 275 mm (11 inches) apart down longitudinal center of each sheet, with nails staggered at 450 mm (18 inches) O.C.

3.2.4 Vapor Retarder on Steel Decks

Solidly mop the mechanically secured insulation surface with asphalt before installing vapor retarder. For a 2 ply vapor retarder, install each sheet lapping 480 mm (19 inches) over the preceding sheet. Lap ends not less than 100 mm (4 inches). Stagger the laps a minimum of 300 mm (12 inches). Cement felts together with solid mopping of asphalt. Apply asphalt moppings at rate of 10 to 18 kgs per 10 square meters (20 to 35 lbs per 100 square feet). For a vapor retarder consisting of one layer of asphalt base sheet, lap each sheet 100 mm (4 inches) over preceding sheet. Lap ends not less than 100 mm 4 inches, and stagger laps a minimum of 300 mm (12 inches). Cement base sheets together with solid mopping of asphalt.

3.2.5 Over Gypsum Insulating Concrete or Lightweight Insulating Concrete One ply of venting inorganic base sheet shall be laid, without mopping, at right angle to the slope with 100 mm (4 inch) side laps and 150 mm (6 inch) end laps. Laps shall be bonded with hot asphalt. End laps shall be staggered. Base sheet shall be nailed 220 mm (9 inches) on centers at side laps and in 2 rows 270 mm (11 inches) apart down the center of the sheet with nails 450 mm 18 inches on centers and staggered, or attached to the concrete as determined by uplift requirements. The 2-ply vapor retarder shall then be applied over the base sheet as specified above.

3.2.6 Over Concrete Decks and First Layer of Insulation on Steel Decks

The 2-ply vapor retarder shall be applied as specified above except that venting inorganic base sheet shall be deleted.

3.2.7 Over Structural Concrete on Non-Venting Support

One ply of venting inorganic base sheet with mopping holes shall be laid dry at right angle to the slope with 100 mm (4 inch) side laps and 150 mm (6 inch) end laps. The vapor retarder shall then be applied as specified.

3.3 INSTALLATION OF VENTILATING FELT

Ventilating felt will be specified for new and existing concrete decks suspected of having retained moisture to aid in dissipation of any moisture retained in concrete. This felt shall not be considered to be a vapor retarder. Apply ventilating felt in accordance with manufacturer's printed instructions, or spot-mopped with asphalt to concrete deck when hot asphalt is applied. Extend over roof cants, up vertical surfaces and terminate under cap flashing; at roof edges terminate under outside edge of perimeter edge nailers or under gravel stop fascia.

3.4 INSULATION INSTALLATION

Apply insulation in two layers with staggered joints when total required thickness of insulation exceeds 13 mm (1/2 inch). Lay insulation so that continuous longitudinal joints are perpendicular to direction of roofing or felts for the built-up roofing and end joints of each course are staggered with those of adjoining courses. When using multiple layers of insulation, joints of each succeeding layer shall be parallel and offset in both directions with respect to layer below. Keep insulation 13 mm (1/2 inch) clear of vertical surfaces penetrating and projecting from roof surface.

3.4.1 Installation Using Asphalt

Firmly embed each layer in solid asphalt mopping; mop only sufficient area to provide complete embedment of one board at a time. Provide 10 to 18 kgs (20 to 35 lbs) of asphalt per 10 square meters (100 square feet) of roof deck for each layer of insulation. Apply asphalt when temperature is within plus or minus 15 degrees C (25 degrees F) of EVT. Do not heat asphalt above asphalt's FBT or 275 degrees C (525 degrees F), whichever is less, for longer than 4 consecutive hours. Use thermometers to check temperatures during heating and application.

3.4.2 Installation Using Asphalt on Steel Decks

Apply this paragraph when a vapor retarder is required over steel decks. Secure first layer of insulation and thermal barrier to deck with piercing or self-drilling, self-tapping fasteners. Engage fasteners by driving them through insulation into top flange of steel deck. Use driving method prescribed by fastener manufacturer. Insulation joints parallel to ribs of deck shall occur on solid bearing surfaces only, not over open ribs. Secure succeeding layers with solid asphalt moppings. Where insulation is applied over steel deck, long edge joints shall continuously bear on surfaces of the steel deck. Insulation which can be readily lifted after installation is not considered to be adequately secured. Insulation shall be applied so that all roof insulation applied each day is waterproofed the same day. Phased construction will not be permitted. Application of impermeable faced insulation shall be performed without damage to the facing.

3.4.3 Installation Using Only Mechanical Fasteners

Secure total thickness of insulation with penetrating type fasteners.

3.4.4 Special Precautions for Installation of Foam Insulation

3.4.4.1 Polyisocyanurate Insulation

Where polyisocyanurate foam board insulation is provided, install 13 mm (1/2 inch) thick wood fiberboard, glass mat gypsum roof board, or 19 mm (3/4 inch) thick expanded perlite board insulation over top surface of foam board insulation. Stagger joints of insulation with respect to foam board insulation below.

3.4.4.2 Polystyrene Insulation

a. Over top surface of non-composite polystyrene board, install 13 mm (1/2 inch) thick high density wood fiberboard, 19 mm (3/4 inch) thick expanded perlite board, glass mat gypsum roof board, or other overlayment approved by roofing sheet manufacturer. Tightly butt and stagger joints of field applied overlayment board at least 150 mm (6 inches) with respect to the polystyrene board below. Apply 150 mm (6 inch) wide glass fiber roofing tape centered over joints and edges of overlayment board.

b. Where composite boards consisting of polystyrene insulation are provided, apply 150 mm (6 inch) wide glass-fiber roofing tape centered over joints and edges of composite board. Apply joint strips as recommended by roofing sheet manufacturer.

3.4.5 Cant Strips

If cant strips are necessary, coordinate location with mechanical drawings to ensure that no projections, such as vent pipes and braces, will be constructed through or within 250 mm (10 inches) of cant strips. Specify wood cants, edge strips, and pressure preservative treatment in Section 06100. Where indicated, provide cant strips at intersections of roof with walls, parapets, and curbs extending above roof. Wood cant strips shall bear on and be anchored to wood blocking. Fit cant strips flush against vertical surfaces. Where possible, nail cant strips to adjoining surfaces. Where cant strips are installed against non-nailable materials, install in heavy mopping of asphalt or set in a heavy coating of asphalt roof cement or an approved adhesive.

3.4.6 Tapered Edge Strips

Where indicated, provide edge strips in the right angle formed by junction of roof and wood nailing strips that extend above level of roof. Install edge strips flush against vertical surfaces of wood nailing strips. Where possible, nail edge strips to adjoining surfaces. Where installed against non-nailable materials, install in heavy mopping of asphalt or set in heavy coating of asphalt roof cement or an approved adhesive.

3.5 PROTECTION

3.5.1 Protection of Applied Insulation

Completely cover each day's installation of insulation with the finished roofing on same day. Do not permit phased construction. Protect open spaces between insulation and parapets or other walls and spaces at curbs, scuttles, and expansion joints, until permanent roofing and flashing are applied. Do not permit storing, walking, wheeling, or trucking directly on insulation or on roofed surfaces. Provide smooth, clean board or plank walkways, runways, and platforms near supports, as necessary, to distribute weight to conform to indicated live load limits of roof construction. Exposed edges of the insulation shall be protected by cutoffs at the end of each work day or whenever precipitation is imminent. Cutoffs shall be 2 layers of bituminous-saturated felt set in plastic bituminous cement or single ply or EPDM membrane set in roof cement. Fill all profile voids in cut-offs to prevent entrapping of moisture into the area below the membrane. Cutoffs shall be removed when work is resumed.

3.5.2 Damaged Work and Materials

Restore work and materials that become damaged during construction to original condition or replace with new materials.

3.6 INSPECTION

The Contractor shall establish and maintain an inspection procedure to assure compliance of the installed roof insulation with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to, the following:

a. Observation of environmental conditions; number and skill level of insulation workers; start and end time of work.

b. Verification of certification, listing or label compliance with FM P9513.

c. Verification of proper storage and handling of insulation and vapor retarder materials before, during, and after installation.

d. Inspection of vapor retarder application, including edge envelopes and mechanical fastening.

e. Inspection of mechanical fasteners; type, number, length, and spacing.

f. Coordination with other materials, cants, sleepers, and nailing strips.

g. Inspection of insulation joint orientation and laps between layers, joint width and bearing of edges of insulation on deck.

h. Installation of cutoffs and proper joining of work on subsequent days.

i. Continuation of complete roofing system installation to cover insulation installed same day.

SECTION 07240

EXTERIOR INSULATION AND FINISH SYSTEM

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 117 (1997) Operating Salt Spray (Fog) Apparatus

ASTM C 67 (2000) Sampling and Testing Brick and Structural Clay Tile

ASTM C 150 (2000) Portland Cement

ASTM C 473 (2000) Physical Testing of Gypsum Panel Products

ASTM C 578 (1995) Rigid, Cellular Polystyrene Thermal Insulation

ASTM C 841 (1999) Standard Specification for Installation of Interior Lathing and Furring

ASTM C 847 (1995; R 2000) Standard Specificaiton for Metal Lath

ASTM C 920 (1998) Elastomeric Joint Sealants

ASTM C 1177/C 1177M (1999) Glass Mat Gypsum Substrate for Use as Sheathing

ASTM C 1186 (1999el) Flat Non-Asbestos Fiber Cement Sheets

ASTM D 968 (1993) Abrasion Resistance of Organic Coatings by Falling Abrasive

ASTM D 2247 (1999) Testing Water Resistance of Coatings in 100% Relative Humidity

ASTM D 3273 (2000) Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber

ASTM E 84 (2000) Surface Burning Characteristics of Building Materials

ASTM E 119 (2000) Fire Tests of Building Construction and Materials

ASTM E 136 (1999) Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C

ASTM E 330 (1997e1) Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference

ASTM E 331 (2000) Water Penetration of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference

ASTM E 695 (1997) Measuring Relative Resistance of Wall, Floor, and Roof Construction to Impact Loading

ASTM G 23 (1996) Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials

EIFS INDUSTRY MEMBERS ASSOCIATION (EIMA)

EIMA TM 101.01 (1995) Freeze/Thaw Resistance of Exterior Insulation and Finish Systems (EIFS), Class PB

EIMA TM 101.86 (1995; Rev Aug 1995) Resistance of Exterior Insulation and Finish Systems (EIFS), Class PB to the Effects of Rapid Deformation (Impact)

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO)

ICBO Bldg Code (1997) Uniform Building Code (3 Vol.)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 268 (1996) Determining Ignitibility of Exterior Wall Assemblies Using a Radiant Heat Energy Source

KOREA STANDARD (KS)

KS F 4552 (2000) Metal Lath

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G.

Drawings showing wall layout, construction and expansion joints, decorative grooves, layout of sheathing board, thermal insulation board, and reinforcing fabric mesh and strip reinforcing fabric mesh; joint and flashing details; types and location of fasteners; details at windows and doors; details at base, roof, parapet, corners; and isometric drawings showing intersection of flashings, window frames, and EIFS at corners, etc.

SD-03 Product Data

Exterior Insulation and Finish System; G.

System manufacturer's literature including specifications and details. Joint and other details, such as end conditions, corners, windows, and parapet, shall be included. For sealants, shelf life and recommended cleaning solvents shall be included. Material safety data sheets (MSDS) shall be supplied for the components of the EIFS and be available at the job site. Two copies of manufacturer's standard printed instructions for installation of the EIFS. Instructions shall include manufacturer's recommended details for corner treatment, jambs, sills, openings, joints and other special applications.

SD-04 Samples

Exterior Insulation and Finish System; G.

Two samples of each exterior insulation and finish system demonstrating aesthetic effects and qualities of materials and execution.

SD-06 Test Reports

Exterior Insulation and Finish System; G.

Test Reports by an approved, independent testing laboratory indicating that the EIFS complies with the specified performance requirements.

SD-07 Certificates

Qualifications; G.

Evidence that the manufacturer has a minimum of 3 years experience manufacturing EIFS. A list of installations using the same products and applicator shall be included.

Certification from sealant manufacturer attesting that the sealant applicator is approved for the proper sealant installation for EIFS.

Third Party Inspection; G.

Certification from Third Party inspector of current Exterior Design Institute, or equal inspector certificate, attesting that the inspector is trained in proper installation of EIFS.

Installer;

Certification attesting that EIFS installer is trained and approved by the EIFS manufacturer.

Warranty; G.

At the completion of the project, signed copies of the 5-year warranty for the EIFS, a sample copy of which is attached to this section, and the manufacturer's standard material warranties.

Insulation Board;

As it may pertain, certificate attesting that the insulation board furnished for the project contains recovered material, and showing an estimated percent of such recovered material.

Quality Control;

Filled-out inspection checklist, certifying that the installation of critical items meets the requirements of this specification.

SD-10 Operation and Maintenance Data

Exterior Insulation and Finish System;

Manufacturer instructions for repair and maintenance procedures.

1.3 DESCRIPTION

The exterior insulation and finish system (EIFS) shall be a job-fabricated exterior wall covering consisting of insulation board, reinforcing fabric mesh, base coat, finish coat, and accessories. The system components shall be compatible with each other and with the substrate and be products of, or approved by, a single manufacturer regularly engaged in furnishing exterior insulation and finish systems. Only an installer trained and approved by the EIFS manufacturer shall be used.

1.4 PERFORMANCE REQUIREMENTS

Unless otherwise noted, the test specimens shall consist of reinforcement, base coat and finish coat applied in accordance with the manufacturer's printed recommendations to an insulation board common to the system. These specimens shall be suitably sized for the apparatus used and allowed to cure for a minimum of 28 days prior to testing.

1.4.1 Abrasion Resistance

The system shall be tested for abrasion resistance in accordance with ASTM D 968, Method A. A minimum of two specimens shall be tested with no cracking, checking, or loss of film integrity after 500 liters (114 gallons) of sand.

1.4.2 Accelerated Weathering

The system shall be tested for accelerated weathering in accordance with ASTM G 23, Method 1. The specimen shall be tested for a period of 2,000 hours without visible cracking, flaking, peeling, blistering, yellowing, fading, or other such deteriorations.

1.4.3 Mildew-Fungus Resistance

The system shall be tested for mildew-fungus resistance using ASTM D 3273. The specimen shall consist of the finish coat material only, applied to clean 75 by 100 mm (3 by 4 inch) glass slides and shall be allowed to cure for 28 days. After 28 days of exposure the specimens shall not show any growth.

1.4.4 Salt Spray Resistance

The system shall be tested for salt spray resistance in accordance with ASTM B 117. The specimens shall be a minimum size of 100 by 150 mm (4 by 6 inch) and shall be tested for 300 hours with no observable deterioration.

1.4.5 Water Penetration

The system shall be tested for water penetration by uniform static air pressure in accordance with ASTM E 331. No penetration of water beyond the plane of the base coat/EPS board interface after 15 minutes at 6.24 psf (299 Pa), or 20% of positive design wind pressure, whichever is greater.

1.4.6 Water Resistance

The system shall be tested for water resistance in accordance to ASTM D 2247. The specimens shall be a minimum size of 100 by 150 mm (4 by 6 inch) and shall be tested for 14 days with no cracking, checking, crazing erosion, blistering, peeling or delamination after 14 days exposure.

1.4.7 Freeze/Thaw Resistance

Class PB specimens shall be tested for 60 cycles with no cracking, checking, or splitting and have negligible weight gain in accordance with EIMA TM 101.01 test method. Class PM specimens shall be tested for 50 cycles, with no deleterious effects according to ASTM C 67.

1.4.8 Fire Resistance

1.4.8.1 Surface Burning Characteristics

Flame spread test samples shall consist of base coat, reinforcing fabric mesh and finish coat, applied to a non-combustible substrate. A minimum of three samples shall be tested in accordance with ASTM E 84 and shall have a flame spread index of 25 or less and a smoke development value of 450 or less.

1.4.8.2 Flammability Characteristics (Full-Scale or Intermediate-Scale Multistory Fire Test)

Multistory wall fire test specimens shall include the complete system with no less than 100 mm (4 inches) of insulation board. Test shall be performed in accordance with UBC Standard 26-4 or (optional) UBC Standard 26-9 both contained in Volume 3 of ICBO Bldg Code, and must meet the conditions of acceptance which include:

a. No vertical spread of flame within the core of the panel from one story to the next.

b. No flame propagation over the exterior surface.

c. No vertical spread of flame over the interior surface from one story to the next.

d. No significant lateral spread of flame from the compartment of fire origin to adjacent spaces.

1.4.8.3 Radiant Heat

The system shall be tested in accordance with NFPA 268 with no ignition during the 20-minute period.

1.4.8.4 Fire Endurance

The system shall be tested according to ASTM E 119 with no effect on the fire resistance rating of the wall assembly.

1.4.9 Impact Resistance

1.4.9.1 Hemispherical Head Test

The Class PB system shall have been tested and shown to be capable of withstanding an impact of 10-17 N-m (90-150 inch pounds) for first floor or high pedestrian traffic areas, 3-6 N-m (25-49 inch pounds) for second or higher floors, when tested in accordance with EIMA TM 101.86.

1.4.9.2 Impact Mass

The Class PM system shall have been tested in accordance with ASTM E 695. No cracking or denting after twelve impacts by 13.6 kg (30 lbs) lead shot mass from 150 to 1800 mm (6 inches to 6 feet) drop heights in 150 mm (6 inch) intervals.

1.4.10 Wind Load

Test panels shall consist of steel stud framing, screw attached exterior sheathing board, minimum 20 mm (3/4 inch) thick insulation board, and the finish system. The system shall have been tested in accordance with ASTM E 330 (Procedure A) to minimum positive and negative pressures of 7.18 Kpa (150 psf). No permanent deformation, delamination, or other deterioration at 1.5 times the design wind load, both positive and negative.

1.5 QUALITY ASSURANCE

1.5.1 Qualifications

a. The EIFS shall be the product of a manufacturer who has been in the practice of manufacturing and designing EIFS for a period of not less than 3 years, and has been involved in at least five projects similar to this project in size, scope and complexity.

b. The Contractor shall be trained and approved by the EIFS manufacturer to install the system and shall have successfully installed at least five projects at or near the size and complexity of this project. The Contractor shall employ qualified workers trained and experienced in installing the manufacturer's EIFS.

c. Sealant applicator shall be experienced and competent in the installation of high performance industrial and commercial sealants and shall have successfully installed at least five projects at or near the size and complexity of this project.

d. Insulation board shall be approved and labeled under a third party quality program as required by applicable building code.

1.5.2 Field Sample Installations

Before installing system, sample installations shall be constructed for each form of construction and finish required to verify selections made under Sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Sample installations shall be built to comply with the following requirements, using materials indicated for completed work:

a. Locate sample installations in the location and of the size directed by the Contracting Officer.

b. Demonstrate the proposed range of color, texture, thickness, installation and workmanship. Include typical joints and sealant.

c. Obtain Contracting Officer's written approval of sample installations before starting fabrication of work.

d. Maintain sample installations during construction as a standard for judging the completed work, protecting them from weather and construction activities.

e. When directed, demolish and remove sample installations from the site.

1.5.3 Pre-Installation Conference

After approval of submittal and before commencing any work on the EIFS, the Contracting Officer will hold a pre-installation conference to review:

a. Drawings and specifications;

b. Procedure for onsite inspection and acceptance of EIFS substrate and pertinent details;

c. Contractor's plan for coordination of work of the various trades involved in providing the EIFS and other components;

d. Inspection procedures;

e. Safety requirements.

Pre-installation conference shall be attended by the Contractor, EIFS Q.C. Specialist (EIFS Inspector), and all personnel directly responsible for installation of the EIFS, including sealant applicator, and personnel responsible for related work, such as flashing and sheet metal, windows and doors, and a representative of the EIFS manufacturer. Before beginning EIFS work, the Contractor shall confirm in writing the resolution of conflicts among those attending the pre-installation conference.

1.6 DELIVERY AND STORAGE

Materials shall be delivered to the jobsite in their original unopened packages, clearly marked with the manufacturer's name, brand name, and description of contents. Storage shall be in accordance with the manufacturer's recommendations in a clean, dry, well-ventilated area. Stored materials shall be protected from sunlight, and kept away from excessive heat. Coating materials which would be damaged by freezing shall be kept at a temperature not less than 4 degrees C (40 degrees F). Insulation board shall not be exposed to flame or other ignition sources.

1.7 ENVIRONMENTAL CONDITIONS

Unless a higher temperature is required by the system manufacturer, the ambient air temperature shall be 4 degrees C (40 degrees F) or greater and rising at the time of installation. Supplemental heat may be used to maintain this ambient temperature. The system shall be protected from exposure to temperatures below 4 degrees C (40 degrees F) for at least 24 hours after installation. EIFS shall not be applied during inclement weather unless appropriate protection is provided. Installed materials shall be protected from inclement weather until they are dry.

1.8 WARRANTY

Manufacturer's standard warranty for the EIFS shall be furnished. Warranty shall run directly to the Government and cover a period of not less than 5 years from date of Government's acceptance.

PART 2 PRODUCTS

2.1 SHEATHING BOARD

Only water resistant sheathing boards shall be used with an adhesively applied Class PB EIFS to prevent delamination of an adhesively applied Class PB EIFS from the substrate sheathing board where water has penetrated and degraded the sheathing boards.

2.1.1 Cement Board

Sheathing, minimum 13 mm (1/2 inch thick), shall be non-combustible exterior cement board per ASTM E 136. Sheathing boards shall meet the requirements of ASTM C 1186, Type B, Grade I, water absorption not to exceed 17 percent maximum. Nail Pull Resistance, when tested in accordance with ASTM C 473, shall be no less than 534 N (120 lb).

2.1.2 Glass Mat Gypsum Sheathing Board

Sheathing shall conform to ASTM C 1177/C 1177M. Nail Pull Resistance, when tested in accordance with ASTM C 473, shall be no less than 534 N (120 lb).

2.2 ADHESIVE

Adhesive shall be the manufacturer's standard product, including primer as required, and shall be compatible with the substrate, insulation board and reinforcing mesh to which the system is applied.

2.3 INSULATION BOARD

2.3.1 General Requirements

Insulation board shall conform to ASTM C 578, type as recommended by the system manufacturer and shall be compatible with other system components. Insulation board shall be certified as aged, in block form prior to cutting and shipping, a minimum of 6 weeks by air drying, or equivalent. Insulation board shall be a standard product of the manufacturer and shall be factory marked with the manufacturer's name or trade mark, the material specification number, the R-value at 24 degrees C (75 degrees F), and the thickness. Thickness of insulation board shall be based on specified R-value, but no single layer shall be less than 20 mm (3/4 inch thick). The maximum thickness of all layers of insulation board combined shall not exceed 100 mm (4 inches). Boards shall be marked individually. The thermal resistance of insulation board in the system shall be not less than the R-value shown on the drawings.

2.4 BASE COAT

Base coat shall be the manufacturer's standard product and shall be compatible with other system components.

2.5 PORTLAND CEMENT

Portland cement shall conform to ASTM C 150, Type I or II as required, shall be fresh, free of lumps, and approved by the system manufacturer.

2.6 REINFORCING FABRIC

Reinforcing fabric mesh shall be alkali-resistant, balanced, open weave, glass fiber fabric made from twisted multi-end strands specifically treated for compatibility with the other system materials, and comply with ASTM E 2098.

2.7 Expanded Metal Lath

Metal lath shall conform to ASTM C 847 or KS F 4552, 1.8 kg/m^2 (3.4 lb/yd^2), self-furring, galvanized.

2.8 MECHANICAL FASTENERS

Mechanical fasteners shall be corrosion resistant and as recommended by the system manufacturer. Select fastener type and pattern based on applicable wind loads and substrate into which the fastener will be attached, to provide the necessary pull-out, tensile and shear strengths.

2.9 FINISH COATING

The finish coat shall be manufacturer's standard product of the color and texture specified. For color consistency, use materials from the same batch or lot number.

2.10 JOINT SEALANT

Joint sealant shall meet requirements of ASTM C 920, Class 25, and shall be compatible with the EIFS materials. Type, Grade, and Use shall be as recommended by both the sealant manufacturer and the system manufacturer. When required, primer, bond breaker and backer rod shall be non-staining, and as recommended by the sealant manufacturer and the system manufacturer. Only closed-cell, non-adsorptive materials shall be used as backer rod. The backer rod shall be sized 25 to 30 percent larger than the width of the joint.

2.11 ACCESSORIES

Accessories shall conform to the recommendations of the system manufacturer and shall include items such as trim, edging, and other specialty components required for proper installation of the system. All metal items shall be corrosion resistant.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Surface shall be sound and free of oil, loose materials or protrusions which will interfere with the system installation. For adhesively attached EIFS, existing deteriorated or weathered paint must be removed. Due to substrate conditions or as recommended by the system manufacturer, a primer may be required. The primer shall be mixed and applied per the manufacturer's instructions. The substrate shall be plane, with no deviation greater than 6 mm (1/4 inch) when tested with a 3 m (10 foot) straightedge. The Contractor shall not proceed with the installation until all noted deficiencies are corrected.

3.2 INSTALLATION

Installation shall conform to the system manufacturer's printed recommendations except as otherwise specified. Acceptable installer shall be prequalified under the requirements of paragraph QUALITY ASSURANCE.

3.3 SHEATHING BOARD

Sheathing board shall be attached to studs with self-tapping drywall screws, or secured to concrete or masonry with approved fasteners. Screws for application of the sheathing board shall be spaced not more than 200 mm (8 inches) on each supporting member, and fasteners into concrete or masonry shall be spaced not more than 300 mm (12 inches) apart horizontally and vertically. Fasteners shall be more closely spaced when required for negative wind load resistance. Edges and ends of sheathing boards shall be butted snugly with vertical joints staggered to provide full and even support for the insulation board.

3.4 METAL LATH

Metal lath shall be applied to painted concrete, masonry and metal wall with the long dimension across the walls, with true even surfaces, and without sags or buckles in accordance with ASTM C 841. Metal lath on vertical surfaces shall be oriented to provide maximum mechanical bond and the upper sheet shall be attached to overlap the lower sheet. The lath shall be secured to walls at intervals not more than 225 mm (9 inches) apart horizontally and vertically. Nails or staples shall be used for securing lath to painted solid walls. Side-laps or junction of sides shall be tied or otherwise secured at intervals not exceeding 225 mm (9 inches) to painted solid walls, in addition to being secured to supports.

3.5 INSULATION BOARD

Insulation board shall be applied using adhesive spread with a notched trowel to the back of the insulation boards in accordance with the manufacturer's instructions. Unless otherwise specified by the system manufacturer, insulation boards shall be placed with the long edge horizontal from a level base line. Vertical joints shall be staggered and insulation boards interlocked at corners. L-shaped insulation board pieces shall be used at corners of openings. Joints of insulation boards shall be butted tightly. Surfaces of adjacent insulation boards shall be flush at joints. Gaps greater than 2 mm (1/16 inch) between the insulation boards shall be filled with slivers of insulation board. Joints of insulation board shall be offset from substrate joints by at least 200 mm (8 inches). Uneven board surfaces with irregularities projecting more than 2 mm (1/16 inch) shall be rasped in accordance with the manufacturer's instructions to produce an even surface. The adhered insulation board shall be allowed to remain undisturbed for 24 hours prior to proceeding with the installation of the base coat/reinforcing mesh, or longer if necessary for the adhesive to dry.

3.6 BASE COAT AND REINFORCING FABRIC MESH

3.6.1 Class PB EIFS

Base coat shall be mixed in accordance with the manufacturer's instructions and applied to insulated wall surfaces to the thickness as specified by the system manufacturer. The reinforcing fabric mesh shall be troweled and fully embedded into the wet base coat material. When properly worked-in, the pattern of the reinforcing fabric mesh shall not be visible. Diagonal reinforcement shall be provided at opening corners. All terminations of the EIFS shall be backwrapped. The reinforcing fabric mesh shall be overlapped a minimum of 65 mm (2-1/2 inches) on previously installed mesh, or butted, in accordance with the manufacturer's instructions. The adhered insulation board shall be allowed to dry for 24 hours, or longer if necessary, prior to proceeding with the installation of the base coat/reinforcing fabric mesh.

3.6.2 Class PM EIFS

Reinforcing fabric mesh shall be mechanically fastened to the insulated wall using the type and spacing of fasteners specified in the manufacturer's instructions. Base coat shall be mixed and applied in accordance with manufacturer's instructions, and shall be troweled into the reinforcing fabric mesh to produce a smooth, continuous coating at a thickness as specified by the manufacturer.

3.7 FINISH COAT

Finish coat shall be applied and leveled in one operation. Final texture shall be obtained by trowels, floats, or by spray application as necessary to achieve the required finish. The finish coat shall be applied to the dry base coat maintaining a wet edge at all times to obtain a uniform appearance. The thickness of the finish coat shall be in accordance with the system manufacturer's current published instructions. Finish coat shall be applied without covering surfaces to which joint sealants are to be applied. The base coat/reinforcing mesh shall be allowed to dry (a minimum of 24-hours) prior to the application of the finish coat. Surface irregularities in the base coat, such as trowel marks, board lines, reinforcing mesh laps, etc., shall be corrected prior to application of the finish coat.

3.8 JOINT SEALANT

EIFS shall be sealed at openings as recommended by the system manufacturer.

3.8.1 Surface Preparation, Backer Rod, and Primer

The following steps shall be performed: a) Immediately prior to application, remove loose matter from joint. b) Ensure that joint is dry and free of paint, finish coat, or other foreign matter. c) Install backer rod. d) Apply primer as required by sealant and EIFS manufacturer. e) Check that joint width is as shown on drawings, but in no case less than 13 mm (1/2 inch) for perimeter seals and 20 mm (3/4 inches) for expansion joints (the width shall not be less than 4 times the anticipated movement). f) Check sealant manufacturer's recommendations regarding proper width to depth ratio.

3.8.2 Sealant

The following requirements shall be adhered to: a) Apply sealant in accordance with sealant manufacturer's instructions with gun having nozzle that fits joint width. b) Do not use sealant that has exceeded shelf life or cannot be discharged in a continuous flow. c) Completely fill the joint solidly with sealant without air pockets so that full contact is made with both sides of the joint. d) Tool sealant with a round instrument that provides a concave profile and a uniformly smooth and wrinkle free sealant surface. e) Do not wet tool the joint with soap, water, or any other liquid tooling aid. f) Do not apply sealant until all EIFS coatings are fully dry. g) During inclement weather, protect the joints until sealant application. h) Use particular caution in sealing joints between window and door frames and the EIFS wall and at all other wall penetrations. i) Clean all surfaces to remove excess sealant.

3.9 CLEAN-UP

Upon completion of the work, all scaffolding, equipment, materials and debris shall be removed from site. All temporary protection installed to facilitate installation of EIFS shall be removed.

3.10 INSPECTION

The Contractor shall establish and maintain an inspection procedure to assure compliance of the installed EIFS with contract requirements. Work found to be not in compliance shall be removed and replaced or corrected in an approved manner. Inspection shall include, but not be limited to the following:

<u>CHECKLIST</u>

Item	Description	Approve
a.	Materials are handled and stored correctly.	_______

b. Environmental conditions are within specified limits, including temperature not below 4 degrees C 40 degrees F, and the work is protected from the elements as required. ________

c. Preparation and installation is performed by qualified personnel using the correct tools. ________

d. Adjacent surfaces, including windows and doors, to which the system is not to be applied shall be protected from accidental application of EIFS materials through the use of masking tapes, plastic films, drop cloths, etc. ________

e. Control, expansion and aesthetic joints are installed as indicated or recommended. Accessories are properly installed. ________

f. Substrate is in-plane, properly attached, clean, dry, and free of contaminants. Concrete substrate is free of efflorescence. ________

g. Materials are mixed thoroughly and in proper proportions. ________

h. Adhesive is applied in sufficient quantity with proper-size notched trowel for the manufacturer recommended pattern. ________

i. Mechanical attachments are of the proper type, spacing, layout and fastener depth. ________

j. Insulation boards are tightly abutted, in running bond pattern, with joints staggered with the sheathing, board corners interlocked, L-shaped boards around openings, edges free of adhesive, and provision for joints. Gaps are filled and surfaces rasped. ________

k. Insulation board adhesive must be allowed to dry (a minimum of 24-hours) prior to the application of the finish coat. ________

l. Reinforcing fabric mesh is properly backwrapped at terminations. ________

m. Reinforcing fabric mesh is fully embedded and properly placed. Corners are reinforced. Openings are diagonally reinforced. Mesh overlaps minimum 65 mm 2-1/2 inches. ________

n. Base coat thickness is within specified limits. ________

o. The base coat/reinforcing fabric mesh must be allowed to dry (a minimum of 24-hours) prior to the application of the finish coat. ________

p. Finish coat is applied with sufficient number of personnel and stopped at suitable points. Floats and methods of texturing are uniform. ________

q. Flashings and joint sealant are properly installed and applied at time specified by the manufacturer. ________

r. All scaffolding, equipment, materials, debris and temporary protection are removed from the site upon completion. ________

SECTION 07311

ROOFING, STRIP SHINGLES

TABLE OF CONTENTS

PART 1 GENERAL

This guide specification covers the requirements of asphalt shingle roofing, surfaced with mineral granules, including roofing felt, ridge vents, underlayments, and flashings. For a more detailed description of asphalt shingle roofing and requirements for asphalt shingle reroofing over existing asphalt shingles, wood shingles, roll roofing, or built-up roofing, see the "Residential Asphalt Roofing Manual," published by Asphalt Roofing Manufacturers Association (ARMA) and "The NRCA Steep Roofing Manual," published by the National Roofing Contractors Association (NRCA). Avoid reroofing with asphalt shingles over more than one layer of existing roofing material.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 41	(1994) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
ASTM D 224	(1989; R 1996) Smooth-Surfaced Asphalt Roll Roofing (Organic Felt)
ASTM D 226	(1997; Rev. A) Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D 249	(1989; R 1996) Asphalt Roll Roofing (Organic Felt) Surfaced with Mineral Granules
ASTM D 1970	(2001) Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection

ASTM D 3018 (2000) Class A Asphalt Shingles Surfaced with Mineral Granules

ASTM D 3462 (2001) Asphalt Shingles Made from Glass Felt and Surfaced with Mineral Granules

ASTM D 4586 (2000) Asphalt Roof Cement, Asbestos Free

ASTM D 4869 (1988; R 1993) Asphalt-Saturated Organic Felt Shingle Underlayment Used in Roofing

NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA)

NRCA Shingle Manual 1996 Asphalt Shingle Roofing Manual

UNDERWRITERS LABORATORIES (UL)

UL 790 (1997) Fire Resistance of Roof Covering Materials

UL 997 (1995) Wind Resistance of Prepared Roof Covering Materials

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 4750 (1997) Asphalt Shingles

KS F 4901 (1997) Asphalt Roofing Felts (Fiber Base, Saturated Bitumen Felts)

1.2 DEFINITIONS

1.2.1 Top Lap

That portion of shingle overlapping shingle in course below.

1.2.2 Head Lap

The triple coverage portion of top lap which is the shortest distance from the butt edge of an overlapping shingle to the upper edge of a shingle in the second course below.

1.2.3 Exposure

That portion of a shingle exposed to the weather after installation.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Shingles; G.

Submit data including type, weight, class, UL labels, and special types of underlayment and eave flashing.

SD-04 Samples

Shingles; G.

Full shingle sample and manufacturer's standard size samples of materials and products requiring color or finish selection.

SD-08 Manufacturer's Instructions

Application;

1.4 DELIVERY AND STORAGE

Deliver materials in the manufacturer's unopened bundles and containers bearing the manufacturer's brand name. Keep materials dry, completely covered, and protected from the weather. Store according to manufacturer's written instructions. Roll goods shall be stored on end in an upright position or in accordance with manufacturer's recommendations. Immediately before laying, roofing felt shall be stored for 24 hours in an area maintained at a temperature not lower than 10 degrees C (50 degrees F).

1.5 WARRANTIES

Warranties shall begin on the date of Government acceptance of the work.

1.5.1 Manufacturer's Warranty

Furnish the asphalt shingle manufacturer's standard 25 year warranty for the asphalt shingles. The warranty shall run directly to the Government.

1.5.2 Contractor's Warranty

The Contractor shall warrant for 5 years that the asphalt shingle roofing system, as installed, is free from defects in workmanship. When repairs due to defective workmanship are required during the Contractor's warranty period, the Contractor shall make such repairs within 72 hours of notification. When repairs are not performed within the specified time, emergency repairs performed by others will not void the warranty.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Shingles

Mineral granule-surfaced asphalt shingles, self-sealing, square tab, strip, ASTM D 3018, Type I, and ASTM D 3462, weighing not less than 10.3 kilograms per square meter (210 pounds per 100 square feet). Shingles shall meet the fire resistance requirements of UL 790 for Class A and the wind resistance requirements of UL 997. Color shall be as determined by the using agency or COR.

2.1.2 Mineral-Surfaced Asphalt Roll Roofing

ASTM D 249.

2.1.3 Smooth-Surfaced Asphalt Roll Roofing

ASTM D 224, Type II.

2.1.4 Underlayment

Asphalt-saturated felt conforming to ASTM D 4869 or ASTM D 226, Type II, number 30, without perforations or other material specified by the shingle manufacturer for use as underlayment.

2.1.4.1 Leak Barrier Underlayment

Self-adhering leak barrier or ice dam underlayment shall comply with ASTM D 1970 for sealability around nails.

2.1.5 Self-Adhering Membrane

Self-adhering rubberized asphaltic membrane, a minimum of one mm (40 mils) thick, and recommended by the shingle manufacturer for use as eaves flashing.

2.1.6 Nails for Applying Shingles and Asphalt-Saturated Felt

Aluminum or hot-dipped galvanized steel or equivalent corrosion resistant with sharp points and flat heads 10 to 11 mm (3/8 to 7/16 inch) in diameter. Shank diameter of nails shall be a minimum of 2.67 mm 0.105 inch and a maximum of 3.43 mm (0.135 inch) with garb or otherwise deformed for added pull-out resistance. Nails shall be long enough to penetrate completely through or extend a minimum of 20 mm (3/4 inch) into roof deck, whichever is less, when driven through materials to be fastened.

2.1.7 Asphalt Roof Cement

ASTM D 4586, Type II.

2.1.8 Asphalt Primer

ASTM D 41.

2.1.9 Ventilators

2.1.9.1 Nailable Plastic Shingle Over Type Ridge Vents

Ridge vents shall be constructed of UV stabilized nailable rigid polypropylene material, approximately 0.30 m 1 foot wide and 25 mm (1 inch) thick, and shall be in 1.2 m (4 foot) long interlocking sections with self-aligning ends or corrugated polyethylene rigid roll or rigid strip ridge vent with aluminum wind deflectors on each side. Vents shall be designed to prevent infiltration of insects, rain, and snow.

2.1.9.2 Nailable Mesh Shingle Over Type Ridge Vents

Ridge vents shall be constructed of UV stabilized nailable polyester mesh material, approximately 0.30 m (one foot) wide. Vents shall be designed to prevent infiltration of insects, rain, and snow.

2.2 COLOR

Color of shingles shall be as selected by the Contracting Officer from the manufacturer’s standard colors.

PART 3 EXECUTION

3.1 VERIFICATION OF CONDITIONS

Ensure that roof deck is smooth, clean, dry, and without loose knots. Roof surfaces shall be firm and free from loose boards, large cracks, and projecting ends that might damage the roofing. Vents and other projections through roofs shall be properly flashed and secured in position, and projecting nails shall be driven flush with the deck.

3.2 SURFACE PREPARATION

Cover knotholes and cracks with sheet metal nailed securely to sheathing. Flash and secure vents and other roof projections, and drive projecting nails firmly home.

3.3 APPLICATION

Apply roofing materials as specified herein unless specified or recommended otherwise by shingle manufacturer's written instructions or by NRCA Shingle Manual.

3.3.1 Underlayment

The installation of asphalt strip shingles at maximum exposure is not recommended on roofs having a slope of less than 1:4. In locations where the January mean temperature is minus one degree C (30 degrees F) or less, a leak barrier underlayment membrane should be used. The leak barrier underlayment membrane may consist of: two plies of No. 15 asphalt saturated felt, one nailed to the deck and the second set in Type III or Type IV hot asphalt or asphalt lap cement; a heavyweight coated base sheet nailed to the deck and another felt ply or plysheet set in hot asphalt or asphalt lap cement; or a self adhering modified bitumen membrane.

In locations where the average daily January temperature is minus 4 degrees C (25 degrees F) or below, provide for roof slopes one in three 4 inches per foot and greater. Apply one layer of shingle underlayment to roof deck. Lay underlayment parallel to roof eaves, starting at eaves. Provide minimum 50 mm (2 inch) head laps, 100 mm (4 inch) end laps, and 150 mm (6 inch) laps from both sides over hips and ridges. Nail sufficiently to hold until shingles are applied. Turn up vertical surfaces a minimum of 100 mm (4 inches).

Provide for roof slopes between one in 6 (2 inches per foot) and one in 3 (4 inches per foot). Apply two layers to roof deck. Provide a 480 mm (19 inch) wide strip as starter sheet to maintain specified number of layers throughout roof. Lay parallel to eaves, starting at eaves. Provide minimum 480 mm (19 inch) head laps, 150 mm (6 inch) laps from both sides over hips and ridges, and 300 mm (12 inch) end laps in the field of the roof. Nail sufficiently to hold until shingles are applied. Turn up vertical surfaces a minimum of 100 mm (4 inches). When a self-adhering membrane is used for eave flashing, start underlayment from upper edge of eave flashing.

3.3.2 Drip Edges

Provide metal drip edges as specified in Section 07600, "Flashing and Sheet Metal," applied directly on the wood deck at eaves and over the underlayment at rakes. Extend back from edge of deck a minimum of 75 mm (3 inches), and secure with nails spaced a maximum of 100 (for high wind area) or 250 millimeters (4 or 10 inches) o.c. along inner edge.

3.3.5 Starter Strip

Apply starter strip at eaves, using 225 mm 9 inch wide strip of mineral-surfaced roll roofing of a color to match shingles. Optionally, use a row of shingles with tabs removed and trimmed to ensure that joints are not exposed at shingle cutouts. Apply starter strip along eaves, overlaying and finishing even with lower edge of eave flashing strip or overhanging the metal drip edge at eaves and rake edges 6 to 10 mm (1/4 inch to 3/8 inch) unless eave flashing is specified; fasten in a line parallel to and 75 to 100 mm (3 to 4 inches) above eave edge. Place nails so top of nail is not exposed in cutouts of first course of shingles. When roll roofing is provided, seal tabs of first course of shingles with asphalt roof cement.

3.3.6 Shingle Courses

Start first course with full shingle, and apply succeeding courses with joints staggered at thirds or halves. Butt-end joints of shingles shall not align vertically more often than every fourth course. Apply shingle courses as follows:

a. Fastening: Do not drive fasteners into or above the factory-applied adhesive unless adhesive is located 16 mm (5/8 inch) or closer to top of cutouts. Place fasteners so they are concealed by shingle top lap and penetrate the head lap.

b. Shingles applied with nails: Nominal 125 mm (5 inch) exposure. Apply each shingle with minimum of four nails. Place one nail 25 mm (one inch) from each end, and evenly space nails on a horizontal line a minimum of 16 mm (5/8 inch) above top of cutouts. For application of shingles on mansard roofs and other steep roofs with slopes more than 1.75 in one (21 inches per foot), cement each tab with one spot of asphalt roof cement placed 25 to 50 mm (one to 2 inches) from bottom edge of shingle.

3.3.7 Hips and Ridges

Form with 225 by 300 mm (9 by 12 inch) individual shingles or with 300 by 300 mm (12 by 12 inch) shingles cut from 300 by 900 mm (12 by 36 inch) strip shingles. Bend shingles lengthwise down center with equal exposure on each side of hip or ridge. Lap shingles to provide a maximum 125 mm (5 inch) exposure, and nail each side in unexposed area 140 mm (5 1/2 inches) from butt and 25 mm (one inch) in from edge.

3.3.8 Valleys

Provide either closed cut, woven, open roll roofing, or open sheet metal valleys.

3.3.8.1 Closed Cut Valleys

Provide 900 mm (36 inch) wide valley lining of single layer of smooth-surfaced or mineral-surfaced roll roofing, with mineral-surface facing down, for full length of valley as follows:

a. Center lining in valley over underlayment. Provide minimum 300 mm (12 inch) end laps in the lining and seal laps with asphalt roof cement. Fasten lining to hold it in place until shingles are applied.

b. Apply first regular course of shingles along eaves of one of the intersecting roof planes and across valley. Extend course at least 300 mm (12 inches) onto adjoining roof.

c. Apply succeeding courses in same manner as first course, extending across valley and onto adjoining roof.

d. Press shingles tightly into valley and nail in normal manner, except apply nails not closer than 150 mm (6 inches) to valley centerline, and apply additional nail in top corner of each shingle crossing valley.

e. Apply shingles on the adjoining roof plane, starting along eaves and across valley onto previously applied shingles. Trim overlapping courses back to a line parallel to and a minimum of 50 mm (2 inches) back from valley centerline.

f. Trim 25 mm (one inch) on a 45 degree angle from upper corner of each end shingle. Embed end shingles in a 75 mm (3 inch) wide band of asphalt roof cement.

3.3.8.2 Woven Valleys

Provide valley lining as specified for closed cut valley. Lay valley shingles over lining by either of the following methods:

a. Method I: Apply regular shingles on both roofs simultaneously. Weave each course in turn over the valley. Lay the first regular course of shingles along eaves of roof up to and over valley. Extend course along adjoining roof deck at least 300 mm (12 inches). Carry first regular course of shingles of adjoining roof over valley on top of previously applied shingles. Lay succeeding courses alternately, weaving valley shingles over each other for full length of valley.

b. Method II: Apply regular shingles on each roof surface separately to a line about 900 mm (3 feet) from center of valley, and weave valley shingles in place later, as specified for Method I. In following either method, press shingles tightly into valley, and fasten in normal manner; except apply nails not closer than 150 mm (6 inches) to valley centerline, and apply additional nail in top corner of terminal shingle on both sides of valley.

3.3.8.3 Open Roll Roofing Valleys

Provide 450 mm 18 inch wide strip of mineral-surfaced asphalt roll roofing, of a color to blend with asphalt shingles, and with granular surface facing down, for the full length of valley as follows:

a. Center roll roofing strip in valley over underlayment. Lay centered in valley over felt underlayment and with granular face down. Nail strip only enough to hold in place. Apply nails in rows 25 mm (one inch) from each edge. As fastening along second side proceeds, press strip firmly into valley.

b. Center second strip 900 mm (36 inches) wide in valley and lay it over first strip with granular face exposed and nail as specified for 450 mm (18 inch) strip.

c. Before applying roofing shingles, snap two chalk lines for full length of valley. Locate each line 75 mm (3 inches) from centerline of valley at top, and increase width between lines by 25 mm for each 2440 mm (one inch for each 8 feet) of valley length, continuing to eaves.

d. Apply a 50 mm (2 inch) band of asphalt roof cement along each edge of 900 mm (36 inch) strip from edge to chalk line. Cut regular shingle courses true along valley chalk lines, and nail in normal manner.

3.3.8.4 Open Sheet Metal Valleys

Sheet metal flashing for valleys is specified in Section 07600, "Flashing and Sheet Metal." Before installing and fastening flashing in place with metal cleats:

a. Install single layer of 900 mm (36 inch) wide, asphalt-saturated felt, centered on valley and extending entire length of valley over felt underlayment.

b. Cut regular shingle courses on each roof on true line 50 mm (2 inches) from valley centerline at top of valley, and increase width between lines by 25 mm for each 2440 mm (one inch for each 8 feet) of valley length, continuing to eaves.

c. Apply 50 mm (2 inch) band of asphalt roof cement over flashing, along and under side of shingles adjoining valley.

d. Press shingles tightly into cement, and nail in normal manner, except apply nails not closer than 125 mm (5 inches) to valley centerline. Do not drive nails through valley flashing.

e. Provide a 100 mm (4 inch) band of asphalt roof cement for fastening shingle tabs down along open metal gutters.

3.3.9 Flashing

3.3.9.1 Eave Flashing

Provide for roof slopes one in 3 (4 inches per foot) and greater. Provide eave flashing strips consisting of smooth-surfaced roll roofing. Flashing strips shall overhang metal drip edge 6 to 10 mm (1/4 inch to 3/8 inch) and extend up the slope far enough to cover a point 300 mm (12 inches) inside interior face of exterior wall. Where overhangs require flashings wider than 900 mm (36 inches), locate laps outside exterior wall face. Laps shall be at least 50 mm (2 inches) wide and cemented with asphalt roof cement over entire length of lap. Lap end 300 mm (12 inches) and cement.

Where the average daily January temperature is minus 4 degrees C (25 degrees F or below), provide for roof slopes between one in 6 and one in 3 (2 inches per foot and 4 inches per foot). Provide either of the following types of eave flashing:

a. From the eaves to a point 600 mm (24 inches) inside interior wall line, apply solid coating of asphalt roof cement between overlapping layers of underlayment. Spread cement to a uniform thickness at rate of 7.5 liters per 10 square meters (2 gallons per 100 square feet) of cemented roof area.

b. From the eaves to a point 600 mm (24 inches) inside interior wall line, apply one layer of self-adhering membrane. Follow membrane manufacturer's printed installation instructions.

3.3.9.2 Stepped Flashing

For sloping roofs which abut vertical surfaces, provide stepped metal flashing as specified in Section 07600, "Flashing and Sheet Metal."

3.3.9.3 Vent and Stack Flashing

Apply shingles up to point where vent or stack pipe projects through roof, and cut nearest shingle to fit around pipe. Before applying shingles beyond pipe, prepare flange of metal pipe vent flashing as specified in Section 07600, "Flashing and Sheet Metal," by applying a 3 mm (1/8 inch) thick coating of asphalt roof cement on bottom side of flashing flange. Slip flashing collar and flange over pipe, and set coated flange in 2 mm (1/16 inch) coating of asphalt roof cement. After applying flashing flange, continue shingling up roof. Lap lower part of flange over shingles. Overlap flange with side and upper shingles. Fit shingles around pipe, and embed in 2 mm (1/16 inch) thick coating of asphalt roof cement where shingles overlay flange.

3.3.9.4 Chimney Flashing

Provide treated wood crickets as specified in Section 06100, "Rough Carpentry." Provide metal base and counterflashing as specified in Section 07600, "Flashing and Sheet Metal." Uniformly coat masonry surfaces which are to receive flashing with asphalt primer applied at rate of 4 liters per 10 square meters (one gallon per 100 square feet). Apply shingles over underlayment up to front face of chimney. Apply metal front base flashing with lower section extending at least 100 mm (4 inches) over shingles. Set base flashing in a 2 mm (1/16 inch) coating of asphalt roof cement on shingles and chimney face. Apply metal step flashing at sides in a coating of asphalt roof cement. Embed end shingles in each course that overlaps step flashing with asphalt roof cement. Apply metal rear base flashing over cricket and back of chimney in coating of asphalt roof cement. Apply end shingles in each course up to cricket, and cement in place. Lap base flashing minimum of 75 mm (3 inches) with metal counterflashing.

SECTION 07320

ROOF TILES

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 67	(1998; Rev. A) Sampling and Testing Brick and Structural Clay Tile
ASTM C 270	(1997; Rev. A) Mortar for Unit Masonry
ASTM C 1177/C 1177M	(1996) Glass Mat Gypsum Substrate for Use as Sheathing
ASTM D 412	(1998;Rev. A) Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension
ASTM D 2178	(1997; Rev. A) Asphalt Glass Felt Used in Roofing and Waterproofing
ASTM D 2822	(1991; R 1997) Asphalt Roof Cement
ASTM E 108	(1996) Fire Tests of Roof Coverings

AMERICAN WOOD-PRESERVERS' ASSOCIATION (AWPA)

AWPA C1 (1996) All Timber Products – Preservative Treatment by Pressure Processes

NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA)

NRCA SRM (1996) Steep Roofing Manual

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3510 (1997) Clay Roof Tiles

KS F 4029 (1997) Pressed Cement Roof Tiles

KS F 4901 (1997) Asphalt Roofing Felt (Fiber Base, Saturated Bitumen Felts)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Tile Roofing Systems; G.

Drawings showing roof tile installation and appearance details, flashing details, and fastening details for the tiles.

SD-03 Product Data

Tile Roofing Systems; G.

Manufacturer's catalog data and installation instructions.

Qualifications; G.

Documentation showing qualifications of personnel proposed to perform the roofing work, and a listing identifying prior installations completed by the Contractor.

SD-04 Samples

Clay Roofing Tile;

One representative tile of each type.

Sealants;

237 mL (8 ounces) of each type.

Underlayment Membrane;

300 by 300 mm (1 by 1 foot) section of each type.

Fasteners;

Representative samples of each fastener with identifying tags.

SD-07 Certificates

Materials; G.

Certificates of compliance attesting that the materials meet specification requirements.

1.3 QUALIFICATIONS

The Contractor shall provide qualified workers, trained and experienced in installing clay tile roofing systems of this configuration, and shall submit documentation of 5 consecutive years of work of this type. A list of installations shall be provided which identifies when, where, and for whom the installations were made.

1.4 DELIVERY AND STORAGE

Materials shall be delivered in manufacturer's unopened bundles and containers with the manufacturer's brand and name marked clearly thereon. Keep materials dry, completely covered, and protected from the weather. Tiles shall be stored in accordance with manufacturer's printed instructions. Roll goods shall be stored on end in an upright position. Immediately before laying, roofing felt shall be stored for 24 hours in an area maintained at a temperature not lower than 10 degrees C (50 degrees F).

1.5 PROJECT/SITE CONDITIONS

1.5.1 Environmental Requirements

Tile roofing work shall proceed when existing and forecasted weather conditions permit work to be performed in accordance with manufacturer's recommendations and warranty requirements.

1.5.2 Material Storage

Materials shall not be stored on roof decks in such a manner as to overstress and/or damage the deck and supporting structure. Placing of loads at midspans of framing shall be avoided. Superimposed loads shall be well distributed.

1.5.3 Units of Work

Units of work shall be established, including removal of existing materials, preparation of existing surfaces and application of underlayment and nailers, and related temporary and/or permanent flashing so that it can be completed prior to the end of each working day.

1.5.4 Temporary Protection Materials

Materials shall be provided and maintained on the site at all times for temporary roofing, flashing, and other protection when delays and/or changed weather conditions do not permit completion of each unit of work prior to the end of each working day. Materials which have been used for temporary roofing, flashing and other protection shall be removed and discarded.

1.6 COORDINATION

Coordinate with the installation of flashing and gutters provided under Section 07600N, "Flashing and Sheet Metal" to ensure proper sequencing. Do not install roofing materials until vent stacks and other penetrations through roof deck have been installed.

1.7 EXTRA STOCK

Provide an extra two percent of each type and color of tile used in clean marked containers. In the extra stock provided, include hip, ridge, and other special shapes in the same proportion as used on the project.

1.8 WARRANTY

The Contractor shall warrant for 5 years that the tile roofing system, as installed, is free from defects in workmanship. When repairs due to defective workmanship are required during the Contractor's warranty period, the Contractor shall make such repairs within 72 hours of notification. When repairs are not performed within the specified time, emergency repairs performed by others will not void the warranty.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Clay Tile

ASTM C 67, Machine formed natural clay tiles, One Piece "S" Mission, Two Piece Spanish Mission consisting of a cover and pan tile, or KS F 3510, kiln-fired to vitrification and free from surface imperfections. Provide specially shaped, color-matched units as indicated or required, including hip and ridge covers, rake covers and birdstops. Provide with fastening holes preformed at factory prior to firing.

2.1.2 Concrete Tile

ASTM C 67, ASTM E 108, Extruded, interlocking concrete roofing tile units, shapes as indicated, or KS F 4029, with integral color. Include specially shaped, color-matched units as indicated or required for ridges, rakes and hips. Provide with cast-in anchor lugs, transverse weather checks and fastening holes.

2.2 UNDERLAYMENT

An underlayment membrane shall be furnished on surfaces to be covered with tile. Membrane shall consist of asphalt-saturated felt and high strength composite self-adhering membrane.

2.2.1 Felt Underlayment

Roofing felt shall be asphalt-saturated rag felt, Type II, No. 30 asphalt felt in accordance with ASTM D 226, or KS F 4901, Type 650 (30 kg type).

2.2.2 Flexible Hip and Ridge Flashing

SBS modified rubberized asphalt adhesive on a lineal, low density polyethylene membrane with a 1.52 mm (60 mil) total thickness.

2.2.3 Self-Adhering Membrane Underlayment

ASTM D 412, Polyethylene-sheet-backed, rubberized asphalt membrane, 1.02 mm (40 mil) thickness.

2.2.4 Primer for Self-Adhering Membrane Underlayment

VOC compliant primer as recommended by membrane manufacturer for application on concrete substrates.

2.3 FASTENERS

2.3.1 Nails For Applying Felt Underlayment

Hot dip galvanized steel, 2.9 mm thick (11 gage), sharp pointed, conventional roofing nails with barbed shanks, minimum 9.5 mm (3/8 inch) diameter head, and of sufficient length to penetrate 19 mm (3/4 inch) into nailable concrete deck, through plywood sheathing, or through substrate panels. Verify that nails are compatible with flashing materials to prevent galvanic action.

2.3.2 Nails for Installation of Tile

Copper ring shank nails, 3.3 mm (10 gage), with minimum 11 mm (7/16 inch) diameter head or 3.3 mm (10 gage) stainless steel ring shank nails with minimum 9.5 mm (3/8 inch) head and of sufficient length to penetrate 19 mm (3/4 inch) into wood ridge and hip boards or battens. Verify that chemicals used in pressure treatment of ridge and hip boards are compatible with copper nails.

2.3.3 Twisted-Wire Tie System

For clay tile on roofs with slopes in excess of 12:12, continuously twisted 3.3 mm (10 gage) copper or brass, or 2.5 mm (12 gage) galvanized steel wire with loops formed at 150 mm (6 inches) on center and with tie wires of 1.8 mm (14 gage) copper or brass, 1.5 mm (16 gage) galvanized steel, or 9.4 mm (0.037 inch) dia. stainless steel wire. Provide clips for anchorage of twisted-wire tie system to substrate as recommended by manufacturer.

2.3.4 Single-Line Wire Tie System

For clay tile on roofs with slopes from 2:12 to 12:12, 3.3 mm (10 gage) copper, 3.3 mm (10 gage) brass, 2.5 mm (12 gage) galvanized steel, or 2.13 mm (0.084 inch) stainless steel pre-formed wire ties with a hook on one end and a loop on the other end. Lengths as required for manufacturer's recommended exposure.

2.3.5 Wind Locks

For the installation of clay tiles for all slopes in high wind areas as designated by local codes, 3.3 mm (10 gage) copper, 3.3 mm (10 gage) brass, 2.5 mm (12 gage) galvanized steel, or 2.13 mm (0.084 inch) dia. stainless steel formed wire clips. Select material type as recommended by manufacturer for specific locations.

2.3.6 Hurricane Clips

For the installation of clay or concrete tiles for all slopes in high wind areas as designated by local codes, tile edge clips fabricated from 1.2 mm (18 gage) brass, 1.05 mm (19 gage) galvanized steel, or 1.07 mm (0.042 inch) type 302 stainless steel strips, 13 mm (1/2 inch) wide. Provide with two nail holes in horizontal leg for anchorage to deck or substrate. Select material type as recommended by manufacturer for specific locations.

2.3.7 Sheet Metal Birdstop for Concrete Tile

Formed 0.5 mm (26 gage) galvanized steel "L" section with 75 mm (3 inch) wide horizontal leg and vertical leg cut to conform with bottom profile of tile. Provide pre-finished to match tile color with drain holes punched in vertical leg prior to application of finish.

2.4 MORTAR

Mortar for filling the openings of cut valley tiles shall consist of 1 part portland cement to 3 parts damp plaster sand, and shall be colored to the nearest possible match with the color of the tile.

2.5 PLASTIC CEMENT

Plastic cement for gable rakes, hip rolls, ridges, stringers and other conditions shall be non-running, heavy body plastic cement composed of ingredients complying with ASTM D 2822.

2.6 WOOD STRIPS

Wood strips for nailers, battens, cant strips, and eave strips shall be of foundation grade redwood or preservative treated Douglas fir. Sizes and lengths shall be provided per tile manufacturer's installation details.

2.7 FLASHINGS

Flashing shall be 0.57 kg (20 ounce), light cold-rolled temper (H00) copper conforming to ASTM B 370. Like metals shall be used on all components of fastening systems and flashing in order to avoid galvanic action. Flashing shall be in accordance with the requirements as specified in Section 07600 SHEET METALWORK, GENERAL.

PART 3 EXECUTION

3.1 EXAMINATION

Examine structural roof deck for compliance with requirements of selected system. Verify that roof penetrations and openings are installed in their proper location.

3.2 PREPARATION

3.2.1 Cleaning

Clean structural deck surfaces to receive substrate panels or underlayment.

3.3 INSTALLATION

Comply with manufacturer's installation instructions and recommendations, but not less than recommended by NRCA SRM. Comply with local building code requirements for special fastening requirements such as wind locks and hurricane clips in high wind areas.

3.3.1 Felt Underlayment

For tile roof installations over concrete and wood roof decks with a slope of 4:12 or greater, apply one layer of felt underlayment horizontally over entire surface to receive roofing tile, lapping succeeding courses a minimum of 50 mm (2 inches), end laps a minimum of 150 mm (6 inches), and hips and valleys a minimum of 300 mm (12 inches). Fasten felt with sufficient number of roofing nails to hold underlayment in place until roofing tile installation. Provide additional layer of felt underlayment when recommended by roof tile manufacturer.

3.3.2 Self-Adhering Membrane Underlayment

For tile roof installations over all substrates with slopes up to 4:12 or for any slope where high wind or freeze/thaw conditions exist, apply self-adhering membrane over wood deck or concrete deck in accordance with manufacturers recommendations. Provide manufacturer recommended primer for application on concrete surfaces.

3.3.3 Clay Roofing Tile Installation

Beginning at eaves, install roofing tiles as indicated and in accordance with recommendations of the tile manufacturer and fastening system manufacturer. Sawcut tiles at hips valleys and ridges. Cut tile at valleys to form a straight border. Taper valleys from a 50 mm (2 inch) exposure on each side of valley at top and increase exposure 25 mm (one inch), each side, per 2400 mm (8 feet) of valley length. Set ridge and hip tile in a full bed of mortar and strike mortar flush with face of cover tiles. Apply flexible hip and ridge flashing over ridge and hip boards and top edge of tile. Apply asphalt plastic cement at lap between tiles at hip and ridge. Nail hip and ridge tiles to hip and ridge boards.

3.3.4 Batten Installation for Concrete Roofing Tile

Install 19 by 38 mm (one by 2 inches) treated wood battens with 13 mm (1/2 inch) drain slots at 1200 mm (4 feet) o.c. horizontally. At eave provide 38 by 38 mm (2 by 2 inches) treated wood starter strip. Provide sheet metal birdstops at eave for "S" Type mission tile. At metal structural decks, attach battens with self-tapping screws through substrate panels into metal deck.

3.3.5 Concrete Roofing Tile Installation

Beginning at eaves, install roofing tiles as indicated and in accordance with manufacturers recommendations. Hook mounting lugs over wood battens and nail through each tile into batten. Sawcut tiles at valleys to form a straight border. Taper valleys from a 50 mm (2 inch) exposure on each side of valley at the top and increase exposure by 25 mm (one inch), each side, per 2400 mm (8 feet) of valley length. Set ridge and hip tile in a full bed of mortar and strike mortar flush with face of cover tile. Apply flexible hip and ridge flashing over ridge and hip boards and top edge of tile. Apply asphalt plastic cement between tiles at hip and ridge. Nail hip and ridge tiles to hip and ridge boards.

3.3.6 CLEANING

Remove mortar and asphalt plastic cement spatter from exposed surfaces of tiles. Upon completion of work, remove excess materials and all refuse generated by the work of this section.

3.4 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of English unit measurement, and not on metric measurement commonly agreed to by the manufacturers or other parties. The English and metric units for the measurements shown are as follows:

Products	English Units	Metric Units
Nails - diameter	11 gage	2.9 mm
head diameter	3/8 inch	9.5 mm
Nails - diameter	10 gage	3.3 mm
head diameter	7/16 inch	11 mm

Wire	10 gage	3.3 mm
	12 gage	2.5 mm
	14 gage	1.8 mm
	0.037 inch	9.4 mm
	0.084 inch	2.13 mm
Edge Clips	18 gage	1.2 mm
	19 gage	1.05 mm
	0.042 inch	1.07 mm
	1/2 inch	13 mm
Birdstop	26 gage	0.5 mm

SECTION 07412

NON-STRUCTURAL METAL ROOFING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 463/A 463M (2000) Steel Sheet, Aluminum-Coated, by the Hot-Dip Process

ASTM A 653/A 653M (2000) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A 792/A 792M (1999) Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process

ASTM B 209 (1996) Aluminum and Aluminum-Alloy Sheet and Plate

ASTM B 209M (2000) Aluminum and Aluminum-Alloy Sheet and Plate (Metric)

ASTM C 518 (1998) Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter

	Apparatus
ASTM C 612	(2000) Mineral Fiber Block and Board Thermal Insulation
ASTM C 991	(1998) Flexible Glass Fiber Insulation for Pre-Engineered Metal Buildings
ASTM C 1289	(1998) Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board
ASTM D 226	(1997a) Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D 522	(1993a) Mandrel Bend Test of Attached Organic Coatings
ASTM D 523	(1989; R 1999) Specular Gloss
ASTM D 610	(1995) Evaluating Degree of Rusting on Painted Steel Surfaces
ASTM D 714	(1987; R 1994el) Evaluating Degree of Blistering of Paints
ASTM D 968	(1993) Abrasion Resistance of Organic Coatings by Falling Abrasive
ASTM D 1308	(1987; R 1998) Effect of Household Chemicals on Clear and Pigmented Organic Finishes
ASTM D 1654	(1992) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 2244	(1995) Calculation of Color Differences from Instrumentally Measured Color Coordinates
ASTM D 2247	(1999) Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM D 2794	(1993; R 1999el) Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D 3359	(1997) Measuring Adhesion by Tape Test
ASTM D 4214	(1998) Evaluating Degree of Chalking of Exterior Paint Films
ASTM D 4397	(1996) Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM D 5894	(1996) Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet
ASTM E 84	(2000a) Surface Burning Characteristics of Building Materials
ASTM E 96	(2000) Water Vapor Transmission of Materials
ASTM G 154	(2000) Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

UNDERWRITERS LABORATORIES (UL)

UL 580 (1994; Rev thru Feb 1998) Tests for Uplift Resistance of Roof Assemblies

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506 (2001) Galvanized Steel Sheet

KS D 3544 (2002) Hot Dip Aluminum Coated Steel Sheets

KS D 3770 (1992) Hot Dip 55% Aluminum-Zinc Alloy-Coated Steel Sheets and Coils

KS D 6701 (2002) Aluminum and Aluminum Alloy Sheets and Plates

KS F 4901 (1997) Asphalt Roofing Felts (Firer Base, Saturated Bitumen Felts)

KS L 9102 (1995) Artificial Mineral Fiber Thermal Insulation Materials

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be s ubmitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Metal Roofing; G.

a. Drawings consisting of catalog cuts, flashing details, erection drawings, shop coating and finishing specifications, and other data as necessary to clearly describe materials, sizes, layouts, construction details, fasteners, and erection. Drawings shall be provided by the metal roofing manufacturer.

b. Drawings showing the UL 580, Class 90 tested roof system assembly.

SD-04 Samples

Accessories; G.

One sample of each type of flashing, trim, fascia, closure, cap and similar items. Size shall be sufficient to show construction and configuration.

Roof Panels; G.

One piece of each type and finish to be used, 225 mm 9 inches long, full width.

Fasteners; G.

Two samples of each type to be used with statement regarding intended use. If so requested, random samples of screws, bolts, nuts, and washers as delivered to the jobsite shall be taken in the presence of the Contracting Officer and provided to the Contracting Officer for testing to establish compliance with specified requirements.

Gaskets and Insulating Compounds;

Two samples of each type to be used and descriptive data.

Sealant;

One sample, approximately 0.5 kg, 1 pound, and descriptive data.

SD-07 Certificates

Roof Panels; G. Installation; G. Accessories; G.

Certificates attesting that the panels and accessories conform to the specified requirements. Certificate for the roof assembly shall certify that the assembly complies with the material and fabrication requirements specified and is suitable for the installation at the indicated design slope. Certified laboratory test reports showing that the sheets to be furnished are produced under a continuing quality control program and that at least 3 representative samples of similar material to that which will be provided on this project have been previously tested and have met the quality standards specified for factory color finish.

Insulation; G.

Certificate attesting that the polyisocyanurate insulation furnished for the project contains recovered material, and showing an estimated percent of such recovered material.

Installer; G.

Certification of installer.

Warranties; G.

At the completion of the project, signed copies of the 5-year Warranty for Non-Structural Metal Roofing System, a sample copy of which is attached to this section, and the 20-year Manufacturer's Material and Weathertightness Warranties.

1.3 GENERAL REQUIREMENTS

The Contractor shall furnish a commercially available roofing system which satisfies the specified design and additional requirements contained herein. The roofing system shall be provided by the Contractor as a complete system, as tested and approved in accordance with UL 580. Roof panels, components, transitions, accessories, and assemblies shall be supplied by the same roofing system manufacturer.

1.3.1 Non-Structural Metal Roof System

The Non-Structural Metal Roof System covered under this specification shall include the entire roofing system; the metal roof panels, fasteners, connectors, roof securement components, and assemblies tested and approved in accordance with UL 580. The system shall be installed on a substrate. In addition, the system shall consist of panel finishes, slip sheet, insulation, vapor retarder, all accessories, components, and trim and all connections with roof panels. This includes roof penetration items such as vents, curbs, skylights; interior or exterior gutters and downspouts, eaves, ridge, hip, valley, rake, gable, wall, or other roof system flashings installed and any other components specified within this contract to provide a weathertight roof system; and items specified in other sections of the specifications that are part of the system.

1.3.2 Manufacturer

The non-structural metal roofing system shall be the product of a manufacturer who has been in the practice of manufacturing metal roofs for a period of not less than 3 years and has been involved in at least five projects similar in size and complexity to this project.

1.3.3 Installer

The installer shall be certified by the metal roof manufacturer to have experience in installing at least three projects that are of comparable size, scope and complexity as this project for the particular roof system furnished. The installer may be either employed by the manufacturer or be an independent installer.

1.4 DESIGN LOADS

Non-structural Metal Roof System assemblies shall be tested as defined in UL 580 and shall be capable of resisting the wind uplift pressures shown on the contract drawings or, as a minimum, shall be approved to resist wind uplift pressures of UL 580, Class 90.

1.5 PERFORMANCE REQUIREMENTS

The metal roofing system supplied shall conform to the roof slope, the underlayment, and uplift pressures shown on the contract drawings. The Contractor shall furnish a commercially available roofing system which satisfies all the specified requirements.

1.6 DELIVERY AND STORAGE

Materials shall be delivered to the site in a dry and undamaged condition and stored out of contact with the ground. Materials shall be covered with weather tight coverings and kept dry. Material shall not be covered with plastic where such covering will allow sweating and condensation. Plastic may be used as tenting with air circulation allowed. Storage conditions shall provide good air circulation and protection from surface staining.

1.7 WARRANTIES

The Non-Structural Metal Roofing System shall be warranted as outlined below. Any emergency temporary repairs conducted by the owner shall not negate the warranties.

1.7.1 Contractor's Weathertightness Warranty

The Non-Structural Metal Roofing System shall be warranted by the Contractor on a no penal sum basis for a period of five years against material and workmanship deficiencies; system deterioration caused by exposure to the elements and/or inadequate resistance to specified service design loads, water leaks, and wind uplift damage. The roofing covered under this warranty shall include the entire roofing system, including but not limited to, the roof panels, fasteners, connectors, roof securement components, and assemblies tested and approved in accordance with UL 580. In addition, the system shall consist of panel finishes, slip sheet, insulation, vapor retarder, all accessories, components, and trim and all connections with roof panels. This includes roof penetration items such as vents, curbs, skylights; interior or exterior gutters and downspouts; eaves, ridge, hip, valley, rake, gable, wall, or other roof system flashings installed and any other components specified within this contract to provide a weathertight roof system; and items specified in other sections of the specifications that are part of the roof system. All material and workmanship deficiencies, system deterioration caused by exposure to the elements and/or inadequate resistance to service design loads, water leaks and wind uplift damage shall be repaired as approved by the Contracting Officer. See the attached Contractor's required warranty for issue resolution of warrantable defects. This warranty shall warrant and cover the entire cost of repair or replacement, including all material, labor, and related markups. The Contractor shall supplement this warranty with written warranties from the installer and system manufacturer, which shall be submitted along with Contractor's warranty; however, the Contractor shall be ultimately responsible for this warranty. The Contractor's written warranty shall be as outlined in attached WARRANTY FOR NON-STRUCTURAL METAL ROOF SYSTEM, and shall start upon final acceptance of the facility. It is required that the Contractor provide a separate bond in an amount equal to the installed total roofing system cost in favor of the owner (Government) covering the Contractor's warranty responsibilities effective throughout the 5 year Contractor's warranty period for the entire roofing system as outlined above.

1.7.2 Manufacturer's Material Warranties

The Contractor shall furnish, in writing, the following manufacturer's material warranties which cover all Non-Structural Metal Roofing System components such as roof panels, flashing, accessories, and trim, fabricated from coil material:

a. A manufacturer's 20 year material warranty warranting that the aluminum, zinc-coated steel, aluminum-zinc alloy coated steel or aluminum-coated steel as specified herein will not rupture, fail structurally, or perforate under normal atmospheric conditions at the site. Liability under this warranty shall be limited exclusively to the cost of either repairing or replacing nonconforming, ruptured, perforated, or structurally failed coil material.

b. A manufacturer's 20 year exterior material finish warranty warranting that the factory color finish, under normal atmospheric conditions at the site, will not crack, peel, or delaminate; chalk in excess of a numerical rating of 8 when measured in accordance with ASTM D 4214; or fade or change colors in excess of 5 NBS units as measured in accordance with ASTM D 2244. Liability under this warranty is exclusively limited to refinishing or replacing the defective coated coil material.

c. A roofing system manufacturer's 20 year system weathertightness warranty.

1.8 COORDINATION MEETING

A coordination meeting shall be held within 45 days after contract award for mutual understanding of the metal roofing system contract requirements. This meeting shall take place at the building site and shall include representatives from the Contractor, the roofing system manufacturer, the roofing supplier, the erector, the designer, and the Contracting Officer. All items required by paragraph SUBMITTALS shall be discussed, including applicable standard manufacturer shop drawings, and the approval process. The Contractor shall coordinate time and arrangements for the meeting.

PART 2 PRODUCTS

2.1 ROOF PANELS

Panels shall be either steel or aluminum and shall have a mill or factory color finish as indicated. Length of sheets shall be sufficient to cover the entire length of any unbroken roof slope for slope lengths that do not exceed 9 m (30 feet). Sheets longer than 9 m (30 feet) may be furnished if approved by the Contracting Officer. Width of sheets shall provide nominal 660 mm (26 inches) of coverage in place. Design provisions shall be made for thermal expansion and contraction consistent with the type of system to be used. All sheets shall be either square-cut or miter-cut. The ridge cap shall be installed as recommended by the metal roofing manufacturer. Height of corrugations, ribs, or seams, at overlap of adjacent roof sheets shall be the building manufacturer's standard for the indicated roof slope.

2.1.1 Steel Panels

Zinc-coated steel conforming to ASTM A 653/A 653M, or KS D 3506; aluminum-zinc alloy coated steel conforming to ASTM A 792/A 792M, AZ 55 coating, or KS D 3770; or aluminum-coated steel conforming to ASTM A 463/A 463M, Type 2, coating designation T2 65, or KS D 3544. Uncoated panels shall be 0.6 mm (0.024 inch) thick minimum. Panels shall be within 95 percent of the nominal thickness. When mill finish panels are used, prior to shipment, mill finish panels shall be treated with a passivating chemical and oiled to inhibit the formation of oxide corrosion products. Panels that have become wet during shipment and have started to oxidize shall be rejected.

2.1.2 Aluminum Panels

Alloy conforming to ASTM B 209M or KS D 6701, temper as required for the forming operation, minimum 0.8 mm (0.032 inch) thick.

2.2 ACCESSORIES

Accessories shall be compatible with the roofing furnished. Flashing, trim, metal closure strips, caps, and similar metal accessories shall be not less than the minimum thicknesses specified for roof panels. Exposed metal accessories shall be finished to match the panels furnished. Molded closure strips shall be bituminous-saturated fiber, closed-cell or solid-cell synthetic rubber or neoprene, or polyvinyl chloride premolded to match configuration of the panels and shall not absorb or retain water.

2.3 FASTENERS

Fasteners for roof panels shall be zinc-coated steel, aluminum, or nylon capped steel, type and size as recommended by the manufacturer to meet the performance requirements. Fasteners for accessories shall be the manufacturer's standard. Exposed roof fasteners shall be gasketed or have gasketed washers on the exterior side of the roofing to waterproof the fastener penetration. Washer material shall be compatible with the panels; and gasketed portion of fasteners or washers shall be neoprene or other equally durable elastomeric material approximately 3 mm (1/8 inch thick).

2.4 FACTORY COLOR FINISH

Panels shall have a factory applied polyvinylidene fluoride finish on the exposed side. The exterior finish shall consist of a baked-on topcoat with an appropriate prime coat. Color shall match the color indicated on the drawings. The exterior coating shall be a nominal 0.025 mm (1 mil) thickness consisting of a topcoat of not less than 0.018 mm (0.7 mil) dry film thickness and the paint manufacturer's recommended primer of not less than 0.005 mm (0.2 mil) thickness. The interior color finish shall consist of the same coating and dry film thickness as the exterior. The exterior color finish shall meet the test requirements specified below.

2.4.1 Cyclic Salt Fog/UV Test

A sample of the sheets shall withstand a cyclic corrosion test for a minimum of 2016 hours in accordance with ASTM D 5894, including the scribe requirement in the test. Immediately upon removal of the panel from the test, the coating shall receive a rating of not less than 10, no blistering, as determined by ASTM D 714; 10, no rusting, as determined by ASTM D 610; and a rating of 6, over 2.0 to 3.0 mm (1/16 to 1/8 inch) failure at scribe, as determined by ASTM D 1654.

2.4.2 Formability Test

When subjected to testing in accordance with ASTM D 522 Method B, 3 mm (1/8 inch) diameter mandrel, the coating film shall show no evidence of fracturing to the naked eye.

2.4.3 Accelerated Weathering, Chalking Resistance and Color Change

A sample of the sheets shall be tested in accordance with ASTM G 154. The coating shall withstand the weathering test without cracking, peeling, blistering, loss of adhesion of the protective coating, or corrosion of the base metal. Protective coating that can be readily removed from the base metal with tape in accordance with ASTM D 3359, Test Method B, shall be considered as an area indicating loss of adhesion. Following the accelerated weathering test, the coating shall have a chalk rating not less than No. 8 in accordance with ASTM D 4214 test procedures, and the color change shall not exceed 5 CIE or Hunter Lab color difference (delta E) units in accordance with ASTM D 2244. For sheets required to have a low gloss finish, the chalk rating shall be not less than No. 6 and the color difference shall be not greater than 7 units.

2.4.4 Humidity Test

When subjected to a humidity cabinet test in accordance with ASTM D 2247 for 1000 hours, a scored panel shall show no signs of blistering, cracking, creepage or corrosion.

2.4.5 Impact Resistance

Factory-painted sheet shall withstand direct and reverse impact in accordance with ASTM D 2794 13 mm (0.500 inch) diameter hemispherical head indenter, equal to 6.7 times the metal thickness in mm, expressed in N-meters, 1.5 times the metal thickness in mils, expressed in inch-pounds, with no cracking.

2.4.6 Abrasion Resistance Test

When subjected to the falling sand test in accordance with ASTM D 968, Method A, the coating system shall withstand a minimum of 50 liters of sand before the appearance of the base metal. The term "appearance of base metal" refers to the metallic coating on steel or the aluminum base metal.

2.4.7 Specular Gloss

Finished roof surfaces for airfields shall have a specular gloss value of 10 or less at an angle of 85 degrees when measured in accordance with ASTM D 523.

2.4.8 Pollution Resistance

Coating shall show no visual effects when covered spot tested in a 10 percent hydrochloric acid solution for 24 hours in accordance with ASTM D 1308.

2.5 UNDERLAYMENTS

2.5.1 Felt Underlayment

Felt underlayment shall be No. 30 felt in accordance with ASTM D 226, Type II, or KS F 4901, Type 650 (30 kg).

2.5.2 Slip Sheet

Slip Sheet shall be 0.24 kg per square meter (5 pounds per 100 sf) rosin sized unsaturated building paper.

2.6 INSULATION

Thermal resistance of insulation shall be not less than the R-values shown on the contract drawings. R-values shall be determined at a mean temperature of 24 degrees C (75 degrees F) in accordance with ASTM C 518. Insulation shall be a standard product with the insulation manufacturer, factory marked or identified with insulation manufacturer's name or trademark and R-value. Identification shall be on individual pieces or individual packages. Blanket insulation shall have a facing as specified in paragraph VAPOR RETARDER. Insulation, including facings, shall have a flame spread not in excess of 75 and a smoke developed rating not in excess of 150 when tested in accordance with ASTM E 84. The stated R-value of the insulation shall be certified by an independent Registered Professional Engineer if tests are conducted in the insulation manufacturer's laboratory.

2.6.1 Rigid Board Insulation for Use Above a Roof Deck

2.6.1.1 Polyisocyanurate

Polyisocyanurate insulation shall conform to ASTM C 1289, Type I, Class 2. For impermeable faced polyisocyanurate (Ex: aluminum foil) the maximum design R-value per 25 mm (1 inch) of insulation used shall be 1.27.

2.6.1.2 Mineral Fiber

Insulation shall conform to ASTM C 612, or KS L 9102.

2.6.2 Blanket Insulation

Flexible mineral fiber blanket insulation for use at temperatures up to 176 degrees C (350 degrees F) shall conform to ASTM C 991.

2.7 INSULATION RETAINERS

Insulation retainers shall be type, size, and design necessary to adequately hold the insulation and to provide a neat appearance. Metallic retaining members shall be nonferrous or have a nonferrous coating. Nonmetallic retaining members, including adhesives used in conjunction with mechanical retainers or at insulation seams, shall have a fire resistance classification not less than that permitted for the insulation.

2.8 SEALANT

Sealant shall be an elastomeric type containing no oil or asphalt. Exposed sealant shall be colored to match the applicable building color and shall cure to a rubberlike consistency. Sealant placed in the roof panel standing seam ribs shall be provided in accordance with the manufacturer's recommendations.

2.9 GASKETS AND INSULATING COMPOUNDS

Gaskets and insulating compounds shall be nonabsorptive and suitable for insulating contact points of incompatible materials. Insulating compounds shall be nonrunning after drying.

2.10 VAPOR RETARDER

The vapor retarder goes on the side of the insulation with the greatest vapor pressure during the course of the year; therefore, it goes on the outside in a climate predominantly warm, and on the inside in a climate predominantly cool. The two systems are as follows:

a. Cool climate. The vapor retarder will be a separate membrane directly on top of the roof deck with board insulation over the vapor retarder and an unfaced blanket cushioning between the board insulation and the roofing.

b. Warm climate. The vapor retarder will be a facing on the top of a blanket insulation above board insulation. The board insulation sits on the roof deck. A slip sheet is required.

Unreinforced foil as the facing in condition b. above, should not be used.

2.10.1 Vapor Retarders as Integral Facing

Insulation facing shall have a permeability of 1.15 ng per Pa-second-square meter (0.02 perm) or less when tested in accordance with ASTM E 96. Facing shall be white or black reinforced plypropylene kraft laminate (PSK). Facings and finishes shall be factory applied.

2.10.2 Vapor Retarders Separate from Insulation

Roof deck shall not be assumed to function as a vapor retarder. Vapor retarder material shall be polyethylene sheeting conforming to ASTM D 4397. A single ply of 0.25 mm (10 mil) polyethylene sheet; or, at the Contractor's option, a double ply of 0.15 mm (6 mil) polyethylene sheet shall be used. A fully compatible polyethylene tape which has equal or better water vapor control characteristics than the vapor retarder material shall be provided. A cloth industrial duct tape in a utility grade shall also be provided to use as needed to protect the vapor retarder from puncturing.

2.10.3 Slip Sheet for Use With Vapor Retarder

Slip sheet for use with vapor retarder shall be a 0.24 kg per square meter (5 per 100 square foot) rosin-sized, unsaturated building paper.

PART 3 EXECUTION

3.1 INSTALLATION

Installation shall be as specified and in accordance with the approved erection instructions and drawings to produce a weather tight structure. Dissimilar materials which are not compatible when contacting each other shall be insulated from each other by means of gaskets or insulating compounds. Improper or mislocated drill holes shall be plugged with an oversize screw fastener and gasketed washer; however, sheets with an excess of such holes or with such holes in critical locations shall not be used. Exposed surfaces and edges shall be kept clean and free from sealant, metal cuttings, hazardous burrs, and other foreign material. Stained, discolored, or damaged sheets shall be removed from the site.

3.1.1 Roof Covering

Roof covering shall be applied with the longitudinal configurations in the direction of the roof slope. Accessories shall be fastened into framing members, except as otherwise approved. Closure strips shall be provided as indicated and where necessary to provide weathertight construction.

3.1.1.1 Lap Type Panels with Exposed Fasteners

End laps shall be made over framing members with fasteners into framing members approximately 50 mm (2 inches) from the end of the overlapping sheet. Side laps shall be laid away from the prevailing winds. Side and end lap distances, joint sealing, and fastening and spacing of fasteners shall be in accordance with manufacturer's standard practice insofar as the maximum spacings specified are not exceeded and provided such standard practice will result in a structure which will be free from water leaks and meet design requirements. Spacing of fasteners shall present an orderly appearance and shall not exceed 200 mm (8 inches) on center at end laps of covering, 200 mm (8 inches) on center at connection of covering to intermediate supports, 300 mm (12 inches) on center at side laps of roof coverings except when otherwise approved. Side laps and end laps of roof covering and joints at accessories shall be sealed. Fasteners shall be installed in straight lines within a tolerance on 13 mm (1/2 inch) in the length of a bay. Fasteners shall be driven normal to the surface and to a uniform depth to seat the gasketed washers properly.

3.1.2 Field Forming of Roof Panels for Unique Areas

When roofing panels are formed from factory-color-finished steel coils at the project site, the same care and quality control measures that are taken in shop forming of roofing panels shall be observed. Rollformer shall be operated by the metal roofing manufacturer's approved installer. In cold weather conditions, preheating of the steel coils to be field formed shall be performed as necessary just prior to the rolling operations.

3.1.3 Underlayment

Underlayment types shall be installed where shown on the drawings; they shall be installed directly over the substrate. If a roof panel rests directly on the underlayments, a slip sheet shall be installed as a top layer, beneath the metal roofing panels, to prevent adhesion. All underlayments shall be installed so that successive strips overlap the next lower strip in shingle fashion. Underlayments shall be installed in accordance with the manufacturer's written instructions. The underlayments shall ensure that any water that penetrates below the metal roofing panels will drain outside of the building envelope.

3.2 INSULATION INSTALLATION

Insulation shall be installed as indicated and in accordance with manufacturer's instructions. Insulation shall be continuous over entire roof surface. Where expansion joints, terminations, and other connections are made, the cavity shall be filled with batt insulation and vapor retarder providing equivalent R-Value and perm rating as remaining insulation.

3.2.1 Board Insulation in Warm Climates

Rigid or semirigid board insulation shall be laid in close contact. If more than one layer of insulation is required, joints in the second layer shall be offset from joints in the first layer. A layer of blanket insulation shall be placed over the rigid or semirigid board insulation to be compressed against the underside of the metal roofing to reduce thermal bridging, dampen noise, and prevent roofing flutter. This layer of blanket insulation shall be compressed a minimum of 50 percent. Rigid insulation shall be attached to the metal roof deck with bearing plates and fasteners, as recommended by the insulation manufacturer, so that the insulation joints are held tight against each other, with no less than 1 fastener and bearing plate per 0.37 square meter (4 square feet) of insulation. Layout and joint pattern of insulation and fasteners shall be indicated on the shop drawings.

3.2.2 Board Insulation in Cool Climates

A layer of unfaced blanket insulation shall be placed over the board insulation and held tight against the metal roofing.

3.3 PROTECTION OF VAPOR RETARDER FROM ROOF DECK

Where the vapor retarder is in direct contact with the roof deck, protect vapor retarder as follows. A cloth industrial duct tape shall be adhered over all the seams of metal roof decking, at any penetration edges, and at all surface areas exhibiting sharp burrs or similar protrusions. For other types of roof decking, cloth industrial duct tape shall be adhered over all irregularities which could potentially puncture polyethylene membrane.

3.4 VAPOR RETARDER INSTALLATION

Apply one paragraph which is applicable to the site.

3.4.1 Integral Facing on Blanket Insulation

Integral facing on blanket insulation shall have the facing lapped and sealed with a compatible tape to provide a vapor tight membrane.

3.4.2 Polyethylene Vapor Retarder

The polyethylene vapor retarder membrane shall be installed over the entire surface. A fully compatible polyethylene tape shall be used to seal the edges of the sheets to provide a vapor tight membrane. Sheet edges shall be lapped not less than 150 mm (6 inches). Sufficient material shall be provided to avoid inducing stresses in the sheets due to stretching or binding. All tears or punctures that are visible in the finished surface at any time during the construction process shall be sealed with polyethylene tape.

3.5 SLIP SHEET INSTALLATION

Where blanket insulation facing is compressed against metal roofing, a slip sheet shall be laid over the blanket insulation facing to prevent the vinyl facing from adhering to the metal roofing.

SECTION 07413

METAL SIDING

TABLE OF CONTENTS

PART 1 GENERAL

This specification covers the requirements for both factory color and mill finish metal siding.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ALUMINUM ASSOCIATION (AA)

AA Design Manual (2000) Aluminum Design Manual: Specifications & Guidelines for Aluminum Structures

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI Cold-Formed Mnl (1996) Cold-Formed Steel Design Manual

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 446 (1993) Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality

ASTM A 463/A 463M (2000) Steel Sheet, Aluminum-Coated, by the Hot-Dip Process

ASTM A 653/A 653M (2000) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

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ASTM D 522	(1993a) Mandrel Bend Test of Attached Organic Coatings
ASTM D 610	(1995) Evaluating Degree of Rusting on Painted Steel Surfaces
ASTM D 714	(1987; R 1994el) Evaluating Degree of Blistering of Paints
ASTM D 968	(1993) Abrasion Resistance of Organic Coatings by Falling Abrasive
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ASTM D 2247	(1999) Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM D 2794	(1993; R 1999el) Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D 3359	(1997) Measuring Adhesion by Tape Test
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ASTM E 84	(2000a) Surface Burning Characteristics of Building Materials
ASTM E 96	(2000) Water Vapor Transmission of Materials
ASTM G 154	(2000) Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7	(1998) Minimum Design Loads for Buildings and Other Structures

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506	(2001) Galvanized Steel Sheet
KS D 3544	(2002) Hot Dip Aluminum Coated Steel Sheets

KS D 3770	(1992) Hot Dip 55% Aluminum-Zinc Alloy-Coated Steel Sheets and Coils
KS D 6701	(2002) Aluminum and Aluminum Alloy Sheets and Plates
KS L 9102	(1997) Thermal Insulation Material Made of Glass Wool

1.2 DESIGN REQUIREMENTS

1.2.1 Design

Criteria, loading combinations, and definitions shall be in accordance with ASCE 7. Maximum calculated fiber stress shall not exceed the allowable value in the AISI or AA manuals; a one third overstress for wind is allowed. Midspan deflection under maximum design loads shall be limited to L/180. Contract drawings show the design wind loads and the extent and general assembly details of the metal siding. Members and connections not shown on the drawings shall be designed by the Contractor. Siding panels and accessories shall be the products of the same manufacturer. Steel siding design shall be in accordance with AISI Cold-Formed Mnl. Aluminum siding design shall be in accordance with AA Design Manual.

1.2.2 Architectural Considerations

Panels profile shall be as shown on the drawings.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Siding; G.

Drawings consisting of catalog cuts, design and erection drawings, shop coating and finishing specifications, and other data as necessary to clearly describe design, materials, sizes, layouts, construction details, fasteners, and erection. Drawings shall be accompanied by engineering design calculations for the siding panels.

SD-04 Samples

Accessories; G.

One sample of each type of flashing, trim, closure, cap and similar items. Size shall be sufficient to show construction and configuration.

Siding; G.

One piece of each type and finish (exterior and interior) to be used, 225 mm 9 inches long, full width.

Fasteners; G.

Two samples of each type to be used with statement regarding intended use. If so requested, random samples of bolts, nuts, and washers as delivered to the jobsite shall be taken in the presence of the Contracting Officer and provided to the Contracting Officer for testing to establish compliance with specified requirements.

Insulation; G.

One piece of each type to be used, and descriptive data covering installation.

Gaskets and Insulating Compounds;

Two samples of each type to be used and descriptive data.

Sealant;

One sample, approximately 0.5 kg (1 pound), and descriptive data.

Wall Liners;

One piece, 225 mm 9 inches long, full width.

SD-07 Certificates

Siding; G. Installation; G. Accessories; G.

Certificates attesting that the panels and accessories conform to the requirements specified. Certified laboratory test reports showing that the sheets to be furnished are produced under a continuing quality control program and that a representative sample consisting of not less than 5 pieces has been tested and has met the quality standards specified for factory color finish. Mill certification for structural bolts, siding, and wall liner panels.

Insulation; G.

Certificate attesting that the insulation furnished for the project contains recovered material, and showing an estimated percent of such recovered material.

1.4 DELIVERY AND STORAGE

Materials shall be delivered to the site in a dry and undamaged condition and stored out of contact with the ground. Materials shall be covered with weathertight coverings and kept dry. Storage accommodations for metal siding shall provide good air circulation and protection from surface staining.

1.5 WARRANTIES

The Contractor shall provide a weather tight warranty for the metal siding for a period of 20 years to include siding panel assembly, 10 years against the wear of color finish, and 10 years against the corrosion of fasteners caused by ordinary wear and tear by the elements. The warranties shall start upon final acceptance of the work or the date the Government takes possession, whichever is earlier.

PART 2 PRODUCTS

2.1 SIDING

Panels shall be either steel or aluminum and shall have a mill or factory color finish. Length of sheets shall be sufficient to cover the entire height of any unbroken wall surface when length of run is 9 m (30 feet) or less. When length of run exceeds 9 m (30 feet), each sheet in the run shall extend over two or more spans. Sheets longer than 9 m (30 feet) may be furnished if approved by the Contracting Officer. Width of sheets with overlapping configurations shall provide not less than 690 mm (27 inches) of coverage in place.

2.1.1 Wall Panels

Wall panels shall have edge configurations for overlapping adjacent sheets or interlocking ribs for securing adjacent sheets. Wall panels shall be fastened to framework using exposed or concealed fasteners.

2.1.2 Steel Panels

Zinc-coated steel conforming to ASTM A 653/A 653M, or KS D 3506; aluminum-zinc alloy coated steel conforming to ASTM A 792/A 792M, AZ 55 coating, or KS D 3770; or aluminum-coated steel conforming to ASTM A 463/A 463M, Type 2, coating designation T2 65, or KS D 3544. Uncoated wall panels shall be 0.6 mm (0.024 inch) thick minimum. When mill finish panels are used, prior to shipment, mill finish panels shall be treated with a passivating chemical and oiled to inhibit the formation of oxide corrosion products. Panels that have become wet during shipment but have not started to oxidize shall be dried, retreated, and re-oiled.

2.1.3 Aluminum Panels

Alloy conforming to ASTM B 209M or KS D 6701, temper as required for the forming operation, minimum 0.8 mm (0.032 inch) thick.

2.1.4 Factory Insulated Panels

Insulated wall panels shall be factory-fabricated units with insulating core between metal face sheets, securely fastened together and uniformly separated with rigid spacers; facing of steel or aluminum of composition and gauge specified for siding; and constructed to eliminate condensation on interior of the panel. Panels shall have a factory color finish or mill finish. Insulation shall be compatible with adjoining materials; nonrunning and nonsettling; capable of retaining its R-value for the life of the metal facing sheets; and unaffected by extremes of temperature and humidity. The assembly shall have a flame spread rating not higher than 25, and smoke developed rating not higher than 50 when tested in accordance with ASTM E 84. The insulation shall remain odorless, free from mold, and not become a source of food and shelter for insects. Panels shall be not less than 200 mm (8 inches) wide and shall be in one piece for unbroken wall heights.

2.2 FACTORY COLOR FINISH

Panels shall have a factory applied polyvinylidene fluoride finish on the exposed side. The exterior finish shall consist of a baked-on topcoat with an appropriate prime coat. Color shall match the color indicated on the drawings. The exterior coating shall be a nominal 0.025 mm (1 mil) thickness consisting of a topcoat of not less than 0.018 mm (0.7 mil) dry film thickness and the paint manufacturer's recommended primer of not less than 0.005 mm (0.2 mil) thickness. The interior color finish shall consist of the same coating and dry film thickness as the exterior. The exterior color finish shall meet the test requirements specified below.

2.2.1 Salt Spray Test

A sample of the sheets shall withstand a cyclic corrosion test for a minimum of 2016 hours in accordance with ASTM D 5894, including the scribe requirement in the test. Immediately upon removal of the panel from the test, the coating shall receive a rating of not less than 10, no blistering, as determined by ASTM D 714; 10, no rusting, as determined by ASTM D 610; and a rating of 6, 2.0 to 3.0 mm (1/16 to 1/8 inch) failure at scribe, as determined by ASTM D 1654.

2.2.2 Formability Test

When subjected to testing in accordance with ASTM D 522 Method B, 3 mm (1/8 inch) diameter mandrel, the coating film shall show no evidence of fracturing to the naked eye.

2.2.3 Accelerated Weathering, Chalking Resistance and Color Change

A sample of the sheets shall be tested in accordance with ASTM G 154. The coating shall withstand the weathering test without cracking, peeling, blistering, loss of adhesion of the protective coating, or corrosion of the base metal. Protective coating that can be readily removed from the base metal with tape in accordance with ASTM D 3359, Test Method B, shall be considered as an area indicating loss of adhesion. Following the accelerated weathering test, the coating shall have a chalk rating not less than No. 8 in accordance with ASTM D 4214 test procedures, and the color change shall not exceed 5 CIE or Hunter Lab color difference (delta E) units in accordance with ASTM D 2244. For sheets required to have a low gloss finish, the chalk rating shall be not less than No. 6 and the color difference shall be not greater than 7 units.

2.2.4 Humidity Test

When subjected to a humidity cabinet test in accordance with ASTM D 2247 for 1000 hours, a scored panel shall show no signs of blistering, cracking, creepage or corrosion.

2.2.5 Impact Resistance

Factory-painted sheet shall withstand direct and reverse impact in accordance with ASTM D 2794 13 mm (0.500 inch) diameter hemispherical head indenter, equal to 6.7 times the metal thickness in mm, expressed in Newton-meters, 1.5 times the metal thickness in mils, expressed in inch-pounds, with no loss of adhesion.

2.2.6 Abrasion Resistance Test

When subjected to the falling sand test in accordance with ASTM D 968, Method A, the coating system shall withstand a minimum of 50 liters of sand before the appearance of the base metal. The term "appearance of base metal" refers to the metallic coating on steel or the aluminum base metal.

2.3 ACCESSORIES

Flashing, trim, metal closure strips, caps, and similar metal accessories shall be the manufacturer's standard products. Exposed metal accessories shall be finished to match the panels furnished. Molded closure strips shall be bituminous-saturated fiber, closed-cell or solid-cell synthetic rubber or neoprene, or polyvinyl chlorided premolded to match configuration of the panels and shall not absorb or retain water.

2.4 FASTENERS

Fasteners for steel panels shall be zinc-coated steel, aluminum, corrosion resisting steel, or nylon capped steel, type and size specified below or as otherwise approved for the applicable requirements. Fasteners for aluminum panels shall be aluminum or corrosion resisting steel. Fasteners for attaching wall panels to supports shall provide both tensile and shear strength of not less than 3340 N (750 pounds) per fastener. Fasteners for accessories shall be the manufacturer's standard. Exposed wall fasteners shall be color finished or provided with plastic color caps to match the panels. Nonpenetrating fastener system for wall panels using concealed clips shall be manufacturer's standard for the system provided.

2.4.1 Screws

Screws shall be as recommended by the manufacturer.

2.4.2 End-Welded Studs

Automatic end-welded studs shall be shouldered type with a shank diameter of not less than 5 mm (3/16 inch) and cap or nut for holding covering against the shoulder.

2.4.3 Explosive Actuated Fasteners

Fasteners for use with explosive actuated tools shall have a shank of not less than 3.68 mm (0.145 inch) with a shank length of not less than 13 mm (1/2 inch) for fastening panels to steel and not less than 25 mm (1 inch) for fastening panels to concrete.

2.4.4 Blind Rivets

Blind rivets shall be aluminum with 5 mm (3/16-inch) nominal diameter shank or stainless steel with 3 mm (1/8-inch) nominal diameter shank. Rivets shall be threaded stem type if used for other than the fastening of trim. Rivets with hollow stems shall have closed ends.

2.4.5 Bolts

Bolts shall be not less than 6 mm (1/4-inch) diameter, shouldered or plain shank as required, with proper nuts.

2.5 INSULATION

Thermal resistance of insulation shall be not less than the R-values shown on the contract drawings. R-values shall be determined at a mean temperature of 24 degrees C (75 degrees F) in accordance with ASTM C 518. Insulation shall be a standard product with the insulation manufacturer, factory-marked or identified with insulation manufacturer's name or trademark and R-value. Identification shall be on individual pieces or individual packages. Blanket insulation shall have a facing as specified in paragraph VAPOR RETARDER. Insulation, including facings, shall have a flame spread not in excess of 75 and a smoke developed rating not in excess of 150 when tested in accordance with ASTM E 84. The stated R-value of the insulation shall be certified by an independent Registered Professional Engineer if tests are conducted in the insulation manufacturer's laboratory.

2.6 VAPOR RETARDER

2.6.1 Vapor Retarders as Integral Facing

Insulation facing shall have a permeability of 1.15 ng per Pa-second-square meter (0.02 perm) or less when tested in accordance with ASTM E 96. Facing shall be white or black reinforced polypropylene kraft laminate (PSK).

Facings and finishes shall be factory applied.

2.6.2 Vapor Retarders Separate from Insulation

Vapor retarder material shall be polyethylene sheeting conforming to ASTM D 4397. A single ply of 0.25 mm (10 mil) polyethylene sheet or, at the Contractor's option, a double ply of 0.15 mm (6 mil) polyethylene sheet shall be used. A fully compatible polyethylene tape which has equal or better water vapor control characteristics than the vapor retarder material shall be provided. A cloth industrial duct tape in a utility grade shall also be provided to use as needed to protect the vapor retarder from puncturing.

2.7 WALL LINERS

Wall liners shall be 0.6 mm (0.024 inch) thick minimum for aluminum or 0.45 mm (0.018 inch) thick minimum for steel with the same composition specified for siding, and formed or patterned to prevent waviness and distortion, and shall extend from floor to the ceiling. Matching metal trim shall be provided at base of wall liner, top of wall liner, around openings in walls and over interior and exterior corners. Wall liners shall have the same factory color finish as specified for the wall panels, or as indicated on drawing.

2.8 SEALANT

Sealant shall be an elastomeric type containing no oil or asphalt. Exposed sealant shall be colored to match the applicable building color and shall cure to a rubberlike consistency.

2.9 GASKETS AND INSULATING COMPOUNDS

Gaskets and insulating compounds shall be nonabsorptive and suitable for insulating contact points of incompatible materials. Insulating compounds shall be nonrunning after drying.

PART 3 EXECUTION

3.1 INSTALLATION

Installation shall be in accordance with the manufacturer's erection instructions and drawings. Dissimilar materials which are not compatible when contacting each other shall be insulated from each other by means of gaskets or insulating compounds. Improper or mislocated drill holes shall be plugged with an oversize screw fastener and gasketed washer; however, panels with an excess of such holes or with such holes in critical locations shall not be used. Exposed surfaces and edges shall be kept clean and free from sealant, metal cuttings, hazardous burrs, and other foreign material. Stained, discolored, or damaged sheets shall be removed from the site.

3.1.1 Siding and Accessories

Siding shall be applied with the longitudinal configurations in the vertical position. Accessories shall be fastened into framing members, except as otherwise approved. Closure strips shall be provided as indicated and where necessary to provide weathertight construction.

3.1.1.1 Lap Type Panels with Exposed Fasteners

End laps shall be made over framing members with fasteners into framing members approximately 50 mm (2 inches) from the end of the overlapping sheet. Side laps shall be laid away from the prevailing winds. Spacing of fasteners shall present an orderly appearance and shall not exceed: 200 mm (8 inches) on center at end laps of siding, 200 mm (8 inches) on center at connection of siding to intermediate supports, and 450 mm (18 inches) on center at side laps of siding except when otherwise approved. Side and end laps of siding and joints at accessories shall be sealed. Fasteners shall be installed in straight lines within a tolerance of 13 mm (1/2 inch) in the length of a bay. Fasteners shall be driven normal to the surface and to a uniform depth to seat the gasketed washers properly.

3.1.1.2   Concealed Fastener Wall Panels

Panels shall be fastened to framing members with concealed fastening clips or other concealed devices standard with the manufacturer. Spacing of fastening clips and fasteners shall be in accordance with the manufacturer's written instructions. Spacing of fasteners and anchor clips along the panel interlocking ribs shall not exceed 300 mm (12 inches) on center except when otherwise approved. Fasteners shall not puncture metal sheets except as approved for flashing, closures, and trim; exposed fasteners shall be installed in straight lines. Interlocking ribs shall be sealed with factory-applied sealant. Joints at accessories shall be sealed.

SECTION 07511

BUILT-UP ASPHALT ROOFING

TABLE OF CONTENTS

PART 1 GENERAL

This guide specification covers the requirements for aggregate surfaced bituminous built-up roofing with slopes from one in 48 to one in 8 (1/4 inch to 1 1/2 inches per foot). The requirements for hot-mopped, four-ply, aggregate surfaced, built-up bituminous roofing systems are included in this guide specification. For new buildings, provide a slope of one in 24 (1/2 inch per foot) minimum. On reroofing projects where the existing roof slopes at least one in 48 (1/4 in./ft.) and it is clearly impractical to provide roofing sloped at least one in 24 (1/2 in./ft.), built-up roofing may be used.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 208 (1995) Cellulosic Fiber Insulating Board

ASTM C 728 (1997) Perlite Thermal Insulation Board

ASTM C 1153 (1997) Location of Wet Insulation in Roofing Systems Using Infrared Imaging

ASTM C 1177/C 1177M (1999) Glass Mat Gypsum Substrate for Use as Sheathing

ASTM D 41 (1994) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing

ASTM D 226 (1997a) Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing

ASTM D 312 (2000) Asphalt Used in Roofing

ASTM D 448 (1986; R 1998) Sizes of Aggregate for Road and Bridge Construction

ASTM D 517 (1998) Asphalt Plank

ASTM D 1668 (1997a) Glass Fabrics (Woven and Treated) for Roofing and Waterproofing

ASTM D 1863 (1993; R 1996) Mineral Aggregate Used on Built-Up Roofs

ASTM D 1864 (1989; R 1999 e1) Moisture in Mineral Aggregate Used on Built-Up Roofs

ASTM D 2170 (1995) Kinematic Viscosity of Asphalts (Bitumens)

ASTM D 2178 (1997a) Asphalt Glass Felt Used in Roofing and Waterproofing

ASTM D 3617 (1983; R 1994el) Sampling and Analysis of New Built-Up Roof Membranes

ASTM D 4402 (1987; R 1995 e2) Viscosity Determinations of Unfilled Asphalts Using the Brookfield Thermosel Apparatus

ASTM D 4586 (1993; R 1999) Asphalt Roof Cement, Asbestos Free

ASTM D 4601 (1998) Asphalt-Coated Glass Fiber Base Sheet Used in Roofing

ASTM D 4897 (1998) Asphalt-Coated Glass-Fiber Venting Base Sheet Used in Roofing

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P7825c (1998) Approval Guide Building Materials

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 4052 (1999) Waterproofing Asphalt for Building Construction

KS M 2270 (1997) Asphalt Primer Used In Roofing, Dampproofing And Waterproofing

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Asphalt; G

Felts; G

Fasteners;

Primer;

Asphalt roof cement;

Walkway Materials;

Inspection;

The inspection procedure for roofing installation, prior to the start of roofing work.

Cants;

Certificate attesting that the fiberboard furnished for the project contains recovered material, and showing an estimated percent of such recovered material.

Warranty certificate; G

SD-06 Test Reports

Samples of built-up roofing;

Submit test results on roofing field samples as required, verifying composition of sample. Submit six copies of laboratory analysis within 30 calendar days after samples are taken. Submit reports in accordance with ASTM D 3617.

SD-07 Certificates

Bill of lading;

Submit when labels of asphalt containers do not indicate the finished blowing temperature, flash point and equiviscous temperature.

Qualifications of applicator;

Submit evidence of the roofing system manufacturer's approval.

SD-11 Closeout Submittals

Information card;

For each roofing installation, submit typewritten card or photoengraved aluminum card containing the information listed on Form 1 located at the end of this section.

1.3 QUALITY ASSURANCE

1.3.1 Qualifications of Applicator

The roofing system applicator shall be approved, authorized, or licensed in writing by the roofing system manufacturer and shall have a minimum of 3 years experience as an approved, authorized, or licensed applicator with the manufacturer and be approved at a level capable of providing the specified warranty.

1.3.2 Preroofing Conference

After approval of submittals and before roofing and insulation work, including associated work, is performed, the Contracting Officer will hold a preroofing conference to review the following:

a. Drawings and specifications

b. Procedure for on site inspection and acceptance of roofing substrate and pertinent structural details relating to roofing system

c. Contractor's plan for coordination of work of the various trades involved in providing roofing system and other components secured to roofing

d. Safety requirements

The preroofing conference shall be attended by the Contractor and personnel directly responsible for the roofing and insulation installation, flashing and sheet metal work, mechanical and electrical] work, and representative of the roofing materials manufacturer. Conflicts among those attending the preroofing conference shall be resolved and confirmed in writing before roofing work, including associated work, is begun.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery

Deliver materials in manufacturers' original unopened containers and rolls with manufacturer's labels intact and legible. Mark and remove wet or damaged materials from site. Where materials are covered by a referenced specification, container shall bear specification number, type, and class, as applicable. Indicate on labels or bill of lading for roofing asphalt the asphalt type, finished blowing temperature (FBT), flash point (FP), and equiviscous temperature (EVT), that is, the temperature at which the viscosity is either 125 centistokes when tested in accordance with ASTM D 2170 or 75 centipoise when tested in accordance with ASTM D 4402. Deliver materials in sufficient quantity to allow work to proceed without interruption.

1.4.2 Storage

Protect materials against moisture absorption. Store roll materials on end on clean raised platforms in dry locations in enclosed buildings or trailers with adequate ventilation. Do not store roll materials in buildings under construction until concrete, mortar, and plaster work are finished and dry. For a 24-hour period immediately prior to application, maintain roll materials at temperature above 10 degrees C 50 degrees F. Aggregate shall be kept dry as defined by ASTM D 1863. Place only those materials to be used during one day's work on the roof at one time. Remove unused materials from the roof at the end of each day's work.

1.4.3 Handling

Select and operate material handling equipment so as not to damage applied roofing. Prevent damage to edges and ends of roll materials.

1.5 ENVIRONMENTAL CONDITIONS

Do not install roofing during precipitation, or fog, or when air temperature is below 4 degrees C (40 degrees F), or when there is ice, frost, moisture or visible dampness on roof deck. Restriction on application of roofing materials below 4 degrees C (40 degrees F) may be waived if Contractor devises a means, satisfactory to Contracting Officer, of: (1) maintaining surrounding temperature above 4 degrees C (40 degrees F); and (2) maintaining application temperature of heated materials without exceeding maximum specified heating temperature.

1.6 PROTECTION OF PROPERTY

1.6.1 Protective Coverings

Install protective coverings at paving and building walls adjacent to hoist and kettles prior to starting work. Lap protective coverings not less than 150 mm (6 inches), secure against wind, and vent to prevent collection of moisture on covered surfaces. Keep protective coverings in place for duration of roofing work.

1.6.2 Flame-Heated Equipment

Do not place flame-heated equipment closer than 8 meters (25 feet) to buildings or combustible materials. Provide a minimum of two 9 kilogram (20 pound) ABC all-purpose type extinguishers at melting kettle and at area of hot material application.

1.7 WARRANTY

Furnish the roofing system manufacturer's warranty for the roofing system. The warranty period shall not be less than 5 years from the date the Government acceptance of the work. The warranty shall be issued directly to the Government and shall not be limited in dollar value. The warranty shall provide that if within the warranty period the built-up roofing system including membrane, flashing,insulation and accessories becomes nonwatertight, blisters or shows evidence of excessive weathering due to deterioration of the roofing system resulting from defective materials or workmanship, the repair or replacement of defective materials or workmanship shall be the responsibility of the manufacturer. While roofing is under warranty perform repairs that become necessary due to defective materials or workmanship within 72 hours of notification, unless additional time is approved by the Contracting Officer. Failure to perform repairs within specified period of time will constitute grounds for the Government having repairs performed by others and cost billed to Contractor.

PART 2 PRODUCTS

2.1 ROOFING SYSTEM

Glass felt, asphalt bitumen, aggregate surfaced.

<u>Substrate: Wood or Plywood</u>

Components:	Quantity:
Unsaturated Felt or Building Paper (for wood substrate only)	1 Ply
Felt:	
Base Sheet (GB)	1 Ply
Ply Felt (GA)	3 Plies
Asphalt: (See a. below)	
On Base Sheet	10-17.5 kg/10 sq m (20-35 lbs/100 sq ft)
Between Each Ply	10-17.5 kg/10 sq m (20-35 lbs/100 sq ft)
Top Coat	27.5-35 kg/10 sq m (55-70 lbs/100 sq ft)
Surfacing:	

Gravel or Crushed Stone	200 kg/10 sq m (400 lbs/100 sq ft)
Other Aggregate	150 kg/10 sq m (300 lbs/100 sq ft)

Substrate: Roof Insulation, Cast-In-Place Concrete or Precast Concrete

Components:	Quantity:
Felt: (apply where substrate is new cast-in-place or precast concrete or aged concrete suspected of having retained moisture)	
Ventilating Base Sheet (VB)	1 Ply
Ply Felt (GA)	3 Plies
Asphalt: (See a. below)	
Between Substrate or Ventilating Base Sheet and First Ply	10-17.5 kg/10 sq m (20-35 lbs/100 sq ft)
Between Each Ply	10-17.5 kg/10 sq m (20-35 lbs/100 sq ft)
Top Coat	27.5-35 kg/10 sq m (55-70 lbs/100 sq ft)
Surfacing:	
Gravel or Crushed Stone	200 kg/10 sq m (400 lbs/100 sq ft)
Other Aggregate	150 kg/10 sq m (300 lbs/100 sq ft)

a. Provide asphalt quantities within the indicated ranges, unless recommended otherwise in the roofing materials manufacturer's printed data.

2.2 MATERIALS

2.2.1 Asphalt

Roof Slope, in./ft.	Specification
One in 48 to one in 24 (1/4 to 1/2)	ASTM D 312, Type II or III or KS F 4052, Class 1 or 2
More than one in 24 (1/2) but not more than one in 8 (1 1/2)	ASTM D 312, Type III or IV or KS F 4052, Class 3 or 4

2.2.1 Felts

For built-up roofing and flashing:

Designation	Use	Felt	Impregnant	Coating	Specification
GB	Base Sheet	Glass	Asphalt	Asphalt	ASTM D 4601, Type II, without Perforations
GA	Ply Felt	Glass	Asphalt	None	ASTM D 2178, Type VI or IV
VB	Ventilating Base Sheet	Glass	Asphalt	Asphalt	ASTM D 4897, Type II
FF	Flashing Felt	Glass	Asphalt	Asphalt	(See a. below)

a. Provide flashing felt specifically prepared in the manufacturing process for use in two-ply base flashing construction of either: a single thickness of glass felt conforming to the properties listed in ASTM D 2178, for Type IV; or glass felt factory-laminated to a woven glass fiber scrim or cotton fabric; or styrene-butadiene-styrene (SBS) or a tactic polypropylene (APP) modified bitumen. Factory-coat each type of flashing construction on both sides with an asphaltic coating which includes a water-insoluble, fine mineral stabilizer and a fine mineral surfacing.

2.2.3 Primer

ASTM D 41 for asphalt roofing systems.

2.2.4 Asphalt Roof Cement

ASTM D 4586 for use with asphalt roofing systems, Type II for vertical surfaces and built-up bituminous flashings; Type I for horizontal surfaces.

2.2.5 Cants

Cants shall be made from treated wood or treated fiberboard not less than 89 mm (3-1/2 inches) high or perlite board, cut to reduce change in direction of the membrane to 45 degrees or less. Treated wood shall be of water-borne preservative-treated material as specified in Section 06100 "Rough Carpentry."

2.2.6 Aggregate for Surfacing Built-up Roofing

Water-worn gravel, crushed stone, or crushed slag, conforming to ASTM D 1863, or marble, expanded slag, or expanded shale, conforming to ASTM D 1863 except density not less than 880 kg/cubic meter 55 pcf. Aggregate conforming to gradation sizes No. 6, No. 7, and No. 67 in conformance with ASTM D 448 is acceptable provided other requirements of ASTM D 1863 are met. 2 percent maximum moisture content as determined by ASTM D 1864. Aggregate shall be light colored and opaque. Limestone, volcanic rock, crushed shells, and cinders are not acceptable.

2.2.7 Unsaturated Felt or Rosin-Sized Building Paper (for wood substrate only)

Minimum weight, 2.5 kg per 10 square meters (5 pounds per 100 square feet).

2.2.8 Fasteners

Provide nonferrous or galvanized fasteners, except where in contact with copper, aluminum, and stainless steel. Use hard copper fasteners in contact with copper; aluminum or stainless steel fasteners in contact with aluminum; and stainless steel fasteners in contact with stainless steel. For fastening only roofing felts, use fasteners driven through metal discs, or one-piece composite fasteners with heads not less than 25 mm (one inch) in diameter or 25 mm one inch square with rounded or 45-degree tapered corners.

2.2.9 Walkway Materials

2.2.9.1 Rubber and Asphalt Composition Pads

Preformed reprocessed rubber pads or granular surfaced treads consisting of asphalt plasticizers, fibers, and inert fillers, not less than 20 mm (3/4 inch) thick.

2.2.9.2 Mineral Asphalt Plank

ASTM D 517, minimum 19.1 mm (3/4 inch) thick.

2.2.9.3 Concrete Slab

Precast Concrete 20.7 MPa, 300 x 600 x 63 mm (3000 psi, 12 x 24 x 2-1/2 inches).

2.2.10 Moisture Release Vents

Provide vents when vapor retarder is provided beneath insulation. Provide venting for roofing over cast-in-place concrete with or without insulation, by applying ventilating felts directly over substrate. For roofs more than 13 meters (40 feet) wide, use stack venting to supplement edge venting. Underside venting for corrugated steel form decking for cast-in-place concrete substrates consists of slotted openings through the sheets which provide not less than 1.5 percent opening. Underside ventilation for steel decks consists of continuous openings 3 to 5 mm (1/8 to 3/16 inch) wide between adjacent deck units. Vents shall be especially manufactured for the purpose of releasing moisture and vapor from the roofing system by heat and pressure. Vents shall be one-way design to prevent reverse flow of moisture-laden air into roofing system. Valve cap shall effectively seal out wind-blown rain and snow and shall not permit water entry when submerged.

2.2.11 Woven Glass Fabric

ASTM D 1668.

2.2.12 Insulation

Insulation shall be as specified in Section 07220, "Roof and Deck Insulation."

2.2.13 Glass Mat Gypsum Roof Board

Glass mat gypsum roof board shall be in accordance with ASTM C 1177/C 1177M, flame spread - 0, smoke developed - 0, 3446 kpa (500 psi) Class A non-combustible. The glass mat gypsum roof board shall be a minimum 6.35 mm (1/4 inch) thickness.

PART 3 EXECUTION

3.1 VERIFICATION OF CONDITIONS

Before applying roofing materials, ensure that the following exist:

a. Drains, curbs, cants, control joints, expansion joints, perimeter walls, roof penetrating components, and equipment supports are in place.

b. Surfaces are rigid, dry, smooth, and free of cracks, holes, and sharp changes in elevation. Joints in substrate are sealed to prevent drippage of bitumen into building or down exterior walls. Surfaces shall be inspected and approved immediately before application of roofing and flashings. The roofing and flashings shall be applied to a smooth and firm surface free from ice, frost, visible moisture, dirt, projections, and foreign materials.

c. Plane of substrate does not vary more than 6 mm (1/4 inch) within an area 3 by 3 meters (10 by 10 feet) when checked with a 3 meter (10-foot) straight edge placed anywhere on substrate.

d. Substrate is sloped as indicated to provide drainage.

e. Walls and vertical surfaces are constructed to receive counterflashing.

f. Treated wood nailers are in place on non-nailable surfaces, to permit nailing of base flashing at minimum height of 200 mm (8 inches) above finished roofing surface.

g. Treated wood nailers are fastened in place at eaves, gable ends, openings, and intersections with vertical surfaces for securing of felts, edging strips, gravel stops, and roof fixtures. Embedded nailers are flush with deck surfaces. Surface-applied nailers are same thickness as roof insulation.

h. Cants are securely fastened in place in the angles formed by walls and other vertical surfaces. The angle of the cant is approximately 45 degrees and the height of the vertical leg is not less than nominal 100 mm (4 inches). Cants are constructed of treated wood or wood fiberboard insulation. Cants shall be laid in a solid coat of asphalt cement just prior to laying the roofing plies. Cants shall be continuous, and shall be installed in lengths as long as practicable. Additional cants are not required at locations where cast-in-place cants are integrally formed with the structural deck or roof fill.

i. Venting is provided in accordance with the following:

(1) Edge Venting: Perimeter nailers are kerfed across width of the nailers to permit escape of gaseous pressure at roof edges.

(2) Underside Venting: Vent openings are provided in steel form decking for cast-in-place concrete substrate.

j. Wood (or plywood) substrates are constructed of treated wood securely fastened to the framing members with exposed nail heads properly set. Warped and split boards (or sheets) have been replaced. There are no cracks or end joints 6 mm (1/4 inch) in width or greater. Knotholes are covered with sheet metal and nailed in place. Joints in plywood substrates are taped with 50 mm (2 inch) wide masking tape to prevent air leakage from the underside.

k. Insulation boards are installed smoothly and evenly, and are not broken, cracked, or curled. Insulation is being roofed over on the same day the insulation is installed.

l. Cast-in-place concrete substrates have been allowed to cure and the surface dryness requirements specified under paragraph entitled "Field Quality Control" have been met.

m. Joints between precast concrete deck units, including weld plates, are grouted, leveled, and covered with 100 mm (4 inch) wide ply felt solidly bedded in asphalt roof cement. Prior to application of primer on precast concrete decks, joints shall be covered with a 4-inch strip of roofing, felt, embedded in and coated with bituminous cement.

3.2 PREPARATION

Coordinate work with other trades to ensure that components which are to be secured to or stripped into roofing system are available and that permanent flashings and counterflashings are installed as work progresses.

3.2.1 Insulation

Application of roofing shall immediately follow application of insulation as a continuous operation. Roofing operations shall be coordinated with insulation work so that all roof insulation applied each day is waterproofed the same day. Insulation is specified in Section 07220, "Roof and Deck Insulation."

3.2.2 Sheet Metalwork

Roofing operations shall be coordinated with sheet metalwork so that sheet metal items are installed to permit continuous roof surfacing operations the same day felts are installed.

3.2.3 Priming of Surfaces

Prime surfaces at rate of 3 liters per 10 square meters (0.75 gallon per 100 square feet).

3.2.3.1 Priming of Concrete and Masonry Surfaces

When roofing and base flashing are applied directly to concrete or masonry surfaces, after surface dryness requirements have been met, coat concrete and masonry surfaces which are to receive roofing and base flashing uniformly with primer. Allow primer to dry before application of roofing and flashing materials.

3.2.3.2 Priming of Metal Surfaces

Prime flanges of metal gravel stops, edging strips, flashing collars, roof drain flashing, and accessories before stripping into roofing system.

3.2.4 Covering of Wood Substrate

Cover wood substrate with a layer of unsaturated felt or rosin-sized building paper lapped 50 mm 2 inches at sides and 100 mm 4 inches at ends. Nail to hold in place prior to application of roofing system.

3.2.5 Heating of Asphalt

Break up solid asphalt on surface free of dirt and debris. Heat in kettle designed to prevent contact of flame with surfaces in contact with asphalt. Kettles shall have visible thermometer and thermostatic controls set to specified temperature limits. Keep controls in working order and calibrated. Use immersion thermometer, accurate within a tolerance of plus or minus one degree C (2 degrees F), for frequent checking of asphalt temperature. If temperature exceeds maximum specified, remove asphalt from site. If temperature of asphalt, at instant of application, is below minimum specified, take a field sample of affected roofing, analyze as specified, and replace with new material if deficiencies are disclosed. Cutting back, adulterating, or fluxing of asphalt are prohibited.

3.2.6 Environmental Conditions

Air temperature shall be above 4 degrees C (40 degrees F) and there shall be no visible ice, frost, or moisture on the roof deck at the time roofing is installed.

3.2.7 Mechanical Application Devices

Mechanical application devices shall be mounted on pneumatic-tired wheels, and shall be designed and maintained to operate without damaging the insulation, roofing membrane, or structural components.

3.3 APPLICATION

Apply roofing materials as specified or recommended by manufacturer's printed application instructions. Keep roofing materials dry before and during application. Phased construction is prohibited. Except for surfacing, complete application of roofing in a continuous operation. Begin and apply only as much roofing in one day as can be completed that same day. Maintain specified temperature for asphalt. Where considerable work by other trades is to be performed on the roof, provide temporary roofing and flashing as specified herein prior to application of permanent roofing system. Do not apply surfacing until the other roofing application procedures specified herein are completed.

3.3.1 Temporary Roofing and Flashing

Provide temporary roofing and flashing where considerable work by other trades such as installing cooling towers, antennas, pipes, or ducts, is to be performed on the roof or where construction scheduling or weather conditions require protection of building interior before permanent roofing system can be installed. Do not install temporary roofing over permanently installed insulation. Provide rigid pads for traffic over temporary roofing.

3.3.1.1 Temporary Roofing Membrane

Install 2 plies of ply felt in accordance with specified application procedures; except spot mop the first ply on cast-in-place concrete decks by squeegeeing felts into 300 mm (12 inch) diameter spots of asphalt spaced 450 mm (18 inches) on center.

3.3.1.2 Temporary Flashing

Install temporary flashing consisting of one ply of ply felt. Place in a trowel coat of asphalt roof cement and cover with a trowel coat of asphalt roof cement.

3.3.1.3 Removal

Completely remove temporary roofing and flashing before continuing with application of permanent roofing system.

3.3.2 Bitumen Stops

Provide bitumen stops at roof edges, openings, and at vertical projections before applying felts unless recommended otherwise by manufacturer's printed application instructions. Form bitumen stops with two 300 mm (12 inch) wide strips of organic ply felt. Laminate with and set strips into a coating of asphalt roof cement with one-half of the width overhanging the edge of the roof or opening. Where nailers are provided, nail the strips with roofing nails spaced 300 mm (12 inches) on center in addition to embedding in asphalt roof cement. The free portion of each strip shall be protected from damage throughout the roofing period. After the plies of felt are in place, fold free portion of the strips back over the roofing membrane and embed in a continuous coating of asphalt roof cement. Secure with roofing nails spaced 75 mm (3 inches) on center.

3.3.3 Mechanically Fastened Base Sheets

When base sheets are specified in paragraph entitled “Roofing System”, apply sheets shingle fashion and in same direction as ply felts with each sheet lapping not less than 50 mm (2 inches) over the preceding. Lap ends not less than 150 mm (6 inches) and stagger a minimum of 900 mm (36 inches). Apply sheets with fasteners at 225 mm (9 inch) intervals along the laps and with fasteners staggered down center of sheets in two rows approximately 280 mm (11 inches) apart. Space nails 450 mm (18 inches) on center. Throughout the area extending 3000 mm (10 feet) in from the edge of the roof, provide fasteners at 125 mm (5 inch) intervals along laps and staggered down center of sheets in two rows approximately 280 mm (11 inches) apart, with nails spaced at 225 mm (9 inches) on center.

3.3.4 Ventilating Base Sheets

When ventilating base sheets are specified in paragraph entitled "Roofing System", apply ventilating base sheets in accordance with the manufacturer's printed installation instructions. Extend sheets over roof cants, up vertical surfaces, and terminate under cap flashing; at roof edges terminate sheets under outside edge of perimeter edge nailers or under gravel stop.

3.3.5 Ply Felts

Apply ply felts shingle fashion in hot-moppings of asphalt, and backnail (When roof slope exceeds 42 mm per meter (1/2 inch per foot)). Apply felts in a continuous operation. Provide starter sheets of felt to maintain the specified number of plies throughout the roofing. Apply felts with side laps in accordance with the material manufacturer's printed instructions and in uniform alignment. Lap ends not less than 150 mm (6 inches) and stagger 900 mm (36 inches) minimum. The full 900 mm (36 inch) width of each ply shall be placed in hot bitumen immediately behind the applicator. A squeegee, broom, or follow through tool shall be used to eliminate air pockets and obtain complete adhesion between plies. Bitumen shall be visible beyond all edges of each ply as it is being installed. Plies shall be laid free of wrinkles, creases or fishmouths. Apply felts at right angles to roof slope so that direction of water flow is over and not against laps. Extend felts approximately 50 mm (2 inches) above top of cant strips at vertical surfaces and to top of cant strips elsewhere. Trim felts to a neat fit around vent pipes, roof drains, and other projections. Workers shall not walk on mopped surfaces when the bitumen is fluid. For slopes exceeding 42 mm per m (1/2 inch per foot), each felt ply, other than venting base sheet, shall be nailed 50 mm (2 inches) and 150 mm (6 inches) from upper edge with nails spaced 300 mm (12 inches) on centers in each row.

3.3.5.1 Hot-Mopping of Ply Felts

Bond plies to each other and to the base sheets or substrate with hot asphalt. Apply felts immediately following application of asphalt. Do not work ahead with asphalt. At the instant felts come into contact with asphalt, asphalt shall be completely fluid, with mop temperatures within specified EVT range. Apply asphalt uniformly in a full, continuous, firmly bonding film at the rate specified. As felts are rolled into the hot asphalt, immediately squeegee, roll or broom down to eliminate trapped air and to provide tight, smooth laminations without wrinkles, buckles, kinks, or fish mouths. The completed roofing system shall be free of pockets, felt delaminations, ridges, fishmouths, dry laps, or blisters. Do not lay felts dry, turn back laps for mopping between plies.

3.3.5.2 Temperature Limitations for Asphalt

Heat and apply asphalt at temperature specified below unless specified otherwise by the manufacturer. Use thermometer to check temperature during heating and application. Have kettle attended constantly during heating process to ensure specified temperatures are maintained. Do not heat asphalt above its finished blowing temperature (FBT). Do not heat asphalt to the flash point (FP). Apply asphalt and embed roofing felts when asphalt temperature is within plus or minus 13 degrees C (25 degrees F) of the equiviscous temperature (EVT). Before heating asphalt refer to manufacturer's label or bill of lading for the FBT, FP and EVT of the asphalt used. Equipment utilizing flame heat shall not be placed on the roof.

3.3.5.3 Backnailing

When roof slope exceeds one in 24 (1/2 inch per foot), in addition to hot-mopping of ply felts with hot asphalt, backnail felts as specified below:

a. Backnailing of Felts to Wood Nailers: Nail felts to wood nailers with two nails spaced approximately 50 and 250 mm 2 and 10 inches from the leading edge of each felt.]

b. Fasten felts to wood, plywood, structural wood fiber, cast-in-place gypsum, or lightweight insulating concrete substrate with fasteners spaced not over 300 mm (12 inches) on center along a line approximately 50 mm (2 inches) from leading edge of each felt.

c. Concealing Fasteners: Conceal fasteners with succeeding plies of felt.

3.3.6 Flashing

Provide bituminous flashing in the angles formed where the roof deck abuts walls, curbs, ventilators, pipes, and other vertical surfaces, and where necessary to make work watertight. Install flashing after plies of felt have been applied but before surfacing is applied. Metal flashings are specified under Section 07600, "Flashing and Sheet Metal."

3.3.6.1 Base Flashing

Use one of the following base flashing systems as recommended by the manufacturer of the ply felts:

a. Three-Ply Bituminous Built-Up Base Flashing: Provide three plies of specified GA ply felt. Embed each in a uniform trowelling of asphalt roof cement not less than 3 mm (1/8 inch) thick. Smooth and press felts firmly into place. Extend felts not less than 150, 225, and 300 mm (6, 9, and 12 inches), respectively, over the roofing membrane beyond toe of cant, and not less than 100 mm (4 inche)s nor more than 250 mm (10 inches) above top of cant on vertical surfaces. Lap ends not less than 300 mm (12 inches) and seal watertight with asphalt roof cement. Stagger end laps. Nail top edges of base flashing to wood nailers with large head roofing nails through metal discs or one-piece composite fasteners spaced not more than 100 mm (4 inches) on center on a line 38 mm (1 1/2 inches) below the top edge of the base flashing. Coat the finished base flashing with asphalt roof cement not less than 3 mm (1/8 inch) thick, extending from 25 mm (one inch) above the top of base flashing on vertical surface to 25 mm (one inch) beyond edge of base flashing on the roofing membrane.

b. Two-Ply Bituminous Built-Up Base Flashing: Provide one ply of GA ply felt and one ply of flashing felt, FF, in accordance with the manufacturer's printed installation instructions and graphic details.

c. Modified Bitumen Base Flashing: Provide SBS or APP modified bitumen base flashing standard with the roofing system manufacturer in accordance with printed installation instructions and graphic details.

3.3.6.2 Strip Flashing

Set flanges of sheet metal work which are to be incorporated into roofing system into a uniform coating of asphalt roof cement not less than 2 mm (1/16 inch) thick applied over the ply felts. Strip-in with either two layers of ply felt or one layer of modified bitumen sheet cemented to the tops of the flanges, roofing membrane, and to each other. Use coatings of asphalt roof cement not less than 2 mm (1/16 inch) thick for ply felt. Use hot steep asphalt for modified bitumen sheets. Extend felts 75 and 150 mm (3 and 6 inches) respectively, beyond flange edges and onto roof membrane. Coat finished felt strip flashing with asphalt roof cement not less than 3 mm (1/8 inch) thick.

3.3.6.3 Flashing at Roof Drain

Roof drains are specified under Section 15400, "Plumbing Systems (General Purpose)." Flashings for roof drains are specified under Section 07600, "Flashing and Sheet Metal." Extend roofing plies to edge of drain bowl opening at roof drain deck flange. Neatly fit and press primed roof drain flashing into heavy coat of asphalt roof cement applied to top of roofing plies. Strip in and completely cover flashing with two layers of modified bitumen sheet, extending the sheets 100 and 150 mm (4 and 6 inches), respectively, on the roofing beyond the edge of flashing. Cement the two layers to the metal flashing and to each other with hot asphalt. Securely clamp membrane, metal flashing, and strip flashing in the flashing clamping ring. Secure clamps so that strip flashing and metal flashing are free from wrinkles and folds. Trim membrane, flashing, and stripping flush with inside of clamping ring.

3.3.7 Valleys and Ridges

Felt plies shall continue across valleys and ridges and terminate approximately 300 mm (12 inches) from the valley or ridge. Exposed lap shall terminate on a line approximately 300 mm (12 inches) from, and parallel to the valley or ridge. Two plies of roofing felt 225 mm (9 inch) wide bottom ply, and 300 mm (12 inch) wide top ply, shall be successively mopped-in over each felt line of termination.

3.3.8 Protection of Applied Roofing

3.3.8.1 Protection Against Moisture Absorption

When precipitation is imminent and at the end of each day's work, protect applied felts as follows:

a. when roof insulation is included as a substrate in paragraph entitled "Roofing System", apply water cut-offs consisting of two strips of ply felt applied to exposed edges of insulation. Where exposed edges of insulation cross flutes of steel deck, place pieces of insulation or wood, fit flush with the deck, into the flutes, and embed in roofing cement at edge of insulation. Extend the first strip 150 mm (6 inches) on roof deck, up vertical edge of insulation, and 150 mm (6 inches) on top of applied felts. The second strip shall lap first strip by 75 mm (3 inches) on each side. Apply the strips with asphalt roof cement to roof deck, applied felts, and to each other. Keep roof cement from edges of insulation. Before resuming application of insulation and roofing system, remove water cut-offs to expose edges of insulation so that new insulation butts properly against insulation already in place.

b. Temporary Flashing: Provide temporary flashing at drains, curbs, walls, and other penetrations and terminations of roofing felts until roofing membrane is complete, and permanent flashings are applied. Use one ply of felt applied in trowel coat of asphalt roof cement over primed surface. Finish with a surface coat of asphalt roof cement. Remove temporary flashing before applying permanent flashing.

3.3.8.2 Glaze Coat

Glaze coating shall be used to waterproof completed sections when more than one day is required to finish the roofing. If there is a probability of rain falling on the felts before the flood coat and aggregate can be applied, a light glaze coat of bitumen 0.49 kg to 0.73 kg per square meter (10 to 15 pounds per square), shall be applied over the exposed felts. The surfacing operation shall be completed within 48 hours after application of the glaze coat. Where glaze coat is used, surface treatment shall be completed as soon as weather conditions permit.

3.3.8.3 Temporary Walkways, Runways, and Platforms

Storing, walking, wheeling, and trucking directly on applied roofing materials is prohibited. Provide temporary walkways, runways, and platforms of smooth clean boards or planks, as necessary, to avoid damage to applied roofing materials, and to distribute weight to conform to indicated live load limits of roof construction. Use rubber-tired equipment for roofing work.

3.3.9 Stack Venting

Distribute moisture release vents uniformly at a minimum rate of one vent for each 100 square meters (1000 square feet) of roof area. Before applying roof surfacing, cut a hole, of diameter to suit base opening size of vent, through the roofing membrane and insulation or ventilating base sheet. Replace cut out or crumbled insulation in hole. Set vent flange over hole on top of roofing membrane in a 3 mm (1/8 inch) thick bed of asphalt roof cement or special adhesive or cement recommended by vent manufacturer. Strip-in vent flanges with two layers of ply felt in accordance with vent manufacturer's printed instructions and details.

3.3.10 Aggregate Surfacing

Provide aggregate surfacing materials after felt flashings, roof drain flashing, work of other trades, tests, repairs, and corrective action have been completed and approved. Embed aggregate surfacing in a flood coat of hot asphalt poured from a dipper or approved spreading device at a rate of 60 pounds per 100 square feet. Aggregate surfacing materials shall be spread on the hot bitumen at a rate of 19.5 kg per square meter (400 pounds per square) for gravel or 14.6 kg per square meter (300 pounds per square) for other approved surfacing aggregate. To aid in proper embedment, aggregate may be lightly rolled, provided that there is no damage to roofing membrane. Remove loose aggregate from roof.

3.3.11 Walkways

3.3.11.1 Rubber and Asphalt Composition Pads

Provide reprocessed rubber pads or granular surfaced treads for access to mechanical equipment and for traffic areas, as indicated. Where walkways are used, make provision for continuous roof drainage. Install walk pads or treads over completed aggregate surfaced roofing membrane, after removing loose aggregate, in a hot-mopping of Type III asphalt applied at rate of 12.5 kg per 10 square meters (25 pounds per 100 square feet). Leave a 150 mm (6 inch) wide space between walk pads or treads for drainage.

3.3.12 Metal Grid, Concrete Slab, Asphalt Plank Walkways

Walkways shall be mineral-surfaced asphalt planks with back-mopped and embedded in the flood coat prior to aggregate surfacing, concrete slab, or metal grid and shall be located as indicated.

3.4 FIELD QUALITY CONTROL

Perform field tests in the presence of the Contracting Officer. Notify the Contracting Officer one day before performing tests.

3.4.1 Test for Surface Dryness

Before starting work on area to be roofed, perform test for surface dryness in accordance with the following:

a. Foaming: When poured on the surface to receive felts, 1/2 liter (one pint) of asphalt heated in the range of 176 to 204 degrees C (350 to 400 degrees F), shall not foam upon contact.

b. Strippability: After asphalt used in foaming test application has cooled to ambient temperature, test for adherence. If a portion of sample is readily stripped clean from surface, do not consider surface to be dry and do not start application. If rain occurs during application, stop work and do not resume until surface has been tested by method above and found dry.

3.4.2 Samples of Built-Up Roofing

After application of specified roofing felts and prior to applying surfacing, when there is reason to believe that deficiencies exist in the roofing membrane, take field samples of built-up roofing in the presence of Contracting Officer. Take and test samples in accordance with ASTM D 3617 and at locations selected by the Contracting Officer immediately prior to cutting. Cut 100 by 1000 mm (4 inch by 40 inch) samples across felt laps in a manner to expose the specified number of piles. The 100 mm (4 inch) edge shall coincide with an edge lap of felt and shall not be positioned over an end lap. The 100 by 100 mm (4 by 40 inch) samples shall be used for visual inspection. The Contracting Officer will inspect the samples for the specified number of plies, bond between plies, skips in interply moppings, uniform asphalt mopping, presence of excessive voids or large voids in the ply construction, presence of harmful foreign materials, visible presence of moisture in the sandwich and wet insulation. 300 by 300 mm (12 by 12 inch) cut samples shall be used to calculate bitumen quantities in accordance with ASTM D 3617 when necessary and directed by the Contracting Officer. Do not proceed with surfacing until all deficiencies disclosed as a result of "cut tests" have been corrected and approved.

3.4.2.1 Number of Cut Tests

Take not less than 2 samples from each 1000 square meters (100 squares) of roofed area, and take at least one sample from each day's application, regardless of quantity applied. If samples show any deficiency, no matter how slight, take additional samples to determine extent of deficiency.

3.4.2.2 Sample Cutting Device

Provide a rectangular, 100 by 1000 mm (4 by 40 inch) template and 300 by 300 mm (12 by 12 inch) template, of a type that will permit accurate cutting of samples with standard roofing knives. Keep cutting edge of knife clean by washing in solvent after each cut.

3.4.2.3 Patching Cut-Out Area

Immediately after inspection, replace cut-out sample. When sample is needed for laboratory analysis or other circumstance makes it unavailable, substitute a new section of equivalent size and structure. For non-nailable decks, replace sample in hot asphalt. For nailable decks, insert one ply of ply felt into opening from which sample was taken and sprinkle nail to hold in place; coat felt heavily with asphalt roof cement and press cutout sample firmly into asphalt roof cement. Cover area over replaced samples with four plies of ply felt, hot mopped in place with first ply overlapping cutout area 75 mm (3 inches) on all sides and each succeeding ply overlapping previous 75 mm (3 inches) on all sides.

3.4.3 Correction of Deficiencies

Where interply moppings are too light, apply additional 2 plies of felt in full moppings of asphalt. Apply with 100 mm (4 inch) side and end laps. Where free water, skips, excessive voids, dry laps, disbonding or any form of delamination are discovered between the plies, remove and rebuild affected area. Correction of inadequate number of plies, improper lap widths, or nonuniform or excessive asphalt mopping shall be as directed by the Contracting Officer. Where insulation is found to be wet, remove insulation and provide new built-up roofing and insulation.

3.5 INSPECTION

The Contractor shall establish and maintain an inspection procedure to assure compliance of the installed roofing with the contract requirements. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Inspection shall include, but not be limited to, the following:

a. Environmental conditions; number and skill level of roofing workers; start and end time of various tasks; condition of substrate.

b. Verification of compliance of materials before, during, and after installation.

c. Inspection of condition of equipment and accuracy of thermometers and metering devices.

d. Inspection of flashings, cants and curbs.

e. Inspection of membrane placement, including edge envelopes, widths of starter sheets, laps, proper use of squeegee, and mechanical fastening.

f. Inspection of application of bitumen, aggregate, and walkways.

g. Inspection of embedment of aggregate for required weight and coverage.

h. Cutout sampling and analysis as directed.

3.6 INFORMATION CARD

For each roof, provide a typewritten card, laminated in plastic for interior display, or a photoengraved 0.8 mm (0.032 inch) thick aluminum card for exterior display. Card shall be 220 by 280 mm (8 1/2 by 11 inches) minimum and contain the information listed on Form 1 located at end of this section. Install card near point of access to roof or where indicated.

FORM 1 - ROOFING SYSTEM DESCRIPTION

1. Location ____________________________ 2. Bldg. Name __________________

3. Bldg. No. _____ 4. Roof Area (SF) _____ 5. Contract No. _________

6. New Construction: ( ) Yes ( ) No 7. Deck Slope: _______________

8. Type of Deck:

( ) Metal
( ) Cast-In-Place Concrete
( ) Precast/Prestressed Concrete
( ) Wood Plank or Plywood
( ) Other ______________________

9. Type of Insulation Board:

( ) Polyisocyanurate/Composite
( ) Polystyrene/Composite
( ) Perlite
( ) Other ____________________
( ) Polyisocyanurate Foam
( ) Polystyrene
( ) Mineral Fiber

10. Insulation Manufacturer: ____

11. Insulation Thickness: ________________________

12. Vapor Treatment: Total coverage ( ) Yes ( ) No

( ) No Vapor Retarder
( ) One Way Roof Vents
( ) Other _______________________
( ) Bituminous Vapor Retarder
( ) Laminated Kraft Paper

13. Vapor Treatment Manufacturer(s): ___________________________________

14. Roofing Type:

( ) Built-Up (Asphalt)
( ) Metal
( ) Shingles
( ) Other ____________
( ) PIB
( ) Modified Bitumen
( ) CSPE
( ) TPA
( ) EPDM
( ) PVC

15. Roofing Manufacturer: ____

16. Roofing Installer/Warrantor: _______________________________________

17. Roofing Application Method:

( ) Bitumen
( ) Mechanically Fastened
( ) Mechanically Fastened/Fully Adhered
( ) Fully Adhered
( ) Torched
( ) Loose-Laid
( ) Ballasted
( ) Other ___________

18. Warranty Period: From _________ To ________

19. Warranty Serial Number: ____

20. Date Roofing Completed: __________ 21. Inspector: _______________

22. Prime Contractor Name/Address: ______________________________________

Signature: __________________________________ Date: _________________

INSTRUCTIONS FOR FORM 1 (Do Not Post)

1. Location: Name of activity as shown on contract.
2. Bldg. Name: As shown on contract or as provided by Contracting Officer.
3. Bldg. Number: As provided by Contracting Officer.
4. Roof Area: Area in square feet of roof for which deck insulation, membrane, etc. are the same. A separate form is required if any part of roof system is different over other areas of the roof.
5. Contract Number: As shown on the contract.
7. Show deck slope.
8. Deck: Check appropriate block.
9. Type of Insulation Board: Check appropriate block.
11. Show minimum thickness of installed insulation.
12. Vapor Treatment: Check appropriate blocks.
13. Show vapor treatment system manufacturer's name.
14. Roofing Type: Check appropriate block.
15. Show roofing manufacturer's name.
16. Roofing Installer's or Contractor's name.
17. Roofing Application Method: Check appropriate block.
18. Warranty Period: Insert start and end dates.
19. Warranty Serial Number: Insert serial number.
20. Show date roofing was accepted by the Contracting Officer. Warranty period begins on this date.
21. Show Government Inspector's name.
22. Prime Contractor Name/Address/Signature: Must be signed and dated by QC Representative or an official of Contracting firm.

FORM 1 - ROOFING SYSTEM DESCRIPTION

1. Location ___________________________ 2. Bldg. Name _________________

3. Bldg. No. _____ 4. Roof Area (SF) _____ 5. Contract No. _________

6. New Construction: ( ) Yes ( ) No 7. Deck Slope: _______________

8. Type of Deck:

( ) Metal
( ) Cast-In-Place Concrete
( ) Precast/Prestressed Concrete
( ) Wood Plank or Plywood
( ) Other _______________________

9. Type of Insulation Board:

( ) Polyisocyanurate/Composite
( ) Polystyrene/Composite
( ) Perlite
( ) Other ____________________
( ) Polyisocyanurate Foam
( ) Polystyrene
( ) Mineral Fiber

10. Insulation Manufacturer: ____

11. Insulation Thickness: ________________________

12. Vapor Treatment: Total coverage ( ) Yes ( ) No

( ) No Vapor Retarder
( ) One Way Roof Vents
( ) Other _______________________
( ) Bituminous Vapor Retarder
( ) Laminated Kraft Paper

13. Vapor Treatment Manufacturer(s): ____________________________________

14. Roofing Type:

( ) Built-Up (Asphalt)
( ) Metal
( ) Shingles
( ) Other ____________
( ) PIB
( ) Modified Bitumen
( ) CSPE
( ) TPA
( ) EPDM
( ) PVC

15. Roofing Manufacturer: ____

16. Roofing Installer/Warrantor: ____

17. Roofing Application Method:

( ) Bitumen
( ) Mechanically Fastened
( ) Mechanically Fastened/Fully Adhered
( ) Fully Adhered
( ) Torched
( ) Loose-Laid
( ) Ballasted
( ) Other ___________

18. Warranty Period: From _________ To ________

19. Warranty Serial Number: ____

20. Date Roofing Completed: __________ 21. Inspector: _______________

22. Prime Contractor Name/Address: _____________________________________

Signature: __________________________________ Date: _________________

INSTRUCTIONS FOR FORM 1 (Do Not Post)

1. Location: Name of activity as shown on contract.
2. Bldg. Name: As shown on contract or as provided by Contracting Officer.
3. Bldg. Number: As provided by Contracting Officer.
4. Roof Area: Area in square feet of roof for which deck insulation, membrane, etc. are the same. A separate form is required if any part of roof system is different over other areas of the roof.
5. Contract Number: As shown on the contract.
7. Show deck slope.
8. Deck: Check appropriate block.
9. Type of Insulation Board: Check appropriate block.
11. Show minimum thickness of installed insulation.
12. Vapor Treatment: Check appropriate blocks.
13. Show vapor treatment system manufacturer's name.
14. Roofing Type: Check appropriate block.
15. Show roofing manufacturer's name.
16. Roofing Installer's or Contractor's name.
17. Roofing Application Method: Check appropriate block.
18. Warranty Period: Insert start and end dates.
19. Warranty Serial Number: Insert serial number.
20. Show date roofing was accepted by the Contracting Officer. Warranty period begins on this date.
21. Show Government Inspector's name.
22. Prime Contractor Name/Address/Signature: Must be signed and dated by QC Representative or an official of Contracting firm.

SECTION 07530

ELASTOMERIC ROOFING (EPDM)

TABLE OF CONTENTS

PART 1 GENERAL

This guide specification covers the requirements for fully adhered, mechanically attached, or loose-laid and ballasted ethylene propylene-diene terpolymer (EPDM) elastomeric sheet roofing. EPDM roofing system shall not be used in areas exposed to asphalt, coal-tar, grease, oil, solvents, vegetable or mineral oil and animal fat, and steam venting. An oil resistant coating may be used where the roofing will be exposed to petroleum, grease, oil and solvents. Roofs must be constructed to drain with a minimum slope ratio, rise to horizontal, of 1 to 48 (1/4 in. per ft). The loose-laid system can be applied on slopes up to 1 to 6 (2 in. per ft.).

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 29/C 29M	(1997) Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM D 448	(1986; R 1993) Sizes of Aggregate for Road and Bridge Construction
ASTM D 4637	(1996) EPDM Sheet Used in Single-Ply Roof Membrane
ASTM E 108	(1996) Fire Tests of Roof Coverings

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P9513	(1996) Loss Prevention Data for Roofing Contractors

SINGLE PLY ROOFING INSTITUTE (SPRI)

SPRI RP-4	(1997) Wind Design Standard for Ballasted Single-Ply Roofing Systems

UNDERWRITERS LABORATORIES (UL)

UL 580	(1994; Rev thru Feb 1998) Tests for Uplift Resistance of Roof Assemblies
UL 790	(1997; Rev thru Jul 1998) Tests for Fire Resistance of Roof Covering Materials
UL 1256	(1998) Fire Test of Roof Deck Constructions

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Roofing System; G.

Drawings showing size of sheets, position of sheets and splices, flashing details, fastening patterns where applicable for insulation and membrane sheets, and expansion joint details.

Detail showing construction of water cutoffs to be used at membrane terminations at the end of a day's work to seal the roofing system from water intrusion.

SD-03 Product Data

Installation; G.

Manufacturer's instructions for preparing and installing the membrane, flashings, seams, insulation, nailers and other accessories.

Protection of Finished Roofing; G.

Protection plan showing areas to be protected, type of material used; a plan to protect the membrane from damage until completion of work by other trades, and a description of the method of repairing the roofing.

Inspection; G.

The inspection procedure for substrate suitability including decks, curbs and insulation installation, prior to start of the work. Inspection procedures during and after placement of the membrane, and after completion of work by other trades.

SD-07 Certificates

Materials; G.

Certificates of compliance attesting that the roofing system and materials meet specification requirements. The certificates shall list the components required for the specified fire and wind uplift resistance ratings.

1.3 GENERAL REQUIREMENTS

Elastomeric membrane roofing shall be fully adhered, mechanically fastened or loose-laid and ballasted to the roof surfaces indicated. Roofing membrane sheet widths shall be consistent with membrane attachment methods and wind uplift requirements, and shall be as large as practical to minimize joints. Membrane shall be free of defects and foreign material. Flashing work shall be coordinated to permit continuous roof-surfacing operations. Applied insulation shall be weatherproofed by the membrane on the same day.

1.3.1 Delivery and Storage

Materials shall be delivered to the jobsite in the manufacturer's original, unopened packages, clearly marked with the manufacturer's name, brand name, and description of contents. Materials other than ballast shall be stored in clean, dry areas. Storage temperatures shall be as specified by the manufacturer. Materials other than ballast stored on the roof shall not exceed one day's supply and shall be distributed so as not to exceed the roof live load capacity. Ballast shall be stored uncovered, shall not be in contact with sod or earth, and shall not be stored on the roof.

1.3.2 Fire Resistance

The completed roof system shall have a ASTM E 108 (same test as UL 790 and FM P9513, Appendix A) Class A classification, and meet fire test requirements of UL 1256 or FM P9513, Appendix B for roof deck construction. Compliance of each component of the roofing system shall be evidenced by label or by written certification from the manufacturer.

1.3.3 Wind Uplift Requirements

Fully adhered and mechanically attached roofing systems shall have a 90 UL 580 Class Rating or FM P9513, Appendix C Windstorm Classification. Ratings from other independent laboratories may be substituted provided that the tests, requirements and ratings are documented to be equivalent, to the satisfaction of the Contracting Officer. Wind resistance of loose-laid ballasted system shall be in accordance with SPRI RP-4.

1.3.4 Warranty

Manufacturer's standard warranty for e roofing system shall be provided for not less than 10 years from acceptance of the work. Warranty shall state that manufacturer shall repair or replace defective materials if the roofing system leaks or allows the insulation beneath the membrane to become wet during the period of the warranty.

PART 2 PRODUCTS

2.1 ADHESIVES

Adhesives, splicing cements, solvents, and sealants shall be as recommended by the membrane manufacturer.

2.2 BALLAST

Ballast should be concrete pavers, smooth round stone, screened gravel, or crushed rock, with gradations conforming to ASTM D 448, sizes 2 and 4, with the additional requirement that particles passing the 9.5 mm (3/8 inch) sieve shall not exceed 2 percent. A protective mat shall be required if the only available ballast is crushed rock. Crushed rock shall be used over a protective layer of extruded polystyrene foam insulation at least 9 mm (3/8 inch) thick and a filter fabric at least 900 gm/ sq. meter (3 oz/sq. ft.), placed between the ballast and the membrane. Ballast laid directly on the membrane shall be pavers or rounded-edge aggregate, and must not break during freeze-thaw cycles. Unit weight of stone ballast shall be no less than 960 kg/cu. m (60 lbs/cu. ft.) when determined in accordance with ASTM C 29/C 29M. Concrete pavers shall be precast air-entrained concrete, minimum 38 mm (1-1/2 inches) thick, having 21 MPa (3000 psi) minimum compressive strength. Pavers other than walkways shall include drainage channels on their lower surfaces, or shall rest on membrane pads extending at least 25 mm (1 inch) beyond the paver edges.

2.3 FASTENERS

Fasteners for sheet-metal flashing shall be corrosion resistant steel annular-type nails or screws. Fasteners for anchoring the roofing membrane shall be as approved by the membrane manufacturer and identical to those used to obtain the wind uplift rating.

2.4 FLASHING

Flashing shall be of ultra-violet resistant materials as recommended by the membrane manufacturer. Prefabricated shaped flashings shall be used where possible. Sheared edges of metal flashings that contact the membrane shall be turned into a tight hem.

2.5 MEMBRANE

Membrane shall conform to ASTM D 4637, Type I EPDM, Grade 1; Class U, 1.52 mm (0.060 inch) minimum thickness or Class SR, 1.00 mm (0.039 inch) minimum thickness. Class SR (reinforced) membrane shall be specified for mechanically attached systems because Class U is unreinforced.

2.6 PREFABRICATED ACCESSORIES

Pipe seals and expansion joints covers shall be types and sizes recommended by the membrane manufacturer.

2.7 WALKWAYS

Walkways shall be concrete pavers, 200 x 400 mm (8 x 16 inch.) or size as indicated, 38 mm (1-1/2 inch) minimum thickness, and made from 21 MPa (3000 psi) air entrained concrete per Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Pavers for walkways less than 1.2 m (4 feet) wide may rest directly on the membrane unless underlayment is recommended by the manufacturer. Where drainage would be blocked by walkway pavers, spaces shall be provided between or below pavers to facilitate drainage. If spaces are provided between pavers, they shall be at least 25 mm (1 in) wide and no more than 0.6 m (24 in.) apart. Space below pavers shall be provided by using pavers with drainage channels or by elevating flat bottom pavers on pedestals. Alternative walkway material may be used if recommended by the manufacturer and approved by the Contracting Officer.

PART 3 EXECUTION

3.1 ENVIRONMENTAL CONDITIONS

Membrane shall not be installed in high wind, inclement weather or when there is visible ice, frost or moisture on the deck, insulation or membrane.

Membrane shall not be installed when air temperature is below minimum specified by the membrane manufacturer.

3.2 PREPARATION

The substrate of any bay or section of the building shall be complete and suitable for insulation and membrane installation before roofing is begun. Insulation over which elastomeric roofing is installed shall conform to Section 07220 ROOF INSULATION. Surfaces against which membrane is applied shall be smooth, clean, and free from dirt, water, dew, oil, grease, sharp edges and construction debris; all joints over 6 mm (1/4 inch) wide shall be sealed; joints over 13 mm (1/2 inch) between insulation boards shall be filled with the same insulation. Wood nailers shall comply with Section 06100 ROUGH CARPENTRY.

3.3 INSTALLATION

Installation shall comply with the manufacturer's approved instructions, except as otherwise specified.

3.3.1 Flashing

Edges of membrane, projections through the roof and changes in roof planes shall be flashed. Flashing material shall be extended and sealed a minimum of 75 mm (3 inches) on each side of the fasteners which attach the membrane to nailers. The installed flashing shall be fastened at the top of the flashing a maximum of 300 mm (12 inches) on center under metal counter-flashing or cap.

3.3.2 Expansion Joints

Expansion joints shall be covered using prefabricated covers or elastomeric flashing in accordance with the manufacturer's recommendations.

3.3.3 Membrane Installation

Membrane shall be applied in accordance with the manufacturer's instructions and the following requirements. Adjoining sheets comprising the membrane shall be adhered one to another using a butyl-based contact adhesive. Minimum width of the laps shall be 75 mm (3 in). A primer shall be used before applying the contact adhesive if required by the membrane manufacturer. In applying the contact adhesive, the minimum thickness of the wet film shall be in accordance with the membrane manufacturer's recommendations. If manufacturer's recommendations are not available, the minimum thickness shall be 0.6 mm (0.025 inch). A wet film thickness gage shall be used to determine wet film thickness. Direction of lap shall be such that water flows over lap. Membrane joints shall be free of wrinkles or fishmouths. Before application of the contact adhesive, the rubber surfaces to be mated shall be well cleaned. Joints shall be inspected over entire length after completion and defective areas shall be resealed and patched. Damaged areas of membrane shall be removed and replaced with new materials, lapping underlying membrane by at least 75 mm (3 inches) on all sides.

3.3.4 Cutoffs

Cutoffs shall be installed if work day is ended or interrupted by bad weather before roof section is complete. The insulation line shall be straightened using loose-laid cut insulation and the membrane shall be sealed to the roof deck. Flutes in metal decking shall be sealed off along the cutoff edge. Membrane shall be pulled free or cut to expose the insulation when resuming work, and cut insulation sheets used for fill-in shall be removed as necessary to maintain the staggered pattern.

3.3.5 Installation of Walkways

Concrete paver walkways shall be installed on a loose-laid pad of the membrane material extending at least 25 mm (1 inch) beyond the walkway material, and as specified by the manufacturer. Stone ballast shall not be placed below or above walkways.

3.4 BALLAST

When ballast is required, ballast shall be applied as the membrane is installed to prevent wind uplift, except that seams and terminations shall be left uncovered until completion and inspection. Membrane shall be protected from mechanical damage from wheeled equipment during ballast application. Minimum ballast weight shall not be less than required by required by RP-4, or indicated. Ballast shall be spread as indicated or as recommended by the manufacturer for the anticipated wind conditions. Unless otherwise specified, size 2 ballast shall be spread at the rate of 620 to 720 Pa (13 to 15 psf) and size 4 ballast shall be applied at the rate of 480 to 575 Pa (10 to 12 psf.)

3.5 PROTECTION OF FINISHED ROOFING

The roofing membrane shall be protected from damage by other trades. After completion of work by other trades, the protection shall be removed and the roof shall be inspected. Any damage shall be repaired in accordance with the recommendations of the roofing manufacturer.

3.6 INSPECTION

The Contractor shall establish and maintain an inspection procedure to assure compliance of the installed elastomeric roofing with the contract requirements. The procedure shall include a checklist of points to be observed. Any work found not to be in compliance with the contract shall be promptly removed and replaced or corrected in an approved manner. Quality control shall include, but not be limited to, the following:

a. Observation of environmental conditions; number and skill level of roofing workers; start and end time of various tasks; condition of substrate.

b. Verification of compliance of materials before, during and after installation.

c. Inspection of insulation, nailers, flashings, penetrations and work requiring coordination with roofing.

d. Inspection of membrane placement, splicing, and attachment.

e. Inspection of placement of ballast and walkways.

f. Verification of ballast weight.

SECTION 07570

SPRAYED POLYURETHANE FOAM (SPF) ROOFING

TABLE OF CONTENTS

PART 1 GENERAL

This guide specification covers the requirements for urethane foam roofing systems with a fluid applied elastomeric protection coating.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 1029 (1996) Spray-Applied Rigid Cellular Polyurethane Thermal Insulation

ASTM D 412 (1998a) Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension

ASTM D 579 (1997) Greige Woven Glass Fabrics

ASTM D 2240 (2000) Rubber Property - Durometer Hardness

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P7825a (1998) Approval Guide Fire Protection

FM P7825c (1998) Approval Guide Building Materials

UNDERWRITERS LABORATORIES (UL)

UL Bld Mat Dir (1999) Building Materials Directory

UL 790 (1997; Rev thru Jul 1998) Tests for Fire Resistance of Roof Covering Materials

UL 1256 (1998) Fire Test of Roof Deck Constructions

1.2 SYSTEM DESCRIPTION

The roofing system shall consist of a layer of sprayed in-place urethane foam roof insulation covered with an elastomeric protective coating and surfaced with ceramic granules. Granules shall be used only where appearance of roof is important and for walkways.

1.3 GENERAL REQUIREMENTS

Roof shall be sloped to drain, with minimum slope after deflection of 21 mm per meter (1/4 inch per foot). Roof slope will be obtained by sloping the structural deck and not by varying the thickness of the sprayed insulation. The roofing system will not be applied when deck is of lightweight concrete, over cold storage areas or when other than light foot traffic is anticipated on the roof. Broomed finish should be specified for concrete decks.

1.3.1 Coordination

Roofing operations shall be coordinated with work of other trades to ensure that components are installed as required to permit continuous self-flashing of the sprayed polyurethane foam and protective coating system. The installed roofing system shall be protected from damage. Damaged areas shall be repaired.

1.3.2 Preparation

Surfaces to receive elastomeric roofing shall be dry and free of loose coatings, surface curing agents, dust, wax or other contaminants. Workmen shall wear clean, soft-soled, sneaker-type shoes.

1.3.3 Protection of Adjacent Surfaces

Surfaces near roofing operations shall be protected from spray of roofing materials.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Installation; G.

Manufacturer's instructions for installation of the roofing system.

SD-04 Samples

Materials; G.

Samples of the following materials:

Urethane foam 4.0 L (1 gallon) each component

Protective Coating 1.0 L (1 quart) each component

Foam Finish Texture 2 samples, each 600 mm (2 feet) square

Ceramic Granules Sample of each color

SD-07 Certificates

Urethane Foam; G. Protective Coating Application; G. Protective Coating; G.

Certificates of compliance attesting that the foam and protective coating materials meet the specified requirements, and that the proposed roofing system has been tested and meets the requirements of Class A system in accordance with UL 790. In lieu of certificates, labels on the containers of foam and protective coating or listing by Underwriters Laboratories will be acceptable as evidence that the elastomeric roofing materials conform to these requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

Materials shall be delivered to the jobsite in their original unopened packages, clearly marked with the manufacturer's name, brand name, and description of contents. Materials shall be stored in clean, dry areas, away from excessive heat, sparks, and open flame. Storage area shall be ventilated to prevent build-up of flammable gases. Not more than half the shelf life shall have expired when materials are applied.

1.6 FIRE AND WIND UPLIFT

For roofing over a metal deck, the complete roof system shall have a UL 1256, or UL 790, Class A or B classification, be listed as "fire classified" in UL Bld Mat Dir, and bear the UL label or be listed as a Class I Roof Deck in FM P7825a. Roofing system over steel deck shall be rated Class I-90, except for low roofs in protected areas (I-60) and areas where higher ratings are required, in accordance with FM P7825c. Ratings from other independent laboratories may be substituted provided that the tests, requirements and ratings are documented to be equivalent, to the satisfaction of the Contracting Officer.

1.7 WARRANTY

Manufacturer's standard warranty for the roofing system shall be provided for not less than 10 years from acceptance of the work. Warranty shall state that manufacturer shall repair or replace defective materials if the roofing system leaks or allows the insulation beneath the membrane to become wet during the period of the warranty.

PART 2 PRODUCTS

2.1 URETHANE FOAM

Urethane foam shall be standard product of the manufacturer, and containers shall be factory marked with the manufacturer's name or trademark. The cured foam shall meet requirements of ASTM C 1029 Type III or IV.

2.2 PROTECTIVE COATING

Coating shall consist of three coats of one-component silicone. Top coat shall be white or light gray color. Coating shall bond to urethane foam and shall have the following minimum properties:

* MINIMUM PROPERTIES

MATERIAL	No. of Components	Tensile Mpa (Psi)	Elongation Percent	Hardness Type A
Silicone	one	2.76 (400)	150	45
Silicone	two	3.45 (500)	100	45
Urethane-aromatic	two	6.89 (1000)	400	60
Urethane-aliphatic (top-coat only)	two	11.03 (1600)	150	80
Urethane-aromatic (base and intermediate coating only)	one	2.76 (400)	500	50
Urethane-aromatic (top coat only)	one	13.79 (2000)	450	80
Acrylic	one	1.03 (150)	265	45

* Minimum properties specified above shall be determined as follows: Tensile strength and elongation: ASTM D 412 Die C, at 24 degrees C (75 degrees F.). Hardness: ASTM D 2240, Type A.

2.3 CERAMIC GRANULES

Ceramic granules shall be No. 11 screen size, color as selected, dry, and free from dust.

2.4 SEALANTS

Sealants shall be as recommended by the coating manufacturer.

2.5 FABRIC

Fabric shall be ASTM D 579, style 1620.

PART 3 EXECUTION

3.1 INSTALLATION

Installation shall comply with the manufacturer's instructions including minimum thickness, except as otherwise specified. Concrete surfaces shall be cured a minimum of 30 days prior to application of foam.

3.1.1 Urethane Foam

Foam shall be sprayed on the prepared surface in 13 to 25 mm (1/2 to 1 inch) lifts. Time between lifts shall not exceed 4 hours. The finished surface shall be "verge of popcorn" or smoother. An approved sample shall be used as the standard for determining the acceptability of the foam finish. Foam shall be extended up walls and around roof projections to form cants and flashings that terminate at least 50 mm (2 inches) above finished roof surface. Cured foam shall be free from water, dust, oils, and other materials which would impair adhesion of the protective coating. No foam shall be allowed to stand overnight without a base protective coating. Foam shall cure at least 1 hour, unless otherwise recommended by the manufacturer before application of protective coating. Any nonadherence of foam to substrate shall be corrected and pinholes shall be finished flush with an approved sealant before finish coating is applied. Overspraying to correct an unacceptable surface condition will not be permitted. The finished roof surface shall not vary more than 13 mm (1/2 inch) when measured with a 3 m (10 foot) straight edge parallel and perpendicular to the roof slope.

3.1.2 Protective Coating Application

Coating shall consist of base, intermediate, and top coats. Coatings shall be spray applied, unless otherwise approved. Coating shall completely cover the foam and extend up vertical surfaces 50 mm (2 inches) beyond foam. The color of each coat shall contrast with the previous coat. Base or intermediate coats exposed for more than 24 hours shall be cleaned, thoroughly rinsed and dried, then given another covering of base coating before applying the top coat. No traffic will be allowed on finished areas for 24 hours after installation.

3.1.2.1 Base and Intermediate Coats

Base and intermediate coats shall each have dry film thicknesses of not less than 0.25 mm (10 mils) for silicones, or 0.375 mm (15 mils) for urethane or acrylic coating. Coating shall be dry and clean before application of top coat.

3.1.2.2 Top Coat

Top coat shall be white or light gray color. Top coat shall be applied at right angles to the directions of the base coat application and shall fully cover the base coat. Top coat dry film thickness shall be not less than 0.25 mm (10 mils).

3.1.2.3 Penetrations

An additional 0.38 mm (15 mils) of coating shall be applied for 900 mm (3 feet) around roof access locations and 600 mm (2 feet) around all other roof penetrations. Thickness of coating at drain sumps shall be double that on the rest of the roof.

3.1.3 Granules

Granules shall be applied within 5 minutes of top coat application, using pressure equipment, at a rate of 1.95 kg (40 pounds) per 9 square meters (100 square feet). Granules shall be applied in a minimum of two passes made at right angles to each other. Finished granule system shall be uniform over entire surface with no apparent void areas.

3.1.4 Service Walks

Service walks shall be applied after the protective coating system has been completed and cured. Walks shall consist of an extra coating system application or nonwoven fiberglass fabric as indicated. Fabric shall be smoothed with brush or roller into an additional layer of protective coating; then a complete coating system shall cover the fabric and a minimum of 150 mm (6 inches) beyond each edge of the fabric. Top coat shall be covered with roofing granules as specified.

3.2 EQUIPMENT CALIBRATION

Spray equipment for two-component systems shall be calibrated each day at start of operations, after each restart if spraying operations have been terminated for more than 1 hour, whenever there is a change in fan pattern or pressure, whenever slow curing areas are noticed, whenever a change is made in hose length or working height and after changeover between materials. Calibration shall consist of demonstrating that the equipment is adjusted to deliver components in the proper proportions. Calibration tests shall be done on cardboard or plywood on the roof adjacent to the area to be sprayed.

SECTION 07600

FLASHING AND SHEET METAL

TABLE OF CONTENTS

PART 1 GENERAL

This specification includes the requirements for flashing and sheet metal work including gutters and downspouts, scuppers, splash pans, and sheet metal roofing. The specified sheet metal roofing is the type commonly used for on-site fabrication which does not include factory fabricated or preformed metal roofing.

Sheet metal color will be long lasting such as anodized aluminum, or baked enamel, and will not be painted in the field. This does not preclude the use of natural materials like copper or aluminum when that is the choice of the designer. Avoid use of copper where drainage from the copper will pass over exposed masonry, stonework, or other metal surfaces.

Galvanized steel will not be permitted as an option to other metals specified. Galvanized steel may be specified for temporary structures or where it may be satisfactory due to climatic conditions.

1.1 REFERENCES

The publications listed below form a partt of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 167 (1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A 308 (1999) Steel Sheet, Terne (Lead-Tin Alloy) Coated by the Hot Dip Process

ASTM A 526 (1990) Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality

ASTM A 653/A 653M (2001, Rev A) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip

	Process
ASTM B 32	(2000) Solder Metal
ASTM B 69	(2001, Rev A) Rolled Zinc
ASTM B 101	(2001) Lead-Coated Copper Sheet and Strip for Building Construction
ASTM B 209M	(2001) Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B 209	(2001) Aluminum and Aluminum Alloy Sheet and Plate
ASTM B 221M	(2000) Aluminum and Aluminum Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM B 221	(2000) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B 370	(1998) Copper Sheet and Strip for Building Construction
ASTM D 41	(1994) Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing
ASTM D 226	(1997, Rev A) Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D 1784	(1999, Rev A) Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D 4586	(2000) Asphalt Roof Cement, Asbestos-Free

AMERICAN WELDING SOCIETY (AWS)

AWS D1.2	(1997) Structural Welding Code Aluminum

SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA Arch. Manual (1993) Architectural Sheet Metal Manual

1.2 GENERAL REQUIREMENTS

Sheet metalwork shall be accomplished to form weathertight construction without waves, warps, buckles, fastening stresses or distortion, and shall allow for expansion and contraction. Cutting, fitting, drilling, and other operations in connection with sheet metal required to accommodate the work of other trades shall be performed by sheet metal mechanics. Application of bituminous strip flashing over various sheet metal items is covered in Section 07511 BUILT-UP AHPHALT ROOFING. Installation of sheet metal items used in conjunction with roofing shall be coordinated with roofing work to permit continuous roofing operations. Sheet metalwork pertaining to heating, ventilating, and air conditioning is specified in Section 15950.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Covering on flat, sloped, or curved surfaces; G

Gutters; G

Downspouts; G

Expansion joints; G

Gravel stops and fascias; G

Splash pans; G

Flashing for roof drains; G

Base flashing; G

Counterflashing; G

Flashing at roof penetrations; G

Reglets; G

Scuppers; G

Copings; G

Drip edge; G

Conductor heads; G

Open valley flashing; G

Eave flashing; G

Indicate thicknesses, dimensions, fastenings and anchoring methods, expansion joints, and other provisions necessary for thermal expansion and contraction. Scaled manufacturer's catalog data may be submitted for factory fabricated items.

SD-11 Closeout Submittals

Quality Control Plan;

Submit for sheet metal work in accordance with paragraph entitled "Field Quality Control."

1.4 DELIVERY, STORAGE, AND HANDLING

Package and protect materials during shipment. Uncrate and inspect materials for damage, dampness, and wet-storage stains upon delivery to the job site. Remove from the site and replace damaged materials that cannot be restored to like-new condition. Handle sheet metal items to avoid damage to surfaces, edges, and ends. Store materials in dry, weather-tight, ventilated areas until immediately before installation.

PART 2 PRODUCTS

2.1 MATERIALS

Lead and lead-coated metal shall not be used. Any metal listed by SMACNA Arch. Manual for a particular item may be used, unless otherwise specified or indicated. Materials shall conform to the requirements specified below and to the thicknesses and configurations established in SMACNA Arch. Manual. Different items need not be of the same metal, except that if copper is selected for any exposed item, all exposed items shall be copper. Fabricate sheet metal items of the materials specified below and to the gage, thickness, or weight shown in Table I at the end of this section. Where more than one material is listed for a particular item in Table I, each is acceptable and may be used except as follows:

2.1.1 Exposed Sheet Metal Items

Shall be of the same material. The following items shall be considered as exposed sheet metal: gutters, including hangers; downspouts; gravel stops and fascias; cap, valley, steeped, base, and eave flashings and related accessories.

2.1.2 Drainage

Do not use copper for an exposed item if drainage from that item will pass over exposed masonry, stonework or other metal surfaces. In addition to the metals listed in Table I, lead-coated copper may be used for such items.

2.1.3 Copper, Sheet and Strip

ASTM B 370, cold-rolled temper, H 00 (standard).

2.1.4 Lead-Coated Copper Sheet

ASTM B 101.

2.1.5 Lead Sheet

Minimum weight 19.6 kilograms per square meter (4 pounds per square foot).

2.1.6 Steel Sheet, Zinc-Coated (Galvanized)

ASTM A 653/A 653M.

2.1.6.1 Finish

Exposed exterior items of zinc-coated steel sheet shall have a baked-on, factory-applied color coating of polyvinylidene fluoride or other equivalent fluorocarbon coating applied after metal substrates have been cleaned and pretreated. Finish coating dry-film thickness shall be 0.020 to 0.033 mm (0.8 to 1.3 mils) and color shall be selected by COR.

2.1.7 Zinc Sheet and Strip

ASTM B 69, Type I, a minimum of 0.61 mm (0.024 inch) thick.

2.1.8 Stainless Steel

ASTM A 167, Type 302 or 304, 2D Finish, fully annealed, dead-soft temper.

2.1.9 Terne-Coated Steel

Minimum of 350 by 500 mm (14 by 20 inches) with minimum of 18 kilogram (40 pound) coating per double base box. ASTM A 308.

2.1.10 Aluminum Alloy Sheet and Plate

ASTM B 209M, ASTM B 209, anodized clear, clad, form alloy, and temper appropriate for use.

2.1.10.1 Alclad

When fabricated of aluminum, the following items shall be fabricated of Alclad 3003, Alclad 3004, Alclad 3005, clad on both sides unless otherwise indicated.

a. Gutters, downspouts, and hangers

b. Gravel stops and fascias

c. Flashing

2.1.10.2 Finish

Exposed exterior sheet metal items of aluminum shall have a baked-on, factory-applied color coating of polyvinylidene fluoride (PVF2) or other equivalent fluorocarbon coating applied after metal substrates have been cleaned and pretreated. Finish coating dry-film thickness shall be 0.020 to 0.033 mm (0.8 to 1.3 mils), and color shall be selected by COR.

2.1.11 Aluminum Alloy, Extruded Bars, Rods, Shapes, and Tubes

ASTM B 221M/B 221.

2.1.12 Solder

ASTM B 32, 95-5 tin-antimony.

2.1.13 Polyvinyl Chloride Reglet

ASTM D 1784, Type II, Grade 1, Class 14333-D, 1.9 mm (0.075 inch) minimum thickness.

2.1.14 Bituminous Plastic Cement

ASTM D 4586, Type I.

2.1.15 Building Paper

ASTM D 226 Type I (30#/in.) Type II (40#/in.).

2.1.16 Asphalt Primer

ASTM D 41.

2.1.17 Through-Wall Flashing

Through-wall flashing for masonry is specified in Section 04200, "Unit Masonry."

2.1.18 Fasteners

Use the same metal or a metal compatible with the item fastened. Use stainless steel fasteners to fasten dissimilar materials.

2.1.19 Galvanized Steel

STM A526, Coating G90.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Metal Roofing

3.1.1.1 Flat Copper, Zinc, or Terne-coated Steel Roofing

Before applying roofing, cover deck with rosin-sized building paper. Lap 50 mm (2 inches) at joints and secure in place with roofing nails. Using solder of equal parts tin and lead, solder slowly with well-heated irons to thoroughly heat sheet and completely sweat solder through full width of seam. Tin edges of copper to be soldered at least 20 mm (3/4 inch) before sheets are locked. Use stainless nails in terne-coated steel; in copper, use solid copper or bronze roofing nails; in zinc, use zinc-coated roofing nails. Where roof decks abut vertical surfaces, turn metal roofing up vertical surfaces about 200 mm (8 inches) where practicable; where vertical surfaces are covered with applied materials, turn up roofing behind applied materials. Use standing-seam method for roofs having rise of more than one in four 3 inches per foot, and use flat-seam method when rise is one in four 3 inches per foot or less. Walking not permitted directly on metal roofs; provide approved walkways.

3.1.1.2 Standing-seam Method

Make standing seams parallel with slope of roof. Fabricate sheets into long lengths at shop by locking short dimensions together and thoroughly soldering joints thus formed. In applying metal, turn up one edge of course at each side seam at right angles 40 mm (1.5 inches). Then install 50 by 75 mm (2 by 3 inch) cleats spaced 300 mm (12 inches) apart by fastening one end of each cleat to roof with two 25 mm (one inch) long nails and folding roof end back over nail heads. Turn end adjoining turned-up side seam up over upstanding edge of course. Turn up adjoining edge of next course 45 mm (1.75 inches) and abutting upstanding edges locked, turned over, and flattened against one side of standing seam. Make standing seams straight, rounded neatly at the top edges, and stand about 25 mm (one inch) above roof deck. All sheets shall be same length, except as required to complete run or maintain pattern. Locate transverse joints of each panel half way between joints in adjacent sheets. Align joints of alternate sheets horizontally to produce uniform pattern, as shown in SMACNA Arch. Manual.

3.1.2 Workmanship

Make lines, arrises, and angles sharp and true. Free exposed surfaces from visible wave, warp, and buckle, and tool marks. Fold back exposed edges neatly to form a 13 mm (1/2 inch) hem on the concealed side. Make sheet metal exposed to the weather watertight with provisions for expansion and contraction.

Make surfaces to receive sheet metal plumb and true, clean, even, smooth, dry, and free of defects and projections which might affect the application. For installation of items not shown in detail or not covered by specifications conform to the applicable requirements of SMACNA Arch. Manual, Architectural Sheet Metal Manual. Provide sheet metal flashing in the angles formed where roof decks abut walls, curbs, ventilators, pipes, or other vertical surfaces and wherever indicated and necessary to make the work watertight. Join sheet metal items together as shown in Table II.

3.1.3 Nailing

Confine nailing of sheet metal generally to sheet metal having a maximum width of 450 mm (18 inches). Confine nailing of flashing to one edge only. Space nails evenly not over 75 mm (3 inches) on centers and approximately 13 mm (1/2 inch) from edge unless otherwise specified or indicated. Face nailing will not be permitted. Where sheet metal is applied to other than wood surfaces, include in shop drawings, the locations for sleepers and nailing strips required to secure the work. Sleepers and nailing strips are specified in Section 06100, "Rough Carpentry."

3.1.4 Cleats

Provide cleats for sheet metal 450 mm (18 inches) and over in width. Space cleats evenly not over 300 mm (12 inches) on centers unless otherwise specified or indicated. Unless otherwise specified, cleats shall be not less than 50 mm wide by 75 mm long (2 inches wide by 3 inches) long and of the same material and thickness as the sheet metal being installed. Secure one end of the cleat with two nails and the cleat folded back over the nailheads. Lock the other end into the seam. Where the fastening is to be made to concrete or masonry, screws shall be used and shall be driven in expansion shields set in concrete or masonry. Pretin cleats for soldered seams.

3.1.5 Bolts, Rivets, and Screws

Install bolts, rivets, and screws where indicated or required. Provide compatible washers where required to protect surface of sheet metal and to provide a watertight connection. Joints in aluminum sheets 1.0 mm (0.040 inch) or less in thickness shall be mechanically made.

3.1.6 Seams

Straight and uniform in width and height with no solder showing on the face.

3.1.6.1 Flat-lock Seams

Finish not less than 20 mm (3/4 inch) wide.

3.1.6.2 Lap Seams

Finish soldered seams not less than 25 mm (one inch) wide. Overlap seams not soldered, not less than 75 mm (3 inches).

3.1.6.3 Loose-Lock Expansion Seams

Not less than 75 mm (3 inches) wide; provide minimum 25 mm (one inch) movement within the joint. Completely fill the joints with the specified sealant, applied at not less than 3 mm (1/8 inch) thick bed. Sealants are specified in Section 07900, "Joint Sealing."

3.1.6.4 Standing Seams

Not less than 25 mm (one inch) high, double locked without solder.

3.1.6.5 Flat Seams

Make seams in the direction of the flow.

3.1.7 Soldering

Where soldering is specified, it shall apply to copper, terne-coated stainless steel, zinc-coated steel, and stainless steel items. Edges of sheet metal shall be pretinned before soldering is begun. Seal the joints in aluminum sheets of one mm (0.040 inch) or less in thickness with specified sealants. Do not solder aluminum.

3.1.7.1 Edges

Scrape or wire-brush the edges of lead-coated material to be soldered to produce a bright surface. Flux brush the seams in before soldering. Treat with soldering acid flux the edges of stainless steel to be pretinned. Seal the joints in aluminum sheets of one mm (0.040 inch) or less in thickness with specified sealants. Do not solder aluminum.

3.1.8 Welding and Mechanical Fastening

Use welding for aluminum of thickness greater than one mm (0.040 inch). Aluminum one mm (0.040 inch) or less in thickness shall be butted and the space backed with formed flashing plate; or lock joined, mechanically fastened, and filled with sealant as recommended by the aluminum manufacturer.

3.1.8.1 Welding of Aluminum

Use welding of the inert gas, shield-arc type. For procedures, appearance and quality of welds, and the methods used in correcting welding work, conform to AWS D1.2.

3.1.8.2 Mechanical Fastening of Aluminum

Use No. 12, aluminum alloy, sheet metal screws or other suitable aluminum alloy or stainless steel fasteners. Drive fasteners in holes made with a No. 26 drill in securing side laps, end laps, and flashings. Space fasteners 300 mm (12 inches) maximum on centers. Where end lap fasteners are required to improve closure, locate the end lap fasteners not more than 50 mm (2 inches) from the end of the overlapping sheet.

3.1.9 Protection from Contact with Dissimilar Materials

3.1.9.1 Copper or Copper-bearing Alloys

Paint with heavy-bodied bituminous paint surfaces in contact with dissimilar metal, or separate the surfaces by means of moistureproof building felts.

3.1.9.2 Aluminum

Aluminum surfaces shall not directly contact other metals except stainless steel, zinc, or zinc coating. Where aluminum contacts another metal, paint the dissimilar metal with a primer followed by two coats of aluminum paint. Where drainage from a dissimilar metal passes over aluminum, paint the dissimilar metal with a non-lead pigmented paint.

3.1.9.3 Metal Surfaces

Paint surfaces in contact with mortar, concrete, or other masonry materials with alkali-resistant coatings such as heavy-bodied bituminous paint.

3.1.9.4 Wood or Other Absorptive Materials

Paint surfaces that may become repeatedly wet and in contact with metal with two coats of aluminum paint or a coat of heavy-bodied bituminous paint.

3.1.10 Expansion and Contraction

Provide expansion and contraction joints at not more than 9750 mm (32 foot) intervals for aluminum and at not more than 12 meter (40 foot) intervals for other metals. Where the distance between the last expansion joint and the end of the continuous run is more than half the required interval, an additional joint shall be provided. Space joints evenly. Join extruded aluminum gravel stops and fascias by expansion and contraction joints spaced not more than 3600 mm (12 feet) apart.

3.1.11 Base Flashing

Lay the base flashings with each course of the roof covering, shingle fashion, where practicable, where sloped roofs abut chimneys, curbs, walls, or other vertical surfaces (for asphalt shingle roof only). Extend up vertical surfaces of the flashing not less than 200 mm (8 inches) and not less than 100 mm (4 inches) under the roof covering. Where finish wall coverings form a counterflashing, extend the vertical leg of the flashing up behind the applied wall covering not less than 150 mm (6 inches). Overlap the flashing strips or shingles with the previously laid flashing not less than 75 mm (3 inches). Fasten the strips or shingles at their upper edge to the deck. Horizontal flashing at vertical surfaces must extend vertically above the roof surface and fastened at their upper edge to the deck a minimum of 6 inches o.c. with large headed aluminum roofing nails or hex headed, galvanized shielded screws a minimum of 2-inch lap of any surface. Solder end laps and provide for expansion and contraction. Extend the metal flashing over crickets at the up-slope side of chimneys, curbs, and similar vertical surfaces extending through sloping roofs, the metal flashings. Extend the metal flashings onto the roof covering not less than 115 mm (4.5 inches) at the lower side of dormer walls, chimneys, and similar vertical surfaces extending through the roof decks. Install and fit the flashings so as to be completely weathertight. Base flashing for interior and exterior corners shall be factory-fabricated. Metal base flashing shall not be used on built-up roofing.

3.1.12 Counterflashing

Except where indicated or specified otherwise, insert counterflashing in reglets located from 230 to 250 mm (9 to 10 inches) above roof decks, extend down vertical surfaces over upturned vertical leg of base flashings not less than 75 mm (3 inches). Fold the exposed edges of counterflashings 13 mm (1/2 inch). Where stepped counterflashings are required, they may be installed in short lengths a minimum 8 inch by 8 inch, 8 inch by 10 inch or may be of the preformed one-piece type. Provide end laps in counterflashings not less than 75 mm (3 inches) and make it weathertight with plastic cement. Do not make lengths of metal counterflashings exceed 3000 mm (10 feet). Form the flashings to the required shapes before installation. Factory-form the corners not less than 300 mm (12 inches) from the angle. Secure the flashings in the reglets with lead wedges and space not more than 450 mm (18 inches) apart; on chimneys and stair/elevator towers short runs, place wedges closer together. Fill caulked-type reglets or raked joints which receive counterflashing with caulking compound. Caulking is covered in Section 07900, "Joint Sealing." Turn up the concealed edge of counterflashings built into masonry or concrete walls not less than 6 mm (1/4 inch) and extend not less than 50 mm (2 inches) into the walls. Install counterflashing to provide a spring action against base flashing. Where bituminous base flashings are provided, the counter flashing shall extend down as close as practicable to the top of the cant strip. Counter flashing shall be factory formed to provide spring action against the base flashing.

3.1.13 Metal Reglets

Caulked type or friction type reglets shall be factory fabricated with a minimum opening of 6 mm (1/4 inch) and a depth of 30 mm (1 1/4 inches), as approved.

3.1.13.1 Caulked Reglets

Provide with rounded edges and metal strap brackets or other anchors for securing to the concrete forms. Provide reglets with a core to protect them from injury during the installation. Provide built-up mitered corner pieces for internal and external angles. Wedge the flashing in the reglets with lead wedges every 450 mm (18 inches), caulked full and solid with an approved compound.

3.1.13.2 Friction Reglets

Provide with flashing receiving slots not less than 16 mm (5/8 inch) deep, 25 mm (one inch) jointing tongues, and upper and lower anchoring flanges installed at 24 inches maximum snaplock receiver. Insert the flashing the full depth of the slot and lock by indentations made with a dull-pointed tool, wedges, and filled with a sealant. For friction reglets, install flashing snaplock receivers at 24 inches o.c. maximum. When the flashing has been inserted the full depth, caulk the slot and lock with wedges and fill with sealant.

3.1.14 Polyvinyl Chloride Reglets (Temporary Construction Installation)

Rigid polyvinyl chloride reglets ASTM D 1784, Type II, Grade 1, Class 14333-D, 0.075 inches minimum thickness may be provided in lieu of metal reglets for temporary construction.

3.1.15 Gravel Stops and Fascias

Prefabricate in the shapes and sizes indicated and in lengths not less than 2400 mm (8 feet). Extend flange at least 100 mm (4 inches) onto roofing. Provide prefabricated, mitered corners internal and external corners. Install gravel stops and fascias after all plies of the roofing membrane have been applied, but before the flood coat of bitumen is applied. Prime roof flange of gravel stops and fascias on both sides with an asphalt primer. After primer has dried, set flange on roofing membrane and strip-in as specified in Section 07511 "Built-Up Asphalt Roofing. Nail flange securely to wood nailer with large-head, barbed-shank roofing nails 38 mm (1.5 inches) long spaced not more than 75 mm (3 inches) on centers, in two staggered rows.

3.1.15.1 Edge Strip

Hook the lower edge of fascias at least 20 mm (3/4 inch) over a continuous strip of the same material bent outward at an angle not more than 45 degrees to form a drip. Nail hook strip to a wood nailer at 150 mm (6 inches) maximum on centers. Where fastening is made to concrete or masonry, use screws spaced 300 mm (12 inches) on centers driven in expansion shields set in the concrete or masonry. Where horizontal wood nailers are slotted to provide for insulation venting, install strips to prevent obstruction of vent slots. Where necessary, install strips over 2 mm (1/16 inch) thick compatible spacer or washers.

3.1.15.2 Joints

Leave open the section ends of gravel stops and fascias 6 mm (1/4 inch) and backed with a formed flashing plate, mechanically fastened in place and lapping each section end a minimum of 100 mm (4 inches) set laps in plastic cement. Face nailing will not be permitted. Install prefabricated aluminum gravel stops and fascias in accordance with the manufacturer's printed instructions and details.

3.1.16 Metal Drip Edge

Provide a metal drip, designed to allow water run-off to drip free of underlying construction, at eaves and rakes prior to the application of roofing shingles. Apply directly on the wood deck at the eaves and over the underlay along the rakes. Extend back from the edge of the deck not more than 75 mm (3 inches) and secure with compatible nails spaced not more than 250 mm (10 inches) on center along upper edge.

3.1.17 Gutters

The hung type of shape indicated and supported on underside by brackets that permit free thermal movement of the gutter. Provide gutters in sizes indicated complete with mitered corners, end caps, outlets, brackets, and other accessories necessary for installation. Bead with hemmed edge or reinforce the outer edge of gutter with a stiffening bar not less than 20 by 5 mm (3/4 by 3/16 inch) of material compatible with gutter. Fabricate gutters in sections not less than 2400 mm (8 feet). Lap the sections a minimum of 25 mm (one inch) in the direction of flow or provide with concealed splice plate 150 mm (6 inches) minimum. Join the gutters, other than aluminum, by riveted and soldered joints. Aluminum gutters shall be joined with riveted sealed joints. Provide expansion-type slip joints midway between outlets. Install gutters below slope line of the roof so that snow and ice can slide clear. Support gutters on as indicated by continuous cleats or by cleats spaced not less than 36 inches apart. Adjust gutters to slope uniformly to outlets, with high points occurring midway between outlets. Fabricate hangers and fastenings from metals compatible with the gutters.

3.1.18 Downspouts

Supports for downspouts shall be spaced according to the manufacturer's recommendation for the wood, masonry, or steel substrate. Types, shapes and sizes are indicated. Provide complete including elbows and offsets. Provide downspouts in approximately 3000 mm (10 foot) lengths. Provide end joints to telescope not less than 13 mm (1/2 inch) and lock longitudinal joints. Provide gutter outlets with wire ball strainers for each outlet. Provide strainers to fit tightly into outlets and be of the same material used for gutters. Keep downspouts not less than 25 mm (one inch) away from walls. Fasten to the walls at top, bottom, and at an intermediate point not to exceed 1500 mm (5 feet) on centers with leader straps or concealed rack-and-pin type fasteners. Form straps and fasteners of metal compatible with the downspouts.

3.1.18.1 Terminations

Neatly fit into the drainage connection the downspouts terminating in drainage lines and fill the joints with a portland cement mortar cap sloped away from the downspout. Provide downspouts terminating in splash blocks with elbow-type fittings.

3.1.19 Flashing for Roof Drains

Roof drains are specified in Section 15400, "Plumbing Systems". Provide a 750 mm (30 inch) square sheet indicated. Taper insulation to drain from 600 mm (24 inches) out. Set flashing on finished felts in a full bed of asphalt roof cement, ASTM D 4586. Apply strip flashing to the drain flashing in accordance with Section 07511 "Built-Up Asphalt Roofing, paragraph entitled "Roof Drain Flashing." Heavily coat the drain flashing ring with asphalt roof cement. Clamp the roof membrane, flashing sheet, and stripping felt in the drain clamping ring. Secure clamps so that felts and drain flashing are free of wrinkles and folds.

3.1.20 Scuppers

Line interior of scupper openings with sheet metal. Extend the lining through and project outside of the wall to form a drip on the bottom edge and form to return not less than 25 mm (one inch) against the face of the outside wall at the top and sides. Fold outside edges under 13 mm (1/2 inch) on all sides. Provide the perimeter of the lining approximately 13 mm (1/2 inch) less than the perimeter of the scupper. Join the top and sides of the lining on the roof deck side to a closure flange by a locked and soldered joint. Join the bottom edge by a locked and soldered joint to the closure flange, where required, form with a ridge to act as a gravel stop around the scupper inlet. Provide surfaces to receive the scupper lining and coat with bituminous plastic cement. Mechanically fasten joints in aluminum and seal.

3.1.21 Conductor Heads

Type indicated and fabricated of the same material as the downspouts. Set the depth of top opening equal to two-thirds of the width. Provide outlet tubes not less than 100 mm (4 inches) long. Flat-lock solder the seams except the mechanically fastened aluminum joints filled with a hard setting sealant. Where conductor heads are used in conjunction with scuppers, set the conductor a minimum of 50 mm (2 inches) wider than the scupper. Attach conductor heads to the wall with masonry fasteners, and loose-lock to provide conductor heads with screens of the same material. Securely fasten screens to the heads.

3.1.22 Splash Pans

Install splash pans where downspouts discharge on roof surfaces and at other locations as indicated. Unless otherwise shown, provide pans not less than 600 mm long by 450 mm wide (24 inches long by 18 inches) wide with metal ribs across the bottom of the pan. Form the sides of the pan with vertical baffles not less than 25 mm (one inch) high in the front, and 100 mm (4 inches) high in the back doubled over and formed continuous with horizontal roof flanges not less than 100 mm (4 inches) wide. Bend the rear flange of the pan to contour of cant strip and extend up 150 mm (6 inches) under the side wall covering or to height of base flashing under counterflashing. Bed the pans and roof flanges in plastic bituminous cement and strip-flash as specified in Roofing Section.

3.1.23 Open Valley Flashing

Provide valley flashing free of longitudinal seams, of width sufficient to extend not less than 150 mm (6 inches) under the roof covering on each side. Provide a 13 mm (1/2 inch) fold on each side of the valley flashing. Lap the sheets not less than 150 mm (6 inches) in the direction of flow and secure to roofing construction with cleats attached to the fold on each side. Nail the tops of sheets to roof sheathing. Space the cleats not more than 300 mm (12 inches) on centers. Provide exposed flashing not less than 100 mm (4 inches) in width at the top and increase 25 mm (one inch) in width for each additional 2400 mm (8 feet) in length. Where the slope of the valley is one in 2.67 or less 4.5 inches or less per foot, or the intersecting roofs are on different slopes, provide an inverted V-joint, 25 mm (one inch) high, along the centerline of the valley; and extend the edge of the valley sheets 200 mm (8 inches) under the roof covering on each side. Valley flashing for asphalt shingle roofs is specified in Section 07311, "Asphalt Shingles."

3.1.24 Eave Flashing

One piece in width, applied in 2400 to 3000 mm (8 to 10 foot) lengths with expansion joints spaced as specified in paragraph entitled "Expansion and Contraction." Provide a 20 mm (3/4 inch) continuous fold in the upper edge of the sheet to engage cleats spaced not more than 250 mm (10 inches) on centers. Locate the upper edge of flashing not less than 450 mm (18 inches) from the outside face of the building, measured along the roof slope. Fold lower edge of the flashing over and loose-lock into a continuous edge strip on the fascia. Where eave flashing intersects metal valley flashing, secure with 25 mm (one inch) flat locked joints with cleats that are 250 mm (10 inches) on centers. Place eave flashing over underlayment and in plastic bituminous cement.

3.1.25 Sheet Metal Covering on Flat, Sloped, or Curved Surfaces

Except as specified or indicated otherwise, cover and flash all minor flat, sloped, or curved surfaces such as crickets, bulkheads, dormers and small decks with metal sheets of the material used for flashing; maximum size of sheets, 375 by 455 mm (16 by 18 inches). Fasten sheets to sheathing with metal cleats. Lock seams and solder. Lock aluminum seams and fill with sealer as recommended by aluminum manufacturer. Provide an underlayment of building paper for all sheet metal covering.

3.1.26 Expansion Joints

Provide expansion joints for roofs, walls, and floors as indicated. Expansion joints in continuous sheet metal shall be provided at 40 foot intervals for copper, stainless steel, or galvanized steel and at 32 foot intervals for aluminum, aluminum gravel stops and fascias which shall have expansion joints at not more than 12 foot spacing. Joints shall be evenly spaced. An additional joint shall be provided where the distance between the last expansion joint and the end of the continuous run is more than half the required interval spacing. Conform to the requirements of Table I.

3.1.26.1 Roof Expansion Joints

Consist of curb with wood nailing members on each side of joint, bituminous base flashing, metal counterflashing, and metal joint cover. Bituminous base flashing is specified in Roofing Section. Provide counterflashing as specified in paragraph "Counterflashing," except as follows: Provide counterflashing with vertical leg of suitable depth to enable forming into a horizontal continuous cleat. Secure the inner edge to the nailing member. Make the outer edge projection not less than 25 mm (one inch) for flashing on one side of the expansion joint and be less than the width of the expansion joint plus 25 mm (one inch) for flashing on the other side of the joint. Hook the expansion joint cover over the projecting outer edges of counterflashing. Provide roof joint with a joint cover of the width indicated. Hook and lock one edge of the joint cover over the shorter projecting flange of the continuous cleat, and the other edge hooked over and loose locked with the longer projecting flange. Joints are specified in Table II.

3.1.26.2 Floor and Wall Expansion Joints

Provide U-shape with extended flanges for expansion joints in concrete and masonry walls and in floor slabs.

3.1.27 Flashing at Roof Penetrations and Equipment Supports

Provide metal flashing for all pipes, ducts, and conduits projecting through the roof surface and for equipment supports, guy wire anchors, and similar items supported by or attached to the roof deck.

3.1.28 Single Pipe Vents

See Table I, footnote (d). Set flange of sleeve in bituminous plastic cement and nail 75 mm (3 inches) on centers. Bend the top of sleeve over and extend down into the vent pipe a minimum of 50 mm (2 inches). For long runs or long rises above the deck, where it is impractical to cover the vent pipe with lead, use a two-piece formed metal housing. Set metal housing with a metal sleeve having a 100 mm (4 inch) roof flange in bituminous plastic cement and nailed 75 mm (3 inches) on centers. Extend sleeve a minimum of 200 mm (8 inches) above the roof deck and lapped a minimum of 75 mm (3 inches) by a metal hood secured to the vent pipe by a draw band. Seal the area of hood in contact with vent pipe with an approved sealant. Sealants are covered under Section 07900, "Joint Sealing."

3.1.29 Stepped Flashing

Stepped flashing shall be installed where sloping roofs surfaced with shingles abut vertical surfaces. Separate pieces of base flashing shall be placed in alternate shingle courses.

3.1.30 Copings

Provide coping using copper sheets 2400 or 3000 mm (8 or 10 feet) long joined by a 20 mm (3/4 inch) locked and soldered seam. Terminate outer edges in edge strips. Install with sealed lap joints, cover plate joints, or standing seam joints as indicated.

3.2 PAINTING

Field-paint sheet metal for separation of dissimilar materials. Finish painting is specified in Section 09900, "Paints and Coatings."

3.2.1 Aluminum Surfaces

Shall be solvent cleaned and given one coat of zinc-molybdate primer and one coat of aluminum paint as specified in Section 09900, "Paints and Coatings."

3.3 CLEANING

Clean exposed sheet metal work at completion of installation. Remove grease and oil films, handling marks, contamination from steel wool, fittings and drilling debris, and scrub-clean. Free the exposed metal surfaces of dents, creases, waves, scratch marks, and solder or weld marks.

3.4 REPAIRS TO FINISH

Scratches, abrasions, and minor surface defects of finish may be repaired in accordance with the manufacturer's printed instructions and as approved. Repair damaged surfaces caused by scratches, blemishes, and variations of color and surface texture. Replace items which cannot be repaired.

3.5 FIELD QUALITY CONTROL

Establish and maintain a Quality Control Plan for sheet metal used in conjunction with roofing to assure compliance of the installed sheet metalwork with the contract requirements. Work not in compliance with the contract shall be promptly removed and replaced or corrected. Quality control shall include, but not be limited to, the following:

a. Observation of environmental conditions; number and skill level of sheet metal workers; condition of substrate.

b. Verification that specified material is provided and installed.

c. Inspection of sheet metalwork, for proper size(s) and thickness(es), fastening and joining, and proper installation.

3.5.1 Procedure

Submit for approval prior to start of roofing work. Include a checklist of points to be observed. Document the actual quality control observations and inspections. Furnish a copy of the documentation to the Contracting Officer at the end of each day.

TABLE I. SHEET METAL WEIGHTS, THICKNESSES, AND GAGES

Sheet Metal Items	Copper, kg/sq m (oz/sq ft)	Aluminum, mm(in)	Stainless Steel, mm(in)	Terne-Coated Stainless Steel, mm(in)	Zinc-Coated Steel, mm(in)
Building Expansion Joints:					
Cover...............	4.9(16)	0.81(.032)	0.38(.015)	0.38(.015)	0.6(24)
Waterstop-bellows or flanged, U-type.....	4.9(16)	-	0.38(.015)	0.38(.015)	-
Covering on minor flat, pitched or curved surfaces............	6.125(20)	1.02(.040)	0.46(.018)	0.46(.018)	-
Downspouts and leaders.............	4.9(16)	0.81(.032)	0.38(.015)	0.38(.015)	0.6(24)
Downspout clips and anchors.........	-	clip 1.02(.04)	-	-	-
	-	anchor 3.175(.125)	-	-	-
Downspout straps, 50 mm (2 inches)....	14.7(48)(a)	1.52(.60)	1.27(.50)	-	-
Conductor heads.....	4.9(16)	0.81(.32)	0.38(.015)	0.38(.015)	-
Scupper lining......	6.125(20)	0.81(.32)	0.38(.015)	0.38(.015)	-
Strainers, wire diameter or gage....	4.0(#9) gage	3.66(.144) diameter	2.77(.109) diameter		-
Flashings:					
Base................	6.125(20)	1.02(.040)	0.46(.018)	0.46(.018)	0.6(24)
Cap (Counter-flashing)	4.9(16)	0.81(.032)	0.38(.015)	0.38(.015)	0.5(26)
Eave................	4.9(16)	-	0.38(.015)	0.38(.015)	0.6(24)
Spandrel beam.......	3.1(10)	-	0.25	0.25	-
Bond barrier........	4.9(16)	-	0.38	0.38	-
Stepped.............	4.9(16)	0.81(.032)	0.38(.015)	0.38(.015)	-
Valley..............	4.9(16)	0.81(.032)	0.38(.015)	0.38(.015)	-
Roof drain..........	4.9(16)(b)				
Pipe vent sleeve(d)					
Coping..............	4.9(16)	-	-	-	-
Gravel stops and fascias:					
Extrusions..........	-	1.91(.075)	-	-	-
Sheets, corrugated..	4.9(16)	0.81(.032)	0.38(.015)	0.38(.015)	-
Sheets, smooth......	6.125(20)	1.27(.050)	0.46(.018)	0.46(.018)	0.6(24)
Edge strip..........	7.35(24)	1.27(.050)	0.635(.025)	-	-
Gutters:					
Gutter section.......	4.9(16)	0.81(.032)	0.38(.015)	0.38(.015)	0.6(24)
Continuous cleat.....	4.9(16)	0.81(.032)	0.38(.015)	0.38(.015)	0.6(24)
Hangers, dimensions..	25 mm x 3 mm	25 mm x 2 mm	25 mm x one mm	-	-

	(a)	(c)			
Joint Cover plates... (See Table II)	4.9(16)	0.81(.032)	0.38(.015)	0.38(.015)	0.6(24)
Reglets (c).........	3.1(10)	-	0.25(.010)	0.25(.010)	-
Splash pans.........	4.9(16)	1.02(.040)	0.46(.018)	0.46(.018)	-

(a) Brass.

(b) May be lead weighing 19.6 kilograms per square meter.

(c) May be polyvinyl chloride.

(d) 12.25 kilogram minimum lead sleeve with 100 mm flange. Where lead sleeve is impractical, refer to paragraph entitled "Single Pipe Vents" for optional material.

TABLE II. SHEET METAL JOINTS

Item Designation	TYPE OF JOINT Copper, Terne-Coated Stainless Steel, Zinc-Coated Steel and Stainless Steel	Aluminum	Remarks
Joint cap for building expansion seam, cleated joint at roof	30 mm (1.25 in) single lock, standing seam, cleated	30 mm (1.25 in) single lock, standing	- - -
Flashings:			
Base	25 mm (1 in) 75 mm (3 in) lap for expansion joint	25 mm (1 in) flat locked, soldered; sealed; 75 mm(3 in) lap for expansion joint	Aluminum producer's recommended hard setting sealant for locked aluminum joints. Fill each metal expansion joint with a joint sealing compound compound. See Section 07900, "Joint Sealants."
Cap-in reglet	75 mm lap (3 in)	75 mm lap (3 in)	Seal groove with joint sealing compound. See Section 07900 "Joint Sealing."
Reglets	Butt joint	- - -	Seal reglet groove with joint sealing compound. See Section 07900, "Joint Sealing."
Eave	25 mm (1 in) flat locked, cleated. 25 mm (1 in) loose locked, sealed	25 mm (1 in) flat locked, cleated 25 mm (1 in) loose locked, sealed	Same as base flashing.

	expansion joint, cleated	expansion joints, cleated	
Stepped	75 mm lap (3 in)	75 mm lap (3 in)	- - -
Valley	150 mm lap cleated (6 in)	150 mm lap cleated (6 in)	- - -
Edge strip	Butt	Butt	- - -
Gravel stops:			
Extrusions	- - -	Butt with 13 mm (1/2 in) space	Use sheet flashing beneath and a cover plate.
Sheet, smooth	Butt with 6 mm(1/4 in) space	Butt with 6 mm(1/4 in) space	Use sheet flashing backup plate.
Sheet corru-gated	Butt with 6 mm(1/4 in) space	Butt with 6 mm(1/4 in) (space)	Use sheet flashing beneath and a cover plate or a combination unit
Gutters	40 mm (1.5 in) lap, riveted and soldered	25 mm (1 in) flat locked riveted, and sealed	Aluminum producers recommended hard setting sealant for locked aluminum joints.

(a) Elastomeric flashing shall have 75 mm lap with manufacturer's recommended sealant.

(b) Polyvinyl chloride reglet shall be sealed with manufacturer's recommended sealant.

SECTION 07810

SPRAY-APPLIED FIREPROOFING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 119 (1998) Fire Tests of Building Construction and Materials

ASTM E 605 (1993; R 1996) Thickness and Density of Sprayed Fire-Resistive Material (SFRM) Applied to Structural Members

ASTM E 736 (1992) Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members

ASTM E 759 (1992; R 1996) Effect of Deflection on Sprayed Fire-Resistive Material Applied to Structural Members

ASTM E 760 (1992; R 1996el) Effect of Impact on Bonding of Sprayed Fire-Resistive Material Applied to Structural Members

ASTM E 761 (1992) Compressive Strength of Sprayed Fire-Resistive Material Applied to Structural Members

ASTM E 937 (1993) Corrosion of Steel by Sprayed Fire-Resistive Material (SFRM) Applied to Structural Members

ASTM E 1042 (1997e1) Acoustically Absorptive Materials Applied by Trowel or Spray ASTM G 21 (1996) Determining Resistance of

Synthetic Polymeric Materials to Fungi

UNDERWRITERS LABORATORIES (UL)

UL 263 (1997; Rev thru Jun 1998) Fire Tests of Building Construction and Materials

UL Fire Resist Dir (1999) Fire Resistance Directory (2 Vol.)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fireproofing Material; G

Data identifying performance characteristics of fireproofing material. Data shall include recommended application requirements and indicate thickness of fireproofing that must be applied to achieve each required fire rating.

SD-04 Samples

Spray-Applied Fireproofing; G

One sample panel, 450 mm 18 inches square, for each specified type of fireproofing. Also, a designated sample area of not less than 9 square meters 100 square feet shall be prepared. Sample area shall be representative of typical installation of fireproofing including metal decks, beams, columns and attachments. Equipment, materials and procedures used in the sample area shall be the same as, or representative of, that to be used in the work. The sample area shall be approved prior to proceeding with fireproofing work in any other area. The approved sample area shall be used as a reference standard for applied fireproofing material. Sample area shall remain in place and open to observation until all spray-applied fireproofing is completed and accepted, at which time it may become part of the work.

SD-06 Test Reports

Fire Resistance Rating; G

Reports and test records, attesting that the fireproofing material conforms to the specified requirements. Each test report shall conform to the report requirements specified by the test method.

Field Tests; G

Test reports documenting results of tests on the applied material in the project. Report shall include defects identified, repair procedures, and results of the retests when required.

SD-07 Certificates

Installer Qualifications; G

Manufacturer's certification that each listed installer is qualified and trained to install the specified fireproofing. Evidence that each fireproofing installer has had a minimum of 3 years experience in installing the specified type of fireproofing.

Surface Preparation; G

Manufacturer's certification that surfaces to be protected have been inspected and are acceptable to receive spray-applied fireproofing. The statement shall list the structural members and the areas that have been inspected and certified.

Manufacturer's Inspection;

Manufacturer's certification that the spray-applied fireproofing in the entire project complies with the manufacturer's criteria and recommendations.

1.3 DELIVERY AND STORAGE

Packaged material shall be delivered in the original unopened containers, marked to show the names of the brand and the manufacturer. Fireproofing material shall be kept dry until ready to be used, and shall be stored off the ground, under cover and away from damp surfaces. Damaged or opened containers will be rejected. Material with shelf-life shall be applied prior to expiration of the shelf-life.

1.4 ENVIRONMENTAL CONDITIONS

1.4.1 Temperature

Substrate and ambient air temperatures shall be maintained above 4 degrees C 40 degrees F during application and for 24 hours before and after application. Relative humidity shall be maintained within the limits recommended by the fireproofing manufacturer.

1.4.2 Ventilation

Adequate ventilation shall be provided to properly dry the fireproofing after application. In enclosed areas, a minimum of 4 air exchanges per hour shall be provided by forced air circulation.

1.5 INSTALLER QUALIFICATIONS

Each installer of fireproofing material shall be trained and have a minimum of 3 years experience in the installation of fireproofing of the type specified.

1.6 FIRE RESISTANCE RATING

Fire resistance ratings shall be in accordance with the fire rated assemblies listed in UL Fire Resist Dir. Proposed materials not listed in UL Fire Resist Dir shall have fire resistance ratings at least equal to the UL Fire Resist Dir ratings as determined by an approved independent testing laboratory, based on tests specified in UL 263 or ASTM E 119.

1.7 EXTENT OF FIREPROOFING

All structural steel, and the underside of steel floor and steel roof decks shall be protected with spray-applied fireproofing to a fire resistance hour-rating as indicated.

PART 2 PRODUCTS

2.1 SPRAY-APPLIED FIREPROOFING

Spray-applied fireproofing material, including sealer, shall conform to ASTM E 1042, Class (a), Category A, either Type I or Type II, except that the dust removed shall not exceed 0.027 gram per square meter (0.0025 gram per square foot) of fireproofing material applied as specified in the project. Material shall be asbestos free, and shall resist fungus for a period of 28 days when tested in accordance with ASTM G 21.

2.1.1 Dry Density and Cohesion/Adhesion

Fireproofing shall have a minimum ASTM E 605 dry density and ASTM E 736 cohesion/adhesion properties as follows:

2.1.1.1 Concealed Structural Components

Fireproofing for structural components concealed above the ceiling, or within a wall, chase, or furred space, shall have a minimum average applied dry density of 240 kg per cubic meter 15 pounds per cubic foot and a cohesion/adhesion strength of 9.57 kPa (200 pounds per square foot.)

2.1.1.2 Exposed Structural Components

Fireproofing for exposed structural components, except where otherwise specified or indicated, shall have a minimum applied dry density of 350 kg per cubic meter (22 pounds per cubic foot) and a cohesion/adhesion strength of 14.36 kPa. (300 pounds per square foot.)

2.1.1.3 Mechanical Rooms and Storage Areas

Fireproofing for structural components located in mechanical rooms and storage areas shall have a minimum applied dry density of 640 kg per cubic meter (40 pounds per cubic foot) and a cohesion/adhesion strength of 19.15 kPa. (400 pounds per square foot.)

2.1.2 Deflection

Spray-applied fireproofing shall not crack, spall, or delaminate when tested in accordance with ASTM E 759.

2.1.3 Bond-Impact

Spray-applied fireproofing material shall not crack, spall or delaminate when tested in accordance with ASTM E 760.

2.1.4 Compressive Strength

The minimum compressive strength shall be 48 kPa (1000 psf) when tested in accordance with ASTM E 761.

2.1.5 Corrosion

Spray-applied fireproofing material shall not contribute to corrosion of test panels when tested as specified in ASTM E 937.

2.2 SEALER

Sealer shall be the type approved by the manufacturer of the fireproofing material and shall be as indicated.

2.3 WATER

Water used for material mixing and surface preparation shall be potable.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Surfaces to be fireproofed shall be thoroughly cleaned of dirt, grease, oil, paint, loose rust, rolling lubricant, mill scale or other contaminants that will interfere with the proper bonding of the sprayed fireproofing to the substrate. Overhead areas to be fireproofed shall be cleared of all obstructions interfering with the uniform application of the spray-applied fireproofing. Hardware such as support sleeves, inserts, clips, hanger attachment devices and the like shall be installed prior to the application of the fireproofing. Condition of the surfaces shall be acceptable to the manufacturer prior to application of spray-applied fireproofing. Applications listed for use on primed surfaces shall be coordinated with the manufacturer and detailed in submittal item SD-03 Product Data.

3.2 PROTECTION

Surfaces not to receive spray-applied fireproofing shall be covered to prevent contamination by splatter, rebound and overspray. Exterior openings in areas to receive spray-applied fireproofing shall be covered prior to and during application of fireproofing with tarpaulins or other approved material. Surfaces not to receive fireproofing shall be cleaned of fireproofing and sealer.

3.3 MIXING

Fireproofing material shall be mixed in accordance with the manufacturer's recommendations.

3.4 APPLICATION

3.4.1 Sequence

Prior to application of fireproofing on each floor, the manufacturer shall inspect and approve application equipment, water supply and pressure, and the application procedures. Fireproofing shall be applied to underside of steel roof deck or steel floor assemblies only after respective roof or floor construction is complete. Fireproofing material shall be applied prior to the installation of ductwork, piping and conduits which would interfere with uniform application of the fireproofing. The Contractor shall not allow roof traffic during application and curing period.

3.4.2 Application Technique

Water pressure and volume shall be maintained to manufacturer's recommendations throughout the fireproofing application. Fireproofing material shall be applied to the thickness established for the specified fire resistance rating, in accordance with the procedure recommended by the manufacturer, and to a uniform density and texture. Fireproofing material shall not be tamped to achieve the desired density.

3.4.3 Sealer Application

Sealer shall be applied to all fireproofing.

3.5 FIELD TESTS

The applied fireproofing shall be tested by an approved independent testing laboratory, in approved locations, for density, cohesion/adhesion force as specified, and for thickness in accordance with ASTM E 605. Two sets of tests shall be conducted on each floor or 930 square meter (10,000-square-foot area), whichever is less, at the approved locations. Any area showing less than minimum requirements shall be corrected. Proposed corrective measures, in writing, shall be approved before starting the corrective action. Corrected work shall be retested.

3.5.1 Thickness, Density, Cohesion/Adhesion

Each structural component type shall be tested at floor and roof decks, beams, columns, joists, and trusses. Minimum average thickness shall be as indicated. Density and cohesion/adhesion shall be as specified.

3.5.2 Repair

Additional fireproofing material may be added to provide proper thickness. Rejected areas of fireproofing shall be corrected to meet specified requirements by adding fireproofing material to provide the proper thickness, or by removing defects and respraying with new fireproofing material. Repairs shall use same type of fireproofing material as originally applied. Repaired areas shall be retested and reinspected. Fireproofing material shall be applied to voids or damaged areas by hand-trowel, or by respraying.

SECTION 07900

JOINT SEALING

TABLE OF CONTENTS

PART 1 GENERAL

This specification covers the requirements for sealing of joints in building construction.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 509	(1994) Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM C 570	(1995) Oil- and Resin-Base Caulking Compound for Building Construction
ASTM C 734	(1993) Low-Temperature Flexibility of Latex Sealants After Artificial Weathering
ASTM C 834	(1995) Latex Sealants
ASTM C 920	(1998) Elastomeric Joint Sealants
ASTM C 1085	(1991) Butyl Rubber-Based Solvent-Release Sealants
ASTM C 1184	(1995el) Structural Silicone-Sealants
ASTM D 217	(1997) Cone Penetration of Lubricating Grease (IP50/88)
ASTM D 1056	(1998) Flexible Cellular Materials - Sponge or Expanded Rubber

ASTM D 1565 (1999) Flexible Cellular Materials – Vinyl Chloride Polymers and Copolymers (Open-Cell Foam)

ASTM E 84 (1999) Surface Burning Characteristics of Building Materials

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3204 (2000) Oil Based Caulking Compounds for Building

KS F 4910 (2000) Sealing Compound Sealing Compounds For Sealing And Glazing In Building For Building

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Backing; G. Bond-Breaker; G. Sealant; G.

Manufacturer's descriptive data including storage requirements, shelf life, curing time, instructions for mixing and application, and primer data (if required). A copy of the Material Safety Data Sheet shall be provided for each solvent, primer or sealant material.

SD-07 Certificates

Sealant; G.

Certificates of compliance stating that the materials conform to the specified requirements.

1.3 ENVIRONMENTAL REQUIREMENTS

The ambient temperature shall be within the limits of 4 to 32 degrees C (40 to 90 degrees F) when the sealants are applied.

1.4 DELIVERY AND STORAGE

Materials shall be delivered to the job in the manufacturer's original unopened containers. The container label or accompanying data sheet shall include the following information as applicable: manufacturer, name of material, formula or specification number, lot number, color, date of manufacture, mixing instructions, shelf life, and curing time at the standard conditions for laboratory tests. Materials shall be handled and stored to prevent inclusion of foreign materials. Materials shall be stored at temperatures between 4 and 32 degrees C (40 and 90 degrees F) unless otherwise specified by the manufacturer.

PART 2 PRODUCTS

2.1 BACKING

Backing shall be 25 to 33 percent oversize for closed cell and 40 to 50 percent oversize for open cell material, unless otherwise indicated.

2.1.1 Rubber Backing

Cellular rubber sponge backing shall be ASTM D 1056, Type 1, open cell for normal cases, or Type 2, closed cell when moisture may migrate to the backing, Class A for most applications, Class B for petroleum oil or fuel resistance, or Class D for temperatures of minus 75 to 175 degrees C (minus 103 to 347 degrees F) with no oil exposure, Grade 3, round cross section.

2.1.2 PVC Backing

Polyvinyl chloride (PVC) backing shall be ASTM D 1565, Grade VO 12, round cross section. Open-cell vinyl foam shall not be used moist areas or below grade.

2.1.3 Synthetic Rubber Backing

Synthetic rubber backing shall be ASTM C 509, Option I, Type I preformed rods, or Option II, Type II when flame resistance is not required.

2.1.4 Neoprene

Neoprene backing shall be ASTM D 1056, closed cell expanded neoprene cord Type 2, Class C, Grade 2C2.

2.2 BOND-BREAKER

Bond-breaker shall be as recommended by the sealant manufacturer to prevent adhesion of the sealant to backing or to bottom of the joint.

2.3 PRIMER

Primer shall be non-staining type as recommended by sealant manufacturer for the application.

2.4 CAULKING

The term "caulking" shall be limited herein to oil-and resin-based caulking which should be used only indoors and where there is little or no anticipated joint movement. where joints may move, a sealant shall be used. Oil- and resin-based caulking shall be ASTM C 570, Type I or II, or KS F 3204.

2.5 SEALANT

2.5.1 Latex Sealant

Latex Sealant shall be ASTM C 834.

2.5.2 Elastomeric Sealant

Elastomeric sealants shall conform to ASTM C 920. Apply the most suitable sealant out of the followings:

a. Polysulfide Sealant: Type S or M, Grade NS or P, Class 25 or 12.5, Use NT, M, G, A, or O.

b. Polyurethane sealant: Grade NS or P, Class 25 or 12.5, Use NT, M, G, A, or O.

c. Silicone sealant: Type S or M, Grade NS or P, Class 25 or 12.5, Use NT, M, G, A, or O.

d. Structural silicone sealant for supporting weight of glass or thin stone: ASTM C 1184, Type S or M, Use G or O.

Notes: Types: S, Single-; M, Multi-component.
Grades: P, Pourable; NS, Non-Sag.
Classes: Withstand 25 or 12.5 percent joint movement.
USES: NT, No Traffic; T, Traffic; M, Mortar; G, Glass; A, Aluminum; and O, Other.

2.5.3 Acoustical Sealant

Rubber or polymer-based acoustical sealant used only in non-moving joints protected from abuse shall have a flame spread of 25 or less and a smoke developed rating of 50 or less when tested in accordance with ASTM E 84. Acoustical sealant shall have a consistency of 250 to 310 when tested in accordance with ASTM D 217, and shall remain flexible and adhesive after 500 hours of accelerated weathering as specified in ASTM C 734, and shall be non-staining.

2.5.4 Butyl Sealant

Butyl sealant shall be ASTM C 1085 or KS F 4910.

2.5.5 Preformed Sealant

Preformed sealant shall be polybutylene or isoprene-butylene based pressure sensitive weather resistant tape or bead sealant capable of sealing out moisture, air and dust when installed as recommended by the manufacturer. At temperatures from minus 34 to plus 71 degrees C (30 to plus 160 degrees F), the sealant shall be non-bleeding and shall have no loss of adhesion.

2.5.5.1 Tape Sealant

Tape sealant: cross-section dimensions shall be as shown on the drawing.

2.5.5.2 Bead Sealant

Bead sealant: cross-section dimensions shall be as shown on the drawing.

2.5.5.3 Foam Strip

Foam strip shall be polyurethane foam; cross-section dimensions shall be as shown on the drawing. Foam strip shall be capable of sealing out moisture, air, and dust when installed and compressed as recommended by the manufacturer. Service temperature shall be minus 40 to plus 135 degrees C (minus 40 to plus 275 degrees F). Untreated strips used where exposed to view or where staining of adjacent surfaces are not acceptable shall be furnished with adhesive to hold them in place. Adhesive shall not stain or bleed into adjacent finishes. Treated strips shall be saturated with butylene waterproofing or impregnated with asphalt.

2.6 SOLVENTS AND CLEANING AGENTS

Solvents, cleaning agents, and accessory materials shall be provided as recommended by the manufacturer.

PART 3 EXECUTION

3.1 GENERAL

Avoid painting elastomeric sealants in joints which move. Most silicones will not accept paint.

3.1.1 Surface Preparation

The surfaces of joints to receive sealant or caulk shall be free of all frost, condensation and moisture. Oil, grease, dirt, chalk, particles of mortar, dust, loose rust, loose mill scale, and other foreign substances shall be removed from surfaces of joints to be in contact with the sealant. Oil and grease shall be removed with solvent and surfaces shall be wiped dry with clean cloths. For surface types not listed below, the sealant manufacturer shall be contacted for specific recommendations.

3.1.2 Concrete and Masonry Surfaces

Where surfaces have been treated with curing compounds, oil, or other such materials, the materials shall be removed by sandblasting or wire brushing. Laitance, efflorescence and loose mortar shall be removed from the joint cavity.

3.1.3 Steel Surfaces

Steel surfaces to be in contact with sealant shall be sandblasted or, if sandblasting would not be practical or would damage adjacent finish work, the metal shall be scraped and wire brushed to remove loose mill scale. Protective coatings on steel surfaces shall be removed by sandblasting or by a solvent that leaves no residue.

3.1.4 Aluminum Surfaces

Aluminum surfaces to be in contact with sealants shall be cleaned of temporary protective coatings. When masking tape is used for a protective cover, the tape and any residual adhesive shall be removed just prior to applying the sealant. Solvents used to remove protective coating shall be as recommended by the manufacturer of the aluminum work and shall be non-staining.

3.1.5 Wood Surfaces

Wood surfaces to be in contact with sealants shall be free of splinters and sawdust or other loose particles.

3.2 APPLICATION

3.2.1 Masking Tape

Masking tape shall be placed on the finish surface on one or both sides of a joint cavity to protect adjacent finish surfaces from primer or sealant smears. Masking tape shall be removed within 10 minutes after joint has been filled and tooled.

3.2.2 Backing

Backing shall be installed to provide the indicated sealant depth. The installation tool shall be shaped to avoid puncturing the backing.

3.2.3 Bond-Breaker

Bond-breaker shall be applied to fully cover the bottom of the joint without contaminating the sides where sealant adhesion is required.

3.2.4 Primer

Primer shall be used on concrete masonry units, wood, or other porous surfaces in accordance with instructions furnished with the sealant. Primer shall be applied to the joint surfaces to be sealed. Surfaces adjacent to joints shall not be primed.

3.2.5 Sealant

Sealant shall be used before expiration of shelf life. Multi-component sealants shall be mixed according to manufacturer's printed instructions. Sealant in guns shall be applied with a nozzle of proper size to fit the width of joint. Joints shall be sealed as detailed in the drawings. Sealant shall be forced into joints with sufficient pressure to expel air and fill the groove solidly. Sealant shall be installed to the indicated depth without displacing the backing. Unless otherwise indicated, specified, or recommended by the manufacturer, the installed sealant shall be tooled so that the surface is uniformly smooth and free of wrinkles and to assure full adhesion to the sides of the joint. Sealants shall be installed free of air pockets, foreign embedded matter, ridges and sags. Sealer shall be applied over the sealant when and as specified by the sealant manufacturer.

3.3 CLEANING

The surfaces adjoining the sealed joints shall be cleaned of smears and other soiling resulting from the sealant application as work progresses.

DIVISION 08 DOORS & WINDOWS

SECTION 08110

STEEL DOORS AND FRAMES

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A250.3 (1999) Test Procedure and Acceptance Criteria for Factory Applied Finish Painted Steel Surfaces for Steel Doors and Frames

ANSI A250.4 (1994) Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors and Hardware Reinforcings

ANSI A250.6 (1997) Hardware on Standard Steel Doors (Reinforcement ? Application)

ANSI A250.8 (1998) SDI-100 Recommended Specifications for Standard Steel Doors and Frames

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 591	(1998) Steel Sheet, Electrolytic Zinc-Coated, for Light Coating Mass Applications
ASTM A 653 (M)	(2000) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process (Metric)
ASTM A 924 (M)	(1999) General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process (Metric)
ASTM C 578	(1995) Rigid, Cellular Polystyrene Thermal Insulation
ASTM C 591	(1994) Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C 612	(1993) Mineral Fiber Block and Board Thermal Insulation
ASTM D 2863	(1997) Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
ASTM E 283	(1991) Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

DOOR AND HARDWARE INSTITUTE (DHI)

ANSI/DHI A115	(1991) Steel Door Preparation Standards (Consisting of A115.1 through A115.6 and A115.12 through A115.18)

HOLLOW METAL MANUFACTURERS ASSOCIATION (HMMA)

HMMA HMM	(1992) Hollow Metal Manual

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80	(1999) Fire Doors and Fire Windows
NFPA 105	(1999) The Installation of Smoke-Control Door Assemblies
NFPA 252	(1999) Standard Methods of Fire Tests of Door Assemblies

STEEL DOOR INSTITUTE (SDOI)

SDI 105	(1998) Recommended Erection Instructions for Steel Frames
SDI 111-B	Recommended Standard Details for Dutch Doors
SDI 111-C	Recommended Louver Details for Standard Steel Doors
SDI 111-F	Recommended Existing Wall Anchors for Standard Steel Doors and Frames
SDI 113	(1979) Apparent Thermal Performance of STEEL DOOR and FRAME ASSEMBLIES

UNDERWRITERS LABORATORIES (UL)

UL 10B (1997) Fire Tests of Door Assemblies

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3109 (2001) Door Sets

1.2 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Doors and frames; G. Accessories and weatherstripping; G.

Show elevations, construction details, metal gages, hardware provisions, method of glazing, and installation details.

Schedule of doors and frames; G.

Submit door and frame locations.

SD-03 Product Data

Doors and frames; G. Accessories and weatherstripping; G.

Submit manufacturer's descriptive literature for doors, frames, and accessories. Include data and details on door construction, panel (internal) reinforcement, insulation, and door edge construction. When "custom hollow metal doors" are provided in lieu of "standard steel doors," provide additional details and data sufficient for comparison to ANSI A250.8 requirements.

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver doors, frames, and accessories undamaged and with protective wrappings or packaging. Strap knock-down frames in bundles. Provide temporary steel spreaders securely fastened to the bottom of each welded frame. Store doors and frames on platforms under cover in clean, dry, ventilated, and accessible locations, with 6 mm (1/4 inch) airspace between doors. Remove damp or wet packaging immediately and wipe affected surfaces dry. Replace damaged materials with new.

PART 2 PRODUCTS

2.1 STANDARD STEEL DOORS

ANSI A250.8 or KS F 3109, except as specified otherwise. Prepare doors to receive hardware specified in Section 08700, "Door Hardware." Undercut where indicated. Exterior doors that open outward shall have top edge closed flush and sealed to prevent water intrusion. Doors shall be 44.5 mm (1 3/4 inches) thick, unless otherwise indicated.

2.1.1 Classification - Level, Performance, Model

Level designations are as follows:

Closet doors (without locks)	Level 1
Individual offices, storage rooms, classrooms, patients' rooms, bathrooms, and bedrooms (except BEQ bedrooms)	Level 2
BEQ sleeping room entrance doors and interior egress doors	Level 3
Exterior Main entrance and circulation doors and other locations	Level 4

Model designations are as follows:

Model 1 Full Flush Design

Model 2 Seamless Design

Model 3, Stile and Rail

Core constructions shall be at the manufacturer's discretion and are as follows:

a. Kraft/Paper Honeycomb

b. Polyurethane

c. Polystyrene

d. Mineral Board

e. Vertical Steel Stiffeners

2.1.1.1 Standard Duty Doors

ANSI A250.8, Level 1, physical performance Level C, Model 1 or 2, of size(s) and design(s) indicated and core construction as required by the manufacturer.

2.1.1.2 Heavy Duty Doors

ANSI A250.8, Level 2, physical performance Level B, Model 1 or 2, with core construction as required by the manufacturer for interior doors and for exterior doors, of size(s) and design(s) indicated. Where vertical stiffener cores are required, the space between the stiffeners shall be filled with mineral board insulation.

2.1.1.3 Extra Heavy Duty Doors

ANSI A250.8, Level 3, physical performance Level A, Model 1, 2 or 3 with core construction as required by the manufacturer for interior doors and for indicated exterior doors, of size(s) and design(s) indicated. Where vertical stiffener cores are required, the space between the stiffeners shall be filled with mineral board insulation.

2.1.1.4 Maximum Duty Doors

ANSI A250.8, Level 4, physical performance Level A, Model 1 or 2 with core construction as required by the manufacturer for interior doors and for indicated exterior doors, of size(s) and design(s) indicated. Where vertical stiffener cores are required, the space between the stiffeners shall be filled with mineral board insulation.

2.2 CUSTOM HOLLOW METAL DOORS

Provide custom hollow metal doors where nonstandard steel doors are indicated. At the Contractor's option, custom hollow metal doors may be provided in lieu of standard steel doors. Door size(s), design, materials, construction, gages, and finish shall be as specified for standard steel doors and shall comply with the requirement of HMMA HMM. Fill all spaces in doors with insulation. Close top and bottom edges with steel channels not lighter than 1.5 mm (16 gage) thick. Close tops of exterior doors flush with an additional channel and seal to prevent water intrusion. Prepare doors to receive hardware specified in Section 08700, "Door Hardware." Undercut doors where indicated. Doors shall be 44.5 mm (1 3/4 inches) thick, unless otherwise indicated.

2.3 INSULATED STEEL DOOR SYSTEMS

At the option of the Contractor, insulated steel doors and frames may be provided in lieu of Grade I standard steel doors and frames. Door size(s), design, and material shall be as specified for standard steel doors. Insulated steel doors shall have a core of polyurethane foam and an R factor of 10.0 or more (based on a k value of 0.16); face sheets, edges, and frames of galvanized steel not lighter than 1.5 mm (16 gage) thick respectively; magnetic weatherstripping; nonremovable-pin hinges; thermal-break aluminum threshold; and vinyl door bottom. Doors and frames shall receive phosphate treatment, rust-inhibitive primer, and baked acrylic enamel finish. Doors shall have been tested in accordance with ANSI A250.4 and shall have met the requirements for Level C. Prepare doors to receive hardware specified in Section 08700, "Door Hardware." Doors shall be 44.5 mm (1 3/4 inches) thick.

2.4 SOUND RATED STEEL DOORS

Doors shall be of the sound classification scheduled.

2.5 ACCESSORIES

2.5.1 Shelves for Dutch Doors

SDI 111-B. Fabricate shelves of steel not lighter than 1.5 mm thick 16 gage, of the size indicated. Brackets shall be stock type fabricated of the same metal used to fabricate shelves.

2.5.2 Louvers

2.5.2.1 Interior Louvers

SDI 111-C, Louvers shall be stationary sightproof and lightproof type. Louvers for lightproof doors shall not transmit light. Detachable moldings on room or non security side of door; on security side of door, moldings to be integral part of louver. Form louver frames of 0.9 mm thick 20 gage steel and louver blades of a minimum 0.6 mm 24 gage. Louvers for lightproof doors shall have minimum of 20 percent net-free opening. Sightproof louvers to be inverted "V" blade design with minimum 55 and inverted "Y" blade design with minimum 40 percent net-free opening.

2.5.2.2 Exterior Louvers

Louvers shall be inverted "Z" type with minimum of 35 percent net-free opening. Weld or tenon louver blades to continuous channel frame and weld assembly to door to form watertight assembly. Form louvers of hot-dip galvanized steel of same gage as door facings. Louvers shall have steel-framed insect screens secured to room side and readily removable. Provide aluminum wire cloth, 7 by 7 per 10 mm or 7 by 6 per 10 mm (18 by 18 or 18 by 16 inch mesh), for insect screens. Net-free louver area to be before screening.

2.5.3 Astragals

For pairs of exterior steel doors which will not have aluminum astragals or removable mullions, as specified in Section 08700, "Door Hardware," provide overlapping steel astragals with the doors. For interior pairs of fire rated and smoke control doors, provide stainless steel astragals complying with NFPA 80 for fire rated assemblies and NFPA 105 for smoke control assemblies.

2.5.4 Moldings

Provide moldings around glass of interior and exterior doors and louvers of interior doors. Provide nonremovable moldings on outside of exterior doors and on corridor side of interior doors. Other moldings may be stationary or removable. Secure inside moldings to stationary moldings, or provide snap-on moldings. Muntins shall interlock at intersections and shall be fitted and welded to stationary moldings.

2.6 INSULATION CORES

Insulated cores shall be of type specified, and provide an apparent U-factor of .48 in accordance with SDI 113 and shall conform to:

a. Rigid Polyurethane Foam: ASTM C 591, Type 1 or 2, foamed-in-place or in board form, with oxygen index of not less than 22 percent when tested in accordance with ASTM D 2863; or

b. Rigid Polystyrene Foam Board: ASTM C 578, Type I or II; or

c. Mineral board: ASTM C 612, Type I.

2.7 STANDARD STEEL FRAMES

ANSI A250.8, except as otherwise specified. Form frames to sizes and shapes indicated, with welded corners or knock-down field-assembled corners.

2.7.1 Welded Frames

Continuously weld frame faces at corner joints. Mechanically interlock or continuously weld stops and rabbets. Grind welds smooth.

2.7.2 Knock-Down Frames

Design corners for simple field assembly by concealed tenons, splice plates, or interlocking joints that produce square, rigid corners and a tight fit and maintain the alignment of adjoining members. Provide locknuts for bolted connections.

2.7.3 Mullions and Transom Bars

Mullions and transom bars shall be closed or tubular construction and shall member with heads and jambs butt-welded thereto or knock-down for field assembly. Bottom of door mullions shall have adjustable floor anchors and spreader connections.

2.7.4 Stops and Beads

Form stops and beads from 0.9 mm (20 gage) thick steel. Provide for glazed and other openings in standard steel frames. Secure beads to frames with oval-head, countersunk Phillips self-tapping sheet metal screws or concealed clips and fasteners. Space fasteners approximately 300 to 400 mm (12 to 16 inches) on centers. Miter molded shapes at corners. Butt or miter square or rectangular beads at corners.

2.7.5 Terminated Stops

Where indicated, terminate interior door frame stops 150 mm (6 inches) above floor. Do not terminate stops of frames for lightproof, soundproof, or lead-lined doors.

2.7.6 Cased Openings

Fabricate frames for cased openings of same material, gage, and assembly as specified for metal door frames, except omit door stops and preparation for hardware.

2.7.7 Anchors

Provide anchors to secure the frame to adjoining construction. Provide steel anchors, zinc-coated or painted with rust-inhibitive paint, not lighter than 1.2 mm thick 18 gage.

2.7.7.1 Wall Anchors

Provide at least three anchors for each jamb. For frames which are more than 2285 mm (7.5 feet) in height, provide one additional anchor for each jamb for each additional 760 mm (2.5 feet) or fraction thereof.

a. Masonry: Provide anchors of corrugated or perforated steel straps or 5 mm (3/16 inch) diameter steel wire, adjustable or T-shaped;

b. Stud partitions: Weld or otherwise securely fasten anchors to backs of frames. Design anchors to be fastened to wood studs with nails, to closed steel studs with sheet metal screws, and to open steel studs by wiring or welding;

c. Completed openings: Secure frames to previously placed concrete or masonry with expansion bolts in accordance with SDI 111-F; and

d. Solid plaster partitions: Secure anchors solidly to back of frames and tie into the lath. Provide adjustable top strut anchors on each side of frame for fastening to structural members or ceiling construction above. Size and type of strut anchors shall be as recommended by the frame manufacturer.

2.7.7.2 Floor Anchors

Provide floor anchors drilled for 10 mm (3/8 inch) anchor bolts at bottom of each jamb member. Where floor fill occurs, terminate bottom of frames at the indicated finished floor levels and support by adjustable extension clips resting on and anchored to the structural slabs.

2.8 FIRE AND SMOKE DOORS AND FRAMES

NFPA 80 and NFPA 105 and this specification. The requirements of NFPA 80 and NFPA 105 shall take precedence over details indicated or specified.

2.8.1 Labels

Fire doors and frames shall bear the label of Underwriters Laboratories, Inc. (UL), Factory Mutual Engineering and Research (FM), or Warnock Hersey International (WHI) attesting to the rating required. Testing shall be in accordance with NFPA 252 or UL 10B. Labels shall be metal with raised letters, and shall bear the name or file number of the door and frame manufacturer. Labels shall be permanently affixed at the factory to frames and to the hinge edge of the door. Door labels shall not be painted.

2.8.2 Oversized Doors

For fire doors and frames which exceed the size for which testing and labeling are available, furnish certificates stating that the doors and frames are identical in design, materials, and construction to a door which has been tested and meets the requirements for the class indicated.

2.8.3 Astragal on Fire and Smoke Doors

On pairs of labeled fire doors, conform to NFPA 80 and UL requirements. On smoke control doors, conform to NFPA 105.

2.9 WEATHERSTRIPPING

As specified in Section 08700, "Door Hardware."

2.9.1 Integral Gasket

Black synthetic rubber gasket with tabs for factory fitting into factory slotted frames, or extruded neoprene foam gasket made to fit into a continuous groove formed in the frame, may be provided in lieu of head and jamb seals specified in Section 08700, "Door Hardware." Insert gasket in groove after frame is finish painted. Air leakage of weatherstripped doors shall not exceed 2.19 by 10-5 cms (0.5 cfm per sq. ft) for residential swinging doors and 5.48 by 10-5 cubic meters per second of air per square meter (1.25 cfm per sq. ft) for non- residential swinging doors of door area when tested in accordance with ASTM E 283.

2.10 HARDWARE PREPARATION

Provide minimum hardware reinforcing gages as specified in ANSI A250.6. Drill and tap doors and frames to receive finish hardware. Prepare doors and frames for hardware in accordance with the applicable requirements of ANSI A250.8 and ANSI A250.6. For additional requirements refer to ANSI/DHI A115. Drill and tap for surface-applied hardware at the project site. Build additional reinforcing for surface-applied hardware into the door at the factory. Locate hardware in accordance with the requirements of ANSI A250.8, as applicable. Punch door frames to receive a minimum of two rubber or vinyl door silencers on lock side of single doors and one silencer for each leaf at heads of double doors. Set lock strikes out to provide clearance for silencers.

2.11 FINISHES

2.11.1 Factory-Primed Finish

All surfaces of doors and frames shall be thoroughly cleaned, chemically treated and factory primed with a rust inhibiting coating as specified in ANSI A250.8 or paintable A25 galvannealed steel without primer. Where coating is removed by welding, apply touchup of factory primer.

2.11.2 Hot-Dip Zinc-Coated and Factory-Primed Finish

Fabricate scheduled doors and frames from hot dipped zinc coated steel, alloyed type, that complies with ASTM A 924(M) and ASTM A 653(M). The Coating weight shall meet or exceed the minimum requirements for coatings having 0.4 ounces per square foot (122 grams per square meter), total both sides, i.e., A40ZF120. Repair damaged zinc-coated surfaces by the application of zinc dust paint. Thoroughly clean and chemically treat to insure maximum paint adhesion. Factory prime as specified in ANSI A250.8.

2.11.3 Electrolytic Zinc-Coated Anchors and Accessories

Provide electrolytically deposited zinc-coated steel in accordance with ASTM A 591, Commercial Quality, Coating Class A. Phosphate treat and factory prime zinc-coated surfaces as specified in ANSI A250.8.

2.11.4 Factory-Applied Enamel Finish

Coatings shall meet test procedures and acceptance criteria in accordance with ANSI A250.3. After factory priming, apply two coats of medium-gloss enamel to exposed surfaces. Separately bake or oven dry each coat. Drying time and temperature requirements shall be in accordance with the coating manufacturer's recommendations. Color(s) of finish coat shall be as indicated and shall match approved color sample(s).

2.12 FABRICATION AND WORKMANSHIP

Finished doors and frames shall be strong and rigid, neat in appearance, and free from defects, waves, scratches, cuts, dents, ridges, holes, warp, and buckle. Molded members shall be clean cut, straight, and true, with joints coped or mitered, well formed, and in true alignment. Dress exposed welded and soldered joints smooth. Design door frame sections for use with the wall construction indicated. Corner joints shall be well formed and in true alignment. Conceal fastenings where practicable. Frames for use in solid plaster partitions shall be welded construction. On wraparound frames for masonry partitions, provide a throat opening 3 mm (1/8 inch) larger than the actual masonry thickness.

2.12.1 Grouted Frames

For frames to be installed in exterior walls and to be filled with mortar or grout, fill the stops with strips of rigid insulation to keep the grout out of the stops and to facilitate installation of stop-applied head and jamb seals.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Frames

Set frames in accordance with SDI 105. Plumb, align, and brace securely until permanent anchors are set. Anchor bottoms of frames with expansion bolts or powder-actuated fasteners. Build in or secure wall anchors to adjoining construction. Where frames require ceiling struts or overhead bracing, anchor frames to the struts or bracing. Backfill frames with mortar. When an additive is provided in the mortar, coat inside of frames with corrosion-inhibiting bituminous material. For frames in exterior walls, ensure that stops are filled with rigid insulation before grout is placed.]

3.1.2 Doors

Hang doors in accordance with clearances specified in ANSI A250.8. After erection and glazing, clean and adjust hardware.

3.1.3 Fire and Smoke Doors and Frames

Install fire doors and frames, including hardware, in accordance with NFPA 80. Install fire rated or smoke doors and frames in accordance with NFPA 80 and NFPA 105.

3.2 PROTECTION

Protect doors and frames from damage. Repair damaged doors and frames prior to completion and acceptance of the project or replace with new, as directed. Wire brush rusted frames until rust is removed. Clean thoroughly. Apply an all-over coat of rust-inhibitive paint of the same type used for shop coat.

3.3 CLEANING

Upon completion, clean exposed surfaces of doors and frames thoroughly. Remove mastic smears and other unsightly marks.

3.4 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurement commonly agreed to by the manufacturers or other parties. The inch-pound and metric measurements are as follows:

PRODUCTS	INCH-POUND	METRIC
Door thickness	1 3/4 inches	44.5 mm
Steel channels	16 gage	1.5 mm
Steel Sheet	23 gage	0.7 mm
	16 gage	1.5 mm
	20 gage	0.9 mm
	18 gage	1.2 mm
Anchor bolts	3/8 inches	10 mm

SECTION 08120

ALUMINUM DOORS AND FRAMES

TABLE OF CPNTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF-45 (1980) Aluminum Finishes

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 603.8 (1992; Addendum 1993) Pigmented Organic Coatings on Extruded Aluminum

AAMA 605.2 (1992; Addendum 1995) High Performance Organic Coatings on Architectural Extrusions and Panels

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36/A 36M (1997; Rev. A) Carbon Structural Steel

ASTM B 209M (1995) Aluminum and Aluminum-Alloy Sheet and Plate (Metric)

ASTM B 209 (1996) Aluminum and Aluminum-Alloy Sheet and Plate

ASTM B 221M (1996) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)

ASTM B 221 (1996) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

ASTM E 283 (1991) Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

ASTM E 331 (1996) Water Penetration of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 6759 (2002) Aluminum and Aluminum Alloy Extruded Shapes

1.2 PERFORMANCE REQUIREMENTS

1.2.1 Structural

Shapes and thicknesses of framing members shall be sufficient to withstand a design wind load of not less than 1.4 kilopascals (30 pounds per square foot) of supported area with a deflection of not more than 1/175 times the length of the member and a safety factor of not less than 1.65. Provide glazing beads, moldings, and trim of not less than 1.25 mm (0.050 incn) nominal thickness.

1.2.2 Air Infiltration

When tested in accordance with ASTM E 283, air infiltration shall not exceed 2.63 by 10-5 cms per square meter (0.06 cubic feet per minute per square foot) of fixed area at a test pressure of 0.30 kPa (6.24 pounds per square foot) (80 kilometers, 50 mile per hour wind).

1.2.3 Water Penetration

When tested in accordance with ASTM E 331, there shall be no water penetration at a pressure of 0.38 kPa (8 pounds per square foot) of fixed area.

1.3 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Doors and frames; G

Show elevations of each door type, size of doors and frames, metal gages, details of door and frame construction, methods of anchorage, glazing details, weatherstripping, provisions for and location of hardware, and details of installation.

SD-08 Manufacturer's Instructions

Doors and frames

Submit detail specifications and instructions for installation, adjustments, cleaning, and maintenance.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the site for damage. Unload and store with minimum handling. Provide storage space in dry location with adequate ventilation, free from dust or water, and easily accessible for inspection and handling. Stack materials on nonabsorptive strips or wood platforms. Do not cover doors and frames with tarps, polyethylene film, or similar coverings. Protect finished surfaces during shipping and handling using manufacturer's standard method, except that no coatings or lacquers shall be applied to surfaces to which calking and glazing compounds must adhere.

PART 2 PRODUCTS

2.1 DOORS AND FRAMES

Swing-type aluminum doors and frames of size, design, and location indicated. Provide doors complete with frames, framing members, subframes, transoms, adjoining sidelights, adjoining window wall, trim, and accessories as indicated.

2.2 MATERIALS

2.2.1 Anchors

Stainless steel or steel with hot-dipped galvanized finish.

2.2.2 Weatherstripping

Continuous wool pile, silicone treated, or type recommended by door manufacturer.

2.2.3 Aluminum Alloy for Doors and Frames

ASTM B 221M/ASTM B 221, Alloy 6063-T5 or KS D 6759 for extrusions. ASTM B 209M ASTM B 209, alloy and temper best suited for aluminum sheets and strips.

2.2.4 Fasteners

Hard aluminum or stainless steel.

2.2.5 Structural Steel

ASTM A 36/A 36M.

2.2.6 Aluminum Paint

Type as recommended by aluminum door manufacturer.

2.3 FABRICATION

2.3.1 Aluminum Frames

Extruded aluminum shapes with contours approximately as indicated. Provide removable glass stops and glazing beads for frames accommodating fixed glass. Use countersunk stainless steel Phillips screws for exposed fastenings, and space not more than 300 mm (12 inches) o.c. Mill joints in frame members to a hairline fit, reinforce, and secure mechanically.

2.3.2 Aluminum Doors

Of type, size, and design indicated and not less than 45 mm (1 3/4 inches) thick. Minimum wall thickness, 3 mm (0.125 inch), except beads and trim, 1.25 mm (0.050 inch). Door sizes shown are nominal and shall include standard clearances as follows: 2.5 mm(0.093 inch) at hinge and lock stiles, 3 mm (0.125 inch) between meeting stiles, 3 mm (0.125 inch) at top rails, 5 mm (0.187 inch) between bottom and threshold, and 17 mm (0.687 inch) between bottom and floor. Bevel single-acting doors 2 or 3 mm (0.063 or 0.125 inch) at lock, hinge, and meeting stile edges. Double-acting doors shall have rounded edges at hinge stile, lock stile, and meeting stile edges.

2.3.2.1 Full Glazed Stile and Rail Doors

Doors shall have narrow, medium or wide stiles and rails as indicated. Fabricate from extruded aluminum hollow seamless tubes or from a combination of open-shaped members interlocked or welded together. Fasten top and bottom rail together by means of welding or by 10 or 13 mm (3/8 or 1/2 inch) diameter cadmium-plated tensioned steel tie rods. Provide an adjustable mechanism of jack screws or other methods in the top rail to allow for minor clearance adjustments after installation.

2.3.2.2 Flush Doors

Use facing sheets with a vertical ribbed, an embossed or a plain smooth surface. Use one of the following constructions:

a. A phenolic resin-impregnated kraft paper honeycomb core, surrounded at edges and around glass and louvered areas with extruded aluminum shapes. The impregnation of core shall have a minimum of 18 percent resin content. Provide sheet aluminum door facings, not less than 0.8 mm (0.032 inch) thick laminated to a 2.5 mm (0.10 inch) thick tempered hardboard backing, and bond the backing to the honeycomb core. Bond facing sheets to core under heat and pressure with a thermosetting adhesive, and mechanically lock to the extruded edge members.

b. A phenolic resin-impregnated kraft paper honeycomb core. Use aluminum facing sheets not less than 1.25 mm (0.050 inch) thick and form into two pans which will eliminate seams on the faces. Bond honeycomb core to the face sheets using an epoxy resin or contact cement-type adhesive.

c. A solid fibrous core, surrounded at edges and around glass and louvered areas and cross-braced at intermediate points with extruded aluminum shapes. Use aluminum facing sheets of not less than 1.25 mm (0.050 inch) thickness. Bond facing sheets to core under heat and pressure with a thermosetting adhesive, and mechanically lock to the extruded edge members.

d. Form from extruded tubular stiles and rails mitered at corners, reinforce, and continuously weld at miters. Facing sheets shall consist of 0.8 mm (0.032 inch) thick sheet aluminum internally reinforced with aluminum channels or Z-bars placed horizontally not more than 400 mm (16 inches) apart and extending full width of panel. Fit spaces between reinforcing with sound-deadening insulation. Facing sheets shall finish flush with faces of stiles and rails and be welded to reinforcing bars or channels and to stiles and rails.

e. Form from an internal grid system composed of extruded aluminum tubular sections. Provide extruded aluminum tubular sections at both sides, and at perimeters of louver and glass cutouts. Provide three extruded aluminum tubular sections at top and bottom of door. Wall thickness of tubular sections shall be not less than 2.25 mm (0.09 inch) except that lock rail shall be not less than 3 mm (0.125 inch) thick, hinge lock rail shall be not less than 3 mm (0.125 inch) thick, and hinge rail edge shall be not less than 5 mm (0.19 inch) thick. Fill spaces in door with mineral insulation. Facing sheets shall be of aluminum not less than 2.25 mm (0.09 inch) thick.

f. Form from extruded aluminum members at top and bottom, both sides, and at perimeters of louver and glass cutouts. Wall sections of extruded aluminum members shall be not less than 2.25 mm (0.09 inch) thick and be properly reinforced for application of hardware. Framing members shall be covered on both sides with aluminum facing sheets not less than 2 mm (0.064 inch) thick. Fill door with foamed-in urethane with a 48 kg per cubic meter (3 pound per cubic feet) density.

2.3.3 Welding and Fastening

Where possible, locate welds on unexposed surfaces. Dress welds on exposed surfaces smoothly. Select welding rods, filler wire, and flux to produce a uniform texture and color in finished work. Remove flux and spatter from surfaces immediately after welding. Exposed screws or bolts will be permitted only in inconspicuous locations, and shall have countersunk heads. Weld concealed reinforcements for hardware in place.

2.3.4 Weatherstripping

Provide on stiles and rails of exterior doors. Fit into slots which are integral with doors or frames. Weatherstripping shall be replaceable without special tools, and adjustable at meeting rails of pairs of doors. Installation shall allow doors to swing freely and close positively. Air leakage of a single leaf weatherstripped door shall not exceed 2.19 x 10-5 for residential swinging doors or 5.48 x 10-5 for non-residential doors cubic meter per second of air per square meter (cms per sq. m) (0.5 or 1.25 cubic feet per minute of air per square foot) of door area when tested in accordance with ASTM E 283.

2.3.5 Anchors

On the backs of subframes, provide anchors of the sizes and shapes indicated for securing subframes to adjacent construction. Anchor transom bars at ends and mullions at head and sill. Where indicated, reinforce vertical mullions with structural steel members of sufficient length to extend up to the overhead structural slab or framing and secure thereto. Reinforce and anchor freestanding door frames to floor construction as indicated on approved shop drawings and in accordance with manufacturer's recommendation. Place anchors as indicated or near top and bottom of each jamb and at intermediate points not more than 635 mm (25 inches) apart.

2.3.6 Provisions for Hardware

Hardware is specified in Section 08700, "Door Hardware." Deliver hardware templates and hardware (except field-applied hardware) to the door manufacturer for use in fabrication of aluminum doors and frames. Cut, reinforce, drill, and tap doors and frames at the factory to receive template hardware. Provide doors to receive surface-applied hardware, except push plates, kick plates, and mop plates, with reinforcing only; drill and tap in the field. Provide hardware reinforcements of stainless steel or steel with hot-dipped galvanized finish, and secure with stainless steel screws.

2.3.7 Provisions for Glazing

Provide extruded aluminum snap-in glazing beads on interior side of doors. Provide extruded aluminum, theft-proof, snap-in glazing beads or fixed glazing beads on exterior or security side of doors. Glazing beads shall have vinyl insert glazing gaskets. Design glazing beads to receive glass of thickness indicated or specified. Glazing is specified in Section 08810, "GLASS AND Glazing."

2.3.8 Finishes

Provide exposed aluminum surfaces with factory finish of anodic coating or organic coating.

2.3.8.1 Anodic Coating

Clean exposed aluminum surfaces and provide an anodized finish conforming to AA DAF-45. Finish shall be clear (natural), designation AA-M10-C22-A31, Architectural Class II 0.01 to 0.0175 mm (0.4 mil to 0.7 mil), clear (natural), designation AA-M10-C22-A41, Architectural Class I 0.0175 mm (0.7 mil) or thicker, integral color-anodized, designation AA-M10-C22-A32, Architectural Class II 0.01 to 0.0175 mm (0.4 mil to 0.7 mil), integral color-anodized, designation AA-M10-C22-A42, Architectural Class I 0.0175 mm (0.7 mil) or thicker, electrolytically deposited color-anodized, designation AA-M10-C22-A34, Architectural Class II 0.01 to 0.0175 mm (0.4 mil to 0.7 mil), electrolytically deposited color-anodized, or designation AA-M10-C22-A44, Architectural Class I 0.0175 mm (0.7 mil) or thicker. Color shall be as indicated.

2.3.8.2 Organic Coating

Clean and prime exposed aluminum surfaces. Provide a baked enamel finish in accordance with AAMA 603.8 with total dry film thickness not less than 0.02 mm (0.8 mil) a high-performance finish in accordance with AAMA 605.2 with total dry film thickness of not less than 0.03 mm (1.2 mils). The finish color shall be as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Plumb, square, level, and align frames and framing members to receive doors, transoms, adjoining sidelights, and adjoining window walls. Anchor frames to adjacent construction as indicated and in accordance with manufacturer's printed instructions. Anchor bottom of each frame to rough floor construction with 2.4 mm (3/32 inch) thick stainless steel angle clips secured to back of each jamb and to floor construction; use stainless steel bolts and expansion rivets for fastening clip anchors. Seal metal-to-metal joints between framing members as specified in Section 07900, "Joint Sealing". "Hang doors to produce clearances specified in paragraph entitled "Aluminum Doors" of this section. After erection and glazing, adjust doors and hardware to operate properly.

3.2 PROTECTION FROM DISSIMILAR MATERIALS

3.2.1 Dissimilar Metals

Where aluminum surfaces come in contact with metals other than stainless steel, zinc, or small areas of white bronze, protect from direct contact by one or a combination of the following methods:

a. Paint the dissimilar metal with one coat of heavy-bodied bituminous paint.

b. Apply a good quality elastomeric sealant between the aluminum and the dissimilar metal.

c. Paint the dissimilar metal with one coat of primer and one coat of aluminum paint.

d. Use a nonabsorptive tape or gasket in permanently dry locations.

3.2.2 Drainage from Dissimilar Metals

In locations where drainage from dissimilar metals has direct contact with aluminum, provide protective paint, to prevent aluminum discoloration.

3.2.3 Masonry and Concrete

Provide aluminum surfaces in contact with mortar, concrete, or other masonry materials with one coat of heavy-bodied bituminous paint.

3.2.4 Wood or Other Absorptive Materials

Provide aluminum surfaces in contact with absorptive materials subject to frequent moisture, and aluminum surfaces in contact with treated wood, with two coats of aluminum paint or one coat of heavy-bodied bituminous paint. In lieu of painting the aluminum, the Contractor shall have the option of painting the wood or other absorptive surface with two coats of aluminum paint and sealing the joints with elastomeric sealant.

3.3 CLEANING

Upon completion of installation, clean door and frame surfaces in accordance with door manufacturer's recommended procedure. Do not use abrasive, caustic, or acid cleaning agents.

3.4 PROTECTION

Protect doors and frames from damage and from contamination by other materials such as cement mortar. Prior to completion and acceptance of the work, restore damaged doors and frames to original condition, or replace with new ones.

SECTION 08210

WOOD DOORS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 90	(1997) Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
ASTM E 152	(1981; Rev. A) Fire Tests of Door Assemblies
ASTM E 283	(1991) Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

ARCHITECTURAL WOODWORK INSTITUTE (AWI)

AWI Qual Stds	(1997) Architectural Woodwork Quality Standards and Quality Certification Program

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA LD 3	(1995) High-Pressure Decorative Laminates

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80	(1995) Fire Doors and Fire Windows

NFPA 252	(1995) Fire Tests of Door Assemblies

WINDOW AND DOOR MANUFACTURERS ASSOCIATION (WDMA)

WDMA I.S. 1-A	(1993) Architectural Wood Flush Doors
WDMA I.S. 4	(1994) Water-Repellent Preservative Non-Pressure Treatment for Millwork
WDMA I.S. 6	(1991) Wood Stile and Rail Doors
WDMA TM-5	(1990) Split Resistance Test
WDMA TM-7	(1990) Cycle - Slam Test
WDMA TM-8	(1990) Hinge Loading Resistance Test

UNDERWRITERS LABORATORIES (UL)

UL 10B	(1997) Fire Tests of Door Assemblies

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3109	(2001) Door Sets

1.2 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Doors; G

Submit drawings or catalog data showing each type of door unit. Drawings and data shall indicate door type and construction, sizes, thickness, door louvers and glazing.

SD-03 Product Data

Doors; G

Accessories

Sound transmission class rating; G

Fire resistance rating; G

SD-04 Samples

Doors

Prior to the delivery of wood doors, submit a sample section of each type of door, which shows the stile, rail, veneer, finish, and core construction.

Door finish colors; G

Submit a minimum of three color selection samples for selection by the Contracting Officer.

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver doors to the site in an undamaged condition and protect against damage and dampness. Stack doors flat under cover. Support on blocking, a minimum of 100 mm (4 inches) thick, located at each end and at the midpoint of the door. Store doors in a well-ventilated building so that they will not be exposed to excessive moisture, heat, dryness, direct sunlight, or extreme changes of temperature and humidity. Do not store in a building under construction until concrete, masonry work, and plaster are dry. Replace defective or damaged doors with new ones.

1.4 WARRANTY

Warranty shall warrant doors free of defects as set forth in the door manufacturer's standard door warranty.

PART 2 PRODUCTS

2.1 DOORS

Provide doors of the types, sizes, and designs indicated.

2.1.1 Stile and Rail Doors

Standard grade Ponderosa Pine doors or standard stile and rail doors conforming to WDMA I.S. 6 or KS F 3109. When laminated panels are furnished, they shall be not less than three ply. Flat panels shall have a minimum finished panel thickness of 13 mm (1/2 inch). Raised panels shall have a minimum finished panel thickness of 20 mm (3/4 inch).

2.1.2 Flush Doors

Flush doors shall conform to WDMA I.S. 1-A or KS F 3109. Hollow core doors shall have lock blocks and 25 mm (one inch) minimum thickness hinge stile. Stile edge bands of doors to receive natural finish shall be hardwood, compatible with face veneer. Stile edge bands of doors to be painted shall be mill option specie. No visible finger joints will be accepted in stile edge bands. When used, locate finger-joints under hardware.

2.1.2.1 Interior Flush Doors

Provide staved lumber, particleboard or hollow core, Type II flush doors conforming to WDMA I.S. 1-A or KS F 3109 with faces of good grade natural birch or good grade red oak. Hardwood veneers shall be plain sliced random or book matched. Finish plastic laminate faced doors on both vertical edges with wood or laminated plastic of color matching faces.

2.1.3 Bi-Fold Closet Doors

Provide hardboard grade flush doors conforming to WDMA I.S. 1-A., paneled or louvered doors standard grade conforming to WDMA I.S. 6. Doors shall be 35 mm (1 3/8 inch) thick. Equip doors with the manufacturer's standard hardware, including tracks, hinges, guides, and pulls.

2.1.4 Sliding Closet Doors

Flush doors shall conform to WDMA I.S. 1-A. Paneled and Louvered doors shall conform to WDMA I.S. 6 standard grade. Doors shall be 35 mm (1 3/8 inch) thick. Equip doors with the manufacturer's standard hardware.

2.1.5 X-Ray Resistant Doors

WDMA I.S. 1-A solid core flush doors, hardwood veneered, minimum 44.5 or 50 mm (1 3/4 or 2 inch) thick, of sizes and construction indicated. Lead sheet shall be 99.9 percent pure lead, 5 mm (3/16 inch) for 44.5 mm thick door, and 6 mm (1/4 inch) for 50 mm thick door, free from dross, oxide, inclusions, laminations, scale, blisters, and cracks. Lead sheets shall be located as standard with the manufacturer, shall extend fully from edge to edge, from top to bottom, and shall be an integral part of the door. Provide wood edge strips compatible with face veneers.

2.1.6 Acoustical Doors

WDMA I.S. 1-A, solid core, constructed to provide Sound Transmission Class rating of 40 when tested in accordance with ASTM E 90.

2.1.7 Fire Doors

Doors specified or indicated to have a fire resistance rating shall conform to the requirements of UL 10B, ASTM E 152, or NFPA 252 for the class of door indicated. Affix a permanent metal label with raised or incised markings indicating testing agency's name and approved hourly fire rating to hinge edge of each door.

2.2 ACCESSORIES

2.2.1 Door Louvers

Fabricate from wood and of sizes indicated. Louvers shall be of the manufacturer's standard design and shall transmit a minimum of 35 percent free air. Louvers shall be the slat or sightproof inverted vee slat type. Mount louvers in the door as indicated with flush wood moldings or wood lip moldings.

2.2.2 Door Light Openings

Provide glazed openings with the manufacturer's standard wood moldings except that moldings for doors to receive natural finish shall be of the same specie and color as the face veneers. Moldings on exterior doors shall have sloped surfaces. Provide glazed openings in fire-rated doors with fire rated frames. Glazing is specified in Section 08810, "Glass and Glazing."

2.2.3 Additional Hardware Reinforcement

Provide fire rated doors with hardware reinforcement blocking. Size of lock blocks shall be as required to secure the hardware specified. Top, bottom and intermediate rail blocks shall measure 125 mm (5 inches) minimum by full core width. Reinforcement blocking shall be in compliance with the manufacturer's labeling requirements and shall not be mineral material similar to the core.

2.3 FABRICATION

2.3.1 Prefitting

At the Contractor's option, doors may be provided factory pre-fit. Doors shall be sized and machined at the factory by the door manufacturer in accordance with the standards under which they are produced. The work shall include sizing, bevelling edges, mortising, and drilling for hardware and providing necessary beaded openings for glass and louvers. Provide the door manufacturer with the necessary hardware samples, and frame and hardware schedules as required to coordinate the work.

2.3.2 Finishes

2.3.2.1 Field Painting

Factory prime or seal doors, and field paint as specified in Section 09900, "Paints and Coatings."

2.3.2.2 Factory Finish

Provide doors finished at the factory by the door manufacturer as follows: AWI Qual Stds Section 1500, specification for System No. 4 Conversion varnish alkyd urea or System No. 5 Vinyl catalyzed. The coating shall be AWI Qual Stds premium, medium rubbed sheen, open or closed grain effect. Use stain when required to produce the finish specified for color. Seal edges, cutouts, trim, and wood accessories, and apply two coats of finish compatible with the door face finish. Touch-up finishes that are scratched or marred, or where exposed fastener holes are filled, in accordance with the door manufacturer's instructions. Match color and sheen of factory finish using materials compatible for field application.

2.3.2.3 Plastic Laminate Finish

Factory applied, NEMA LD 3, General or Specific purpose type, 1.25 mm (0.050 inch) minimum thickness. Glue laminated plastic for hollow core doors to wood veneer, plywood, or hardboard backing to form door panel. Combined minimum thickness of laminate sheet and backing shall be 2.5 mm (0.10 inch).

2.3.3.4 Color

Provide door finish colors as selected by the Contracting Officer from the color selection samples.

2.4 SOURCE QUALITY CONTROL

Stiles of "B" and "C" label fire doors utilizing standard mortise leaf hinges shall meet the following performance criteria:

a. Split resistance: Average of ten test samples shall be not less than 225 kilograms (500 pounds) load when tested in accordance with WDMA TM-5.

b. Cycle-slam: 200,000 cycles with no loose hinge screws or other visible signs of failure when tested in accordance with the requirements of WDMA TM-7.

c. Hinge loading resistance: Average of ten test samples shall be not less than 315 kilograms (700 pounds) load when tested for direct screw withdrawal in accordance with WDMA TM-8 using a No. 12, 30 mm (1 1/4 inch) long, steel, fully threaded wood screw. Drill 4 mm (5/32 inch) pilot hole, use 40 mm (1 1/2 inch) opening around screw for bearing surface, and engage screw full, except for last 3 mm (1/8 inch). Do not use a steel plate to reinforce screw area.

PART 3 EXECUTION

3.1 INSTALLATION

Before installation, seal top and bottom edges of doors with the approved water-resistant sealer. Seal cuts made on the job immediately after cutting using approved water-resistant sealer. Fit, trim, and hang doors with a 2 mm (1/16 inch) minimum, 3 mm (1/8 inch) maximum clearance at sides and top, and a 5 mm (3/16 inch) minimum, 6 mm (1/4 inch) maximum clearance over thresholds. Provide 10 mm (3/8 inch) minimum, 11 mm (7/16 inch) maximum clearance at bottom where no threshold occurs. Bevel edges of doors at the rate of 3 mm in 50 mm (1/8 inch in 2 inches). Door warp shall not exceed 6 mm (1/4 inch) when measured in accordance with WDMA I.S. 1-A.

3.1.1 Fire Doors

Install fire doors in accordance with NFPA 80. Do not paint over labels.

3.2 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurement commonly agreed to by the manufacturers or other parties. The inch-pound and metric measurements are as follows:

PRODUCTS	INCH-POUND	METRIC
Closet doors	1 3/8 inches	35 mm
X-Ray resistant doors	1 3/4 inches	44.5 mm
	2 inches	50 mm

SECTION 08330

OVERHEAD ROLLING DOORS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A 653/A 653M (2001a) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip process

ASTM E 84 (2001) Surface Burning Characteristics of Building Materials

ASTM E 330 (1997el) Structural Performance of Exterior Windows, Curtain walls,and Doors by Uniform Static Air Pressure Difference

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE Hdbk-IP (2001) Fundamentals Handbook, IP Edition

ASHRAE Hdbk-SI (2001) Fundamentals Handbook, SI Edition

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2 (2002) Industrial Controls and Systems Controllers, Contactors, and Overload Relays Rated Not More Than 2,000 Volts AC or 750 Volts DC

NEMA ICS 6	(1993; R 2001) Industrial Control and Systems Enclosures
NEMA MG 1	(1998) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2002) National Electrical Code
NFPA 80	(1999) Fire Doors and Fire Windows

1.2 DESCRIPTION

Overhead rolling doors shall be spring counterbalanced, rolling type, with interlocking slats, complete with guides, fastenings, hood, brackets, and operating mechanisms, and shall be designed for use on openings as indicated. Fire doors shall bear the Underwriters Laboratories, Warnock Hersey, Factory Mutual or other nationally recognized testing laboratory label for the rating listed on the drawings. Each door shall be provided with a permanent label showing the manufacturer's name and address and the model/serial number of the door. Doors in excess of the labelled size shall be deemed oversize and shall be provided with a listing agency oversize label, or a listing agency oversize certificate, or a certificate signed by an official of the manufacturing company certifying that the door and operator have been designed to meet the specified requirements.

1.2.1 Wind Load Requirements

Doors and components shall be designed to withstand the minimum design wind load of 960 Pa (20 psf) or as indicated on the drawings. Doors shall be constructed to sustain a superimposed load, both inward and outward, equal to 1-1/2 times the minimum design wind load. Test data showing compliance with design windload requirements for the specific door design tested in accordance with the uniform static air pressure difference test procedures of ASTM E 330 shall be provided. Recovery shall be at least 3/4 of the maximum deflection within 24 hours after the test load is removed. Sound engineering principles may be used to interpolate or extrapolate test results to door sizes not specifically tested

1.2.2 Operational Cycle Life

All portions of the door and door operating mechanism that are subject to movement, wear, or stress fatigue shall be designed to operate through a minimum number of 10 cycles per day. One complete cycle of door operation is defined as when the door is in the closed position, moves to the full open position, and returns to the closed position.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings; G.

Installation

Drawings showing the location of each door including schedules. Drawings shall include elevations of each door type, details and method of anchorage, details of construction, location and installation of hardware, shape and thickness of materials, details of joints and connections, and details of guides, power operators, controls, and other fittings.

SD-03 Product Data

Overhead Rolling Doors; G.

Manufacturer's catalog data, test data, and summary of forces and loads on the walls/jambs. Manufacturer's preprinted installation instructions.

SD-06 Test Reports

Tests

Written record of fire door drop test.

SD-07 Certificates

Fire Doors; G.

Oversize labels or certificates stating that the overhead rolling doors conform to requirements of this section. Certificates for oversize fire doors stating that the doors and hardware are manufactured in compliance with the requirements for doors of this type and class and have been tested and meet the requirements for the class indicated. Certificate is not required when fire door has a listing agency label or oversize label on the door bottom bar.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

Two (2) copies of the system operation manual and system maintenance and repair manual for each type of door and control system.

1.4 DELIVERY AND STORAGE

Doors shall be delivered to the jobsite wrapped in a protective covering with the brands and names clearly marked thereon. Doors shall be stored in a dry location that is adequately ventilated and free from dirt and dust, water, and other contaminants, and in a manner that permits easy access for inspection and handling.

1.5 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a 1-year period shall be provided.

1.6 OPERATION AND MAINTENANCE MANUALS

Operating instructions outlining the step-by-step procedures required for motorized door and shutter operation for the overhead rolling door unit shall be provided. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, troubleshooting guides, and simplified diagrams for the equipment as installed shall be provided. A complete list of parts and supplies, source of supply, and a list of the high mortality maintenance parts shall be provided.

PART 2 PRODUCTS

2.1 OVERHEAD ROLLING DOORS

Doors shall be surface-mounted type with guides at jambs set back a sufficient distance to clear the opening. Exterior doors shall be mounted as indicated.

2.1.1 Curtains

The curtains shall roll up on a barrel supported at the head of opening on brackets, and shall be balanced by helical torsion springs. Steel or stainless steel slats for doors less than 4.6 m (15 feet) wide shall be minimum bare metal thickness of 0.71 mm (0.0281 inches). Steel or stainless steel slats for doors from 4.6 to 6.4 m (15 to 21 feet) wide shall be minimum bare metal thickness of 0.87 mm (0.0344 inches). Steel or stainless steel slats for doors 6.4 m (21 feet) wide and wider shall be minimum bare metal thickness of 1.1 mm (0.0438 inches). Aluminum slats for doors up to 5.6 m (18 feet 4 inches) wide shall be minimum 1.3 mm (0.050 inches). Slats shall be of the minimum bare metal decimal thickness required for the width indicated and the wind pressure specified above. Slats for fire doors over 3.6 m (12 feet) wide and under 6 m (20 feet) wide shall be not less than 0.87 mm (0.0329 inches) steel. Slats for fire doors 6 m (20 feet) wide or wider shall be not less than 1.1 mm (0.0438 inches) steel.

2.1.1.1 Non-Insulated Curtains

Curtains shall be formed of interlocking slats of shapes standard with the manufacturer. Slats for exterior doors shall be flat type.

2.1.1.2 Insulated Curtains

The slat system shall supply a minimum R-value of 4 when calculated in accordance with ASHRAE Hdbk-IP ASHRAE Hdbk-SI. Slats shall be of the flat type as standard with the manufacturer. Slats shall consist of a urethane OR polystyrene core not less than 17 mm (11/16 inch) thick, completely enclosed within metal facings. Exterior face of slats shall be gauge as specified for curtains. Interior face shall be not lighter than 0.56 mm (0.0219 inches). The insulated slat assembly shall have a flame spread rating of not more than 25 and a smoke development factor of not more than 50 when tested in accordance with ASTM E 84.

2.1.2 Endlocks and Windlocks

The ends of each alternate slat for interior doors shall have steel or iron endlocks of manufacturer's stock design. Endlocks shall be provided in accordance with manufacturer's listing on fire doors when required by test results performed by the code listing agency. In addition to endlocks, non-rated exterior doors shall have the manufacturer's standard windlocks as required to withstand the wind load. Windlocks shall prevent the curtain from leaving guides because of deflection from specified wind pressure.

2.1.3 Bottom Bar

The curtain shall have a standard or sloped bottom bar consisting of two hot-dip galvanized steel angles for steel doors, two aluminum angles for aluminum doors, or extruded aluminum T-shape. A sensing edge shall be attached to the bottom bar of doors that are electric-power operated.

2.1.4 Guides

Guides shall be steel structural shapes or formed steel shapes, of a size and depth to provide proper clearance for operation and resistance under the design windload. Guides shall be attached to adjoining construction with fasteners recommended by the manufacturer. Spacing of fasteners shall be as required to meet the minimum design windload. Doors and guides in hazardous areas shall have static grounding.

2.1.5 Barrel

The barrel shall be steel pipe or commercial welded steel tubing of proper diameter for the size of curtain. Deflection shall not exceed 2.5 mm per meter (0.03 inch per foot) of span. Ends of the barrel shall be closed with metal plugs, machined to fit the pipe. Aluminum plugs are acceptable on non-fire door barrels.

2.1.6 Springs

Oil tempered helical steel counter-balance torsion springs shall be installed within the barrel and shall be capable of producing sufficient torque to assure easy operation of the door curtain. Access shall be provided for spring tension adjustment from outside of the bracket without removing the hood.

2.1.7 Brackets

Brackets shall be of steel plates to close the ends of the roller-shaft housing, and to provide mounting surfaces for the hood. An operation bracket hub and shaft plugs shall have sealed prelubricated ball bearings.

2.1.8 Hoods

Hoods shall be steel, stainless steel, or aluminum with minimum bare metal thickness of 0.56 mm (0.0219 inches) formed to fit contour of the end brackets, and shall be reinforced with steel rods, rolled beads, or flanges at top and bottom edges. Multiple segment and single piece hoods shall be provided with support brackets of the manufacturer's standard design as required for adequate support.

2.1.9 Weatherstripping

Exterior doors shall be fully weatherstripped. A compressible and replaceable weather seal shall be attached to the bottom bar. Weather seal at door guides shall be continuous vinyl or neoprene, bulb or leaf type, or shall be nylon-brush type. A weather baffle shall be provided at the lintel or inside the hood. Weatherstripping shall be easily replaced without special tools.

2.1.10 Slat Openings

2.1.10.1 Vision Lites

Vision lites shall be those standard for the manufacturer. The lite assembly shall consist of 3 separate lites across and 5 slats high or as indicated. Opening shall have manufacturer's standard acrylic coverings.

2.1.10.2 Ventilation/Vision Perforations

Perforations shall be manufacturer's standard design and size. Weather stripping for door guides and hoods shall be omitted from perforated doors.

2.1.11 Operation

Doors shall be operated by means of manual, push-up, hand-chain, crank, or electric power with auxiliary chain hoist as indicated.

2.1.11.1 Manual Push-Up Operation

One lifting handle shall be provided on each side of the door. The maximum force required for lift-handle operation shall not exceed 111 N (25 lbf). Pull-down straps or pole hooks shall be provided on bottom rail of doors over 2.1 m (7 feet) high.

2.1.11.2 Manual Hand-Chain Operation

Operation shall be by means of a galvanized or bronze (in hazardous areas) endless chain extending to within 915 mm (3 feet) of floor. Reduction shall be provided by use of roller chain and sprocket drive or suitable gearing, to reduce the pull required on hand chain to not over 156 N (35 lbf). Gears shall be high grade gray cast iron.

2.1.11.3 Manual Crank Operation

Operation shall be by means of a vertical shaft, gear box, and crank located approximately 864 mm (34 inches) above the floor or reduction gearing and awning type handle. Gears shall be of high grade gray cast-iron. Gear reduction shall be provided to reduce pressure exerted on the crank to not over 156 N (35 lbf).

2.1.11.4 Electric Power Operator With Auxiliary Chain Hoist Operation

Electric power operators shall be heavy-duty industrial type. The unit shall operate the door through the operational cycle life specified. The electric power operator shall be complete with electric motor, auxiliary operation, self-locking worm gear in oil bath for heavy-duty doors, brake, mounting brackets, push button controls, limit switches, magnetic reversing starter, and all other accessories necessary to operate components specified in other paragraphs of this section. The operator shall be so designed that the motor may be removed without disturbing the limit-switches settings and without affecting the emergency chain operator. Doors shall be provided with an auxiliary operator for immediate emergency manual operation of the door in case of electrical failure. Auxiliary operation shall be by means of galvanized or bronze (in hazardous areas) endless chain extending to within 915 mm (3 feet) of the floor. The emergency manual operating mechanism shall be so arranged that it may be operated from the floor without affecting the settings of the limit switches. A mechanical device shall be included that will disconnect the motor from the drive operating mechanism when the auxiliary operator is used. Where control voltages differ from motor voltage, a control voltage transformer shall be provided in and as part of the electric power operator system. Control voltage shall not exceed 120 volts.

a. Motors: Drive motors shall conform to NEMA MG 1, shall be high-starting torque, reversible type, and shall be of sufficient wattage horsepower and torque output to move the door in either direction from any position at a speed range of 0.18 m per second (6 to 8 inches per second) without exceeding the rated capacity. Motors shall be suitable for operation on 115/200 volts, 60 hertz, single/3 phase current and shall be suitable for across-the-line starting. Motors shall be designed to operate at full capacity over a supply voltage variation of plus or minus 10 percent of the motor voltage rating. Motors shall be provided with overload protection.

b. Controls: Control equipment shall conform to NEMA ICS 2. Enclosures shall conform to NEMA ICS 6, Type 12 (industrial use), Type 7 or 9 in hazardous locations, in accordance with NFPA 70. Exterior control stations shall be weatherproof key-operated type with corrosion-resistant cast-metal cover. Each control station shall be of the three position button or switch type, marked "OPEN," "CLOSE," and "STOP." The "OPEN" and "STOP" controls shall be of the momentary contact type with seal-in contact. The "CLOSE" control shall be of the momentary contact type or constant pressure type. When the door is in motion and the "STOP" control is pressed, the door shall stop instantly and remain in the stop position; from the stop position, the door shall be operable in either direction by the "OPEN" or "CLOSE" controls. Controls shall be of the full-guarded type to prevent accidental operation. Readily adjustable limit switches shall be provided to automatically stop the doors at their fully open and closed positions.

c. Sensing Edge Device: The bottom edge of electric power operated doors shall have an electric or a pneumatic sensing edge for hazardous or non-hazardous areas that will reverse the door movement upon contact with an obstruction and cause the door to return to its full open position. The sensing edge shall not substitute for a limit switch. Exterior doors shall be provided with a combination compressible weather seal and sensing edge.

d. Electrical Work: Conduit and wiring necessary for proper operation shall be provided under Section 16415 ELECTRICAL WORK, INTERIOR. Flexible connections between doors and fixed supports shall be made with flexible type SJO cable, except in hazardous locations where wiring shall conform to NFPA 70, as appropriate. The cable shall have a spring-loaded automatic take up reel or a coil cord equivalent device.

2.1.12 Inertia Brake

Overhead rolling door shall have a mechanical inertia brake device which will stop the door from free fall in any position, should there be a failure in the motor operator brake or roller chain drive. The unit shall be capable of being reset with a back drive action.

2.1.13 Locking

Locking shall consist of interior slide bolts, suitable for padlock by others, for manual push-up doors, or chain lock keeper, suitable for padlock by others, for chain operated doors, or locking disc or slide bolt, suitable for padlock by others, for crank operated doors. Locking for motor operated doors shall consist of self-locking gearing and optional master keyed cylinder with electrical interlock with chain lock for emergency hand chain.

2.1.14 Finish

Steel slats and hoods shall be hot-dip galvanized G60 in accordance with ASTM A 653/A 653M, and shall be treated for paint adhesion and shall receive a factory baked-on finish coat or factory baked-on prime coat for field finishing. Aluminum slats and hoods shall receive a clear anodized or color anodized finish. Stainless steel slats and hoods shall receive a #4 finish. Surfaces other than slats, hood, and faying surfaces shall be cleaned and treated to assure maximum paint adherence and shall be given a factory dip or spray coat of rust inhibitive metallic oxide or synthetic resin primer. Color shall be as indicated.

2.2 FIRE DOORS

Fire rated rolling doors shall be provided at locations shown on the drawings. Fire doors shall conform to the requirements specified herein and to NFPA 80 for the class indicated. Doors shall bear the label or oversize label, or be provided with oversize certification of a recognized testing agency indicating the listed rating for the fire door. The construction details necessary for the listed rating shall take precedence over conflicting details shown or specified herein. Fire doors shall be complete with hardware, accessories, and automatic closing device. An automatic closing device shall operate upon the fusing of a 74 degree C (165 degree F) replaceable fusible link, or activation of the building's fire alarm system.

PART 3 EXECUTION

3.1 INSTALLATION

Doors shall be installed in accordance with approved detail drawings and manufacturer's instructions. Anchors and inserts for guides, brackets, motors, switches, hardware, and other accessories shall be accurately located. Upon completion, doors shall be free from warp, twist, or distortion. Doors shall be lubricated, properly adjusted, and demonstrated to operate freely. Fire doors shall be installed in conformance with the requirements of NFPA 80 and the manufacturer's instructions.

3.2 FIELD PAINTED FINISH

Steel doors and frames shall be field painted in accordance with Section 09900 PAINTING, GENERAL. Weatherstrips shall be protected from paint. Finish shall be free of scratches or other blemishes. Color shall be as indicated on the drawings.

3.3 TESTS

The fire doors shall be drop tested in accordance with NFPA 80 to show proper operation and full automatic closure and shall be reset in accordance with the manufacturer's instructions. A written record of initial test shall be provided to the Contracting Officer.

SECTION 08331

METAL ROLLING COUNTER DOORS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 240/A 240M (1999b) Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels

ASTM A 653/A 653M (1999a) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM B 209 (1996) Aluminum and Aluminum-Alloy Sheet and Plate

ASTM B 209M (1995) Aluminum and Aluminum-Alloy Sheet and Plate (Metric)

ASTM B 221 (1996) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

ASTM B 221M (1996) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80 (1999) Fire Doors and Fire Windows

1.2 GENERAL

Rolling counter doors shall be of the type, size, and design indicated on the drawings, and shall be the standard product of a manufacturer regularly engaged in the production of rolling counter doors. Each door shall be provided with a permanent label showing the manufacturer's name and address and the model number of the door.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings; G.

Drawings showing elevations of each door type, details of anchorage, details of construction, location and description of hardware, shape and thickness of materials, details of joints and connections, and details of guides and fittings. A schedule showing the location of each counter door shall be included with the drawings.

SD-03 Product Data

Rolling Counter Doors; G.

Manufacturer's descriptive data and catalog cuts.

Installation

Cleaning

Manufacturer's preprinted installation and cleaning instructions.

SD-10 Operation and Maintenance Data

Operation;

Two (2) complete copies of maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, troubleshooting guides, and simplified diagrams for the equipment as installed.

1.4 DELIVERY AND STORAGE

Rolling counter doors shall be delivered to the jobsite wrapped in a protective covering with the brands and names clearly marked thereon. Rolling counter doors shall be stored in accordance with the manufacturer's instructions in a dry location that is adequately ventilated and free from dust, water, or other contaminants, and in a manner that permits easy access for inspecting and handling. Doors shall be handled carefully to prevent damage. Damaged items that cannot be restored to like-new condition shall be replaced.

1.5 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period shall be provided.

PART 2 PRODUCTS

2.1 BASIC COMPONENTS

2.1.1 Curtain

The curtain shall be fabricated of extruded aluminum slats conforming to ASTM B 221M ASTM B 221, Alloy 6063, 22 gauge Type 304 stainless steel slats conforming to ASTM A 240/A 240M, Type 304 or Type 430, or 22 gauge galvanized steel slats conforming to ASTM A 653/A 653M, Coating Designation G60 as specified. Thickness of slat material shall be as required by width of opening or as required by specified fire-rating. Slats shall be approximately 32 to 38 mm (1-1/4 to 1-1/2 inch) wide with a depth of crown of 13 mm (1/2 inch). Alternate slats shall be fitted with end locks to maintain curtain alignment. Bottom of curtain shall be provided with angle or tubular bar reinforcement matching the curtain, and fitted with a resilient bottom seal.

2.1.2 Jamb Guides

Guides shall be of 3 mm (1/8 inch) minimum thickness extruded aluminum conforming to ASTM B 221M ASTM B 221, Alloy 6063, and shall be fitted with neoprene silencers or replaceable heavy nap striping to eliminate noise and dust infiltration, or 13 gauge minimum thickness stainless steel conforming to ASTM A 240/A 240M, Type 304 or Type 430, or 13 gauge minimum thickness galvanized steel angles conforming to ASTM A 653/A 653M, Coating Designation G60 as indicated.

2.1.3 Counterbalance Shaft Assembly

The curtain shall be coiled around a steel tube of sufficient thickness and diameter to prevent deflection exceeding 2.5 mm per meter (0.03 inch per foot). The barrel shall contain oil tempered helical steel torsion springs capable of sufficient torque to counterbalance the weight of the curtain. Springs shall be calculated to provide a minimum of 7,500 operating cycles (one complete cycle of door operation will begin with the door in the closed position, move to the full open position and return to the closed position).

2.1.4 Brackets

Brackets shall be a minimum 12 gauge thickness steel if flat plate, or 16 gauge thickness if there are a minimum of 3 returns of 19 mm (3/4 inch) width.

2.1.5 Hood

The hood shall be of 1.02 mm (0.040 inch) minimum thickness aluminum sheet conforming to ASTM B 209M ASTM B 209, Alloy 5005, or 24 gauge stainless steel conforming to ASTM A 240/A 240M, Type 304 or Type 430, or 24 gauge galvanized steel conforming to ASTM A 653/A 653M, Coating Designation G60 as indicated.

2.1.6 Locks

The curtain shall be locked at each side of the bottom bar by an integral slide bolt suitable for padlocks by others, or both sides of bottom bar by a chrome-plated cylinder lock keyed into the building keying system as indicated. Lock shall be on the user¡¯s room side of the counter door. Pad locks and keying shall be as shown.

2.2 ROLLING COUNTER DOOR (NON-RATED)

Rolling counter doors shall conform to the requirements specified herein and shall be constructed of aluminum, stainless steel or galvanized steel curtains, guides and hood components as indicated.

2.3 FIRE-RATED ROLLING COUNTER DOOR

Fire-rated rolling counter doors shall be Class A (3 hr.), Class B (1-1/2 hr.), Class C (3/4 hr.) or Class D (1-1/2 hr.) rated as shown and shall conform to the requirements specified and to NFPA 80 for the class indicated. Doors shall bear the labels of a recognized testing agency indicating the applicable fire resistance rating. The construction details necessary for labeled rolling counter doors shall take precedence over details indicated or specified herein. Door curtains, guides and hood shall be stainless steel or galvanized steel. Fire-rated rolling counter doors shall be complete with hardware, accessories, and automatic closing device. Rolling counter doors in exit corridor walls shall be provided with perimeter smoke and draft control gasketing.

2.4 INTEGRAL FRAME ROLLING COUNTER DOOR (RATED OR NON-RATED)

Integral frame rolling counter door shall be aluminum (non-rated only), stainless steel or galvanized steel as shown. Fire-rated doors, Class A (3 hr.), Class B (1-1/2 hr.), Class C (3/4 hr.) or Class D (1-1/2 hr.) shall be stainless steel or galvanized steel. Fire-rated doors shall conform to the requirements of NFPA 80 for the Class indicated and shall bear the labels of a recognized testing agency indicating the applicable fire resistance rating. Jambs shall be formed to create guides for the curtain. Head and jambs shall be 16 gauge thickness. Counter shall be 14 gauge thickness. Rolling counter doors in exit corridor walls shall be provided with perimeter smoke and draft control gasketing.

2.5 OPERATION

2.5.1 Manual Operation

The curtain shall be operated by means of manual push-up with lift handles or continuous full width lift bar, or manual crank with removable handle.

2.5.2 Power Operation

A high-starting torque, reversible type motor of sufficient power and torque output to move the door in either direction from any position at the required speed shall be furnished. Power operator shall have an emergency push-up operation, limit switch, three-button type control marked "OPEN", "CLOSE", and "STOP". Control voltage shall be 24 vac or 120 vac. Conduit and wiring necessary for proper operation shall be provided in accordance with Section 16415 ELECTRICAL WORK, INTERIOR.

2.6 AUTOMATIC CLOSING DEVICE

Fire-rated counter doors shall be equipped with an automatic closing device which shall operate upon the fusing of a 74 degrees C (165 degree F) fusible link, activation of the building's fire alarm system or smoke alarm system. Fire and smoke doors shall be easily reset by the facility user after they have been released by the detection system. Resetting the door shall not require the use of special tools.

2.7 FINISH

Exposed parts of the counter door, including the curtain, bottom rail, guides, and hood shall be of uniform finish and appearance. Aluminum shall have a clear anodized finish. Stainless steel shall have a No. 4 finish. Steel galvanized coating shall have a prime coat and a baked-on or powder-coated Factory top coat finish. All other steel parts shall be given a shop coat of primer paint standard with the manufacturer. Factory coated color shall be as shown.

PART 3 EXECUTION

3.1 INSTALLATION

Doors shall be installed in accordance with approved detail drawings and manufacturer's instructions. Anchors and inserts for guides, brackets, hardware, and other accessories shall be accurately located. Upon completion, doors shall be free from warp, twist, or distortion. Doors shall be lubricated, properly adjusted, and demonstrated to operate freely. Fire-door installation shall be in conformance with NFPA 80 for the class indicated and the manufacturer's instructions.

3.2 FIELD FINISHING

Doors to receive field finishing shall be factory primed, as required, and then shall be finished in accordance with Section 09900 PAINTING, GENERAL. Color shall be as indicated.

3.3 CLEANING

Aluminum and stainless steel doors shall be cleaned in accordance with manufacturer's approved instructions.

3.4 TESTS

The fire doors shall be drop tested in accordance with NFPA 80 to show proper operation and full automatic closure and shall be reset in accordance with the manufacturer's instructions. A written record of initial test shall be provided to the Contracting Officer.

SECTION 08353

ACCORDION PARTITIONS AND FOLDING DOORS

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PAGE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 84	(1999) Surface Burning Characteristics of Building Materials
ASTM E 90	(1999) Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions
ASTM E 413	(1987; R 1999) Rating Sound Insulation
ASTM F 793	(1993; R 1998) Standard Classification of Wallcovering by Durability Characteristics

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA LD 3	(1995) High-Pressure Decorative Laminates

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Folding Doors; G. Accordion Partitions; G

Drawings containing complete schematic diagrams and details required demonstrating that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

SD-03 Product Data

Folding Doors; G. Accordion Partitions; G

Manufacturer's descriptive data, performance charts, catalog cuts, and installation instructions.

SD-04 Samples

Accordion Partitions; G. Folding Doors; G

Manufacturer's standard color samples of specified surfaces and finishes.

SD-07 Certificates

Materials; G. Accordion Partitions; G. Folding Doors; G

Certificate attesting that the materials meet the requirements specified and those partitions have specified acoustical and flame retardant properties, as determined by test.

SD-10 Operation and Maintenance Data

Accordion Partitions; Folding Doors

Three (3) complete copies of operating instructions outlining the procedures required for electrically operated partitions. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and operating features. Data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 year and 3 years of service.

Three (3) complete copies of maintenance instructions explaining routine maintenance procedures including inspection, adjustments, lubrication, and cleaning. The instructions shall list possible breakdown, methods of repair, and a troubleshooting guide. The instructions shall include equipment layout and simplified wiring and control diagrams of the system as installed.

1.3 DELIVERY AND STORAGE

Materials shall be delivered to the jobsite in the manufacturer's original, unopened packages and shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.4 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period shall be provided.

PART 2 PRODUCTS

2.1 MATERIALS

Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Door and partition finishes shall have a Class A rating when tested in accordance with ASTM E 84.

2.1.1 Vinyl Covering

The vinyl coated fabric shall conform to ASTM F 793, Category V, Type II (Medium duty). Covering shall have wood grain, solid color or textured design as indicated on the drawings.

2.1.2 Plastic Laminate

Plastic laminate shall conform to NEMA LD 3, 1.5 mm (1/16 inch) minimum thickness, wood grain, patterned or solid color finish as indicated on the drawings.

2.1.3 Wood Veneer

Wood veneer shall be Premium Grade, book matched birch, red oak or American walnut hardwood as indicated on the drawings.

2.1.4 Wall Carpet Surfacing

Wall carpet surfacing shall be a vertically-ribbed acoustical synthetic fiber material. Pile height shall be minimum 2.5 mm (0.098 inch) thickness.

2.1.5 Hardware

Accordion partitions or Folding doors shall be furnished with grip handles with locking hardware as indicated on the drawings. An upper latch with extended pulls shall be provided on units over 2400 mm (8 feet high). Hardware shall be anodized aluminum with a natural finish, chrome plated or brass plated metal, or painted finish.

2.1.6 Sweep Strips

Sweep strips shall be vinyl or other material which will not crack or craze with severe usage. Sweep strip shall control STC to the specified rating.

2.1.7 Track

Track shall be recessed or surface mounted as shown and shall be of extruded aluminum or enamel finish steel. Track shall be manufacturer's standard product designed for the weight of door or partition furnished. Track sections shall be provided in the maximum lengths practicable, not less than 1800 mm (6 feet) long except for narrow doors and at ends of runs where short length is required. Suitable joint devices such as interlocking keys shall be provided at each joint to provide permanent alignment of track.

2.1.8 Ceiling Guard

Ceiling guard shall be provided when steel track is recessed. Guard shall be of metal of adequate thickness to protect the ceiling from damage by door operation and shall be provided with the door manufacturer's standard neutral-color applied finish. Guard on aluminum track shall be an integral part of the track.

2.1.9 Vinyl Restrictions

Vinyls shall contain a non-mercury based mildewcide and shall be manufactured without the use of cadmium-based stabilizers.

2.2 ACCORDION PARTITIONS

Accordion partitions shall consist of top hung ball bearing carriers which support a system of hinged folding panels with a durable surface finish. Partitions shall have perimeter and jamb seals which shall provide the indicated STC rating. Ferrous metal parts shall be either cadmium plated or zinc coated and post shall have manufacturer's standard shop finish paint. Partitions shall be manually or electrically operated as shown. Opening width shall be as shown.

2.2.1 Pantograph Framework with Flexible Covering

Accordion partitions shall have a steel pantograph hinged framework and shall be non-STC rated or have a sound liner and shall meet the STC rating of as shown in accordance with ASTM E 90 and ASTM E 413. Intermediate pantographs shall be provided as required and partition shall have a control device to prevent flattening of the folds when the panel is fully extended. The covering shall be vinyl coated fabric or wall carpet.

2.2.2 Wood Core Panels

Accordion partitions shall have bracketed supports or bracketed hinged steel yoke supports with engineered wood core panels surfaced with architectural wood veneer, plastic laminate, vinyl wall covering or wall carpet as shown. Panels shall be hinged and sealed to reduce sound. The STC rating shall be as shown on the drawings in accordance with ASTM E 90 and ASTM E 413.

2.2.3 Steel Panels

Accordion partitions shall be vinyl-clad cold rolled steel panels connected by full length steel hinges. Inner surface of the panels shall be covered with insulating material. A spacing chain shall be provided to control panel spacing and extension. The STC rating of the partition shall be as shown in accordance with ASTM E 90 and ASTM E 413.

2.3 FOLDING DOORS

Folding doors (Serpentine) shall consist of engineered wood core panels supported by top hung nylon tired ball bearing carriers. Panels shall be 10 mm (0.38 inches) minimum thick particle board continuously connected by extruded vinyl hinges. Panels shall have factory applied vinyl finish. Folding door system shall be non-STC rated. Doors shall be manually operated. Opening width shall be as shown.

2.4 ELECTRICAL OPERATORS

Electrical operator shall be furnished and installed where indicated. Operation shall cause retraction of seals providing minimum 25 mm (1 inch) clearance with the floor. Final closing movement shall automatically seal the partition in place without the use of supplementary manually operated devices. Operation shall be two key controls wired in series and located on opposite sides of the room and opposite ends of the partition. Minimum travel speed shall be 15 mm/second (30 fpm). Operator shall have motor adequate for partition weight, complete with speed reducer, friction clutch, relays, limit switches, and an emergency release mechanism to permit manual operation.

2.5 SAFETY DEVICE

The leading edge of electrically operated doors shall have an electric or a pneumatic as shown safety device that will immediately reverse the door movement upon contact with an obstruction and cause the door to return to its full open position.

2.6 COLOR

Color shall be as indicated on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

Installation shall be in accordance with the manufacturer's approved installation instructions. Electrical work shall conform to Section 16415 ELECTRICAL WORK, INTERIOR.

SECTION 08360

SECTIONAL OVERHEAD DOORS

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36/A 36M (1997; Rev. A) Carbon Structural Steel

ASTM A 123/A 123M (1997; Rev. A) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 227/A 227M (1993) Steel Wire, Cold-Drawn for Mechanical Springs

ASTM A 229/A 229M (1993) Steel Wire, Oil-Tempered for Mechanical Springs

ASTM A 653/A 653M (1998) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM B 209M (1995) Aluminum and Aluminum-Alloy Sheet and Plate (Metric)

ASTM B 209 (1996) Aluminum and Aluminum-Alloy Sheet and Plate

ASTM B 221M	(1996) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B 221	(1996) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM C 236	(1989; R 1993) Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box
ASTM E 330	(1997) Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM MFM	(1988) Metal Finishes Manual

DOOR AND ACCESS SYSTEMS MANUFACTURERS ASSOCIATION (DASMA)

DASMA 102	(1988) Sectional Overhead Type Doors

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(1993) Industrial Control and Systems
NEMA ICS 2	(1993) Industrial Control and Systems Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC
NEMA ICS 6	(1993) Industrial Control and Systems Enclosures
NEMA MG 1	(1993; Rev. 1-4) Motors and Generators
NEMA ST 20	(1992) Dry-Type Transformers for General Applications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

1.2 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Doors; G.

Show types, sizes, locations, metal gages including minimum metal decimal thickness, hardware provisions, installation details, and other details of construction. For electrically-operated doors, include supporting brackets for motors, location, type, and ratings of motors, switches, and safety devices.

SD-03 Product Data

Doors; G.

Electric operators; G.

For electrically motor-operated doors, submit manufacturer's wiring diagrams for motor and controls.

SD-08 Manufacturer's Instructions

Doors

SD-10 Operation and Maintenance Data

Doors

Two (2) complete copies of maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. The instructions shall include simplified diagrams for the equipment as installed. Also spare parts data for each different item of material and equipment specified, including a complete list of parts and supplies, source of supply, and a list of high mortality maintenance parts. Two (2) complete copies of operation instructions outlining the step-by-step procedure required for motorized door and shutter operation. The instructions shall include the manufacturer's name, model/serial number, service manual, parts list, and brief description of all equipment and their basic operating features.

1.3 DELIVERY, STORAGE, AND HANDLING

Protect doors and accessories from damage during delivery, storage, and handling. Clearly mark manufacturer's brand name. Store doors in dry locations with adequate ventilation, free from dust and water. Storage shall permit easy access for inspection and handling. Remove damaged items and provide new.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Hard-Drawn Springwire

ASTM A 227/A 227M.

2.1.2 Oil-Tempered Springwire

ASTM A 229/A 229M.

2.1.3 Steel Sheet

ASTM A 653/A 653M.

2.1.4 Steel Shapes

ASTM A 36/A 36M.

2.1.5 Aluminum Extrusions

ASTM B 221MASTM B 221, Alloy 6063-T5.

2.1.6 Aluminum Sheets and Strips

ASTM B 209MASTM B 209, alloy and temper best suited for the purpose.

2.1.7 Glass

Fully tempered, clear float glass 3 mm (1/8 inch) thick.

2.2 DOORS

DASMA 102. Commercial or Industrial doors. Metal doors shall be horizontal sections hinged together which operate in a system of tracks to completely close the door opening in the closed position and make the full width and height of the door opening available for use in the open position. Provide a permanent label on the door indicating the name and address of the manufacturer. Doors shall be of the standard lift type designed to slide up and back into a horizontal overhead position and requiring a maximum of 400 mm (16 inches) of headroom for 50 mm (2 inch) tracks and 535 mm (21 inches) of headroom for 75 mm (3 inch) tracks, or low headroom type designed to slide up and back into a horizontal overhead position and requiring a maximum of 250 mm (10 inches) of headroom for 50 mm (2 inch) tracks and 300 mm (12 inches) of headroom for 75 mm (3 inch) tracks, or high lift type designed to slide up and back into a combination vertical and horizontal position, or vertical lift type designed to slide upward into a vertical position. Doors shall be operated by hand chain with gear or sprocket reduction, by hand crank with gear or sprocket reduction, or by electric power with auxiliary hand chain operation.

2.3 DESIGN REQUIREMENTS

DASMA 102 except that design wind load shall be as indicated for the building. Doors shall remain operable and undamaged after conclusion of tests conducted in accordance with ASTM E 330 using the design wind load.

2.4 FABRICATION

2.4.1 Steel Overhead Doors

Form door sections of hot-dipped galvanized steel not lighter than 1.5 mm thick (16 gage) with flush surface without ribs or grooves or 0.9 mm thick (20 gage) with longitudinal integral reinforcing ribs or 0.6 mm thick (24 gage) with longitudinal integral reinforcing ribs and flat bottom V-grooves. Sections shall be not less than 50 mm (2 inches) in thickness. Meeting rails shall have interlocking joints to ensure a weathertight closure and alignment for full width of the door. Sections shall be of the height indicated or the manufacturer's standard, except the height of an intermediate section shall not exceed 600 mm thick (24 inches). Bottom sections may be varied to suit door height, but shall not exceed 750 mm (30 inches) in height. Provide glass panels as indicated. Install panels using rubber gaskets as standard with the door manufacturer.

2.4.1.1 Insulated Sections

Insulate door sections with fibrous glass or plastic foam to provide a "U" factor of 0.14 or less when tested in accordance with ASTM C 236. Cover interior of door sections with steel sheets of not lighter than 0.6 mm thick (24 gage) to completely enclose the insulating material.

2.4.1.2 Aluminum Sections

At the Contractor's option, door sections may be constructed of aluminum in lieu of steel. Aluminum sections shall, as a minimum, provide the same structural and thermal properties as specified for steel sections.

2.4.2 Aluminum Panel Overhead Doors

Door sections shall be of panel construction with extruded aluminum stiles and rails with aluminum and glass panels. Stiles and rails shall have a minimum wall thickness of 1.5 mm (0.060 inch). Meeting rails shall have interlocking joints to ensure a weathertight closure and alignment for full width of door. Sections shall be of the height indicated or the manufacturer's standard, but the height of an intermediate section shall not exceed 600 mm (24 inches). Bottom sections may be varied to suit door height, but shall not exceed 750 mm (30 inches) in height. Aluminum panels shall be not less than 1.0 mm (0.040 inch) in thickness. Install panel using a continuous vinyl gasket and snap-in type of aluminum or vinyl glazing bead. Install glass panels as specified for aluminum panels.

2.4.3 Tracks

Provide galvanized steel tracks not lighter than 1.8 mm thick for 50 mm (14 gage) for 2 inch tracks and not lighter than 2.5 mm thick for 75 mm (12 gage for 3 inch) tracks. Provide vertical tracks with continuous steel angle not lighter than 2.1 mm thick (13 gage) for installation to walls. Incline vertical track through use of adjustable brackets to obtain a weathertight closure at jambs. Reinforce horizontal track with galvanized steel angle; support from track ceiling construction with galvanized steel angle and cross bracing to provide a rigid installation.

2.4.4 Hardware

Provide hinges, brackets, rollers, locking devices, and other hardware required for complete installation. Roller brackets and hinges shall be 14 gage galvanized steel. Rollers shall have ball bearings and case-hardened races. Provide reinforcing on doors where roller hinges are connected. Provide a positive locking device and cylinder lock with two keys on manually operated doors.

2.4.5 Counterbalancing

Counterbalance doors with an oil-tempered, helical-wound torsional spring mounted on a steel shaft. Spring tension shall be adjustable; connect spring to doors with cable through cable drums. Cable safety factor shall be at least 7 to 1.

2.5 MANUAL OPERATORS

2.5.1 Pushup Operators

Provide lifting handles on both sides of door. The force required to operate the door shall not exceed 11.25 kilograms (25 pounds). Provide pulldown straps or ropes at bottom of doors over 2130 mm (7 feet) high.

2.5.2 Chain Hoist Operators

Provide a galvanized, endless chain operating over a sprocket. Extend chain to within 1200 mm (4 feet) of the floor and mount on inside of building. Obtain reduction by use of roller chain and sprocket drive or gearing. Provide chain cleat and pin for securing operator chain. Hoist shall allow for future installation of power operators. The force required to operate the door shall not exceed 15.75 kilograms (35 pounds).

2.6 ELECTRIC OPERATORS

2.6.1 Operator Features

Provide operators of the drawbar type or side mount (jack shaft) type as recommended by the manufacturer. Operators shall include electric motor, machine-cut reduction gears, steel chain and sprockets, magnetic brake, brackets, pushbutton controls, limit switches, magnetic reversing contactor, a manual chain hoist operator as specified above for emergency use, and other accessories necessary for operation. Design electric operator so motor may be removed without disturbing the limit switch timing and without affecting the manual operator. Provide the operator with slipping clutch coupling to prevent stalling the motor. The emergency manual operator shall be clutch controlled so that it may be engaged and disengaged from the floor; operation shall not affect limit switch timing. The manual operator is not required if door can be manual-pushup operated with a force not to exceed 11.25 kilograms (25 pounds). Provide an electrical or mechanical device that disconnects the motor from the operating mechanism when the manual operator is engaged.

2.6.2 Motors

NEMA MG 1, high-starting torque, reversible type with sufficient horsepower and torque output to move the door in either direction from any position. Motor shall produce a door travel speed of not less than 200 mm (two-thirds foot) or more than 300 mm (one foot) per second without exceeding the rated capacity. Motors shall be operate on current of the characteristics indicated at not more than 377 rad/s (3600 rpm). Single-phase motors shall not have commutation or more than one starting contact. Motor enclosures shall be drip-proof type or NEMA TENV type.

2.6.3 Controls

Each door motor shall have an enclosed, across-the-line type, magnetic reversing contactor, thermal overload and undervoltage protection, solenoid-operated brake, limit switches, and control switches. Locate control switches at least 1500 mm (5 feet) above the floor so the operator will have complete visibility of the door at all times. Control equipment shall conform to NEMA ICS 1 and NEMA ICS 2. Control enclosures shall be NEMA ICS 6, Type 12 or Type 4, except that contactor enclosures may be Type 1. Each control switch station shall be of the three-button type with buttons marked "OPEN," "CLOSE," and "STOP." The "OPEN" and "STOP" buttons shall require only momentary pressure to operate. The "CLOSE" button shall require constant pressure to maintain the closing motion of the door. If the door is in motion and the "STOP" button is pressed or the "CLOSE" button released, the door shall stop instantly and remain in the stop position; from the stop position, the door may be operated in either direction by the "OPEN" or "CLOSE" button. Pushbuttons shall be full-guarded to prevent accidental operation. Provide limit switches to automatically stop doors at the fully open and closed positions. Limit switch positions shall be readily adjustable.

2.6.4 Safety Device

Provide a pneumatic or electric type safety device on the bottom edge of electrically-operated doors. The device shall immediately stop and reverse the door movement during the closing travel upon contact with an obstruction in the door opening or upon failure of any component of the control system. The door-closing circuit shall be automatically locked out and the door shall be operable manually until the failure or damage has been corrected. Do not use the safety device as a limit switch.

2.6.5 Control Transformers

NEMA ST 20. Provide transformers in power circuits as necessary to reduce the voltage on the control circuits to 120 volts or less.

2.6.6 Electrical Components

NFPA 70. Furnish manual or automatic control and safety devices, including extra flexible Type SO cable and spring-loaded automatic takeup reel or equivalent device, as required for operation of the doors.

2.7 WEATHER SEALS AND SAFETY DEVICE

Provide exterior doors with weatherproof joints between sections by means of tongue-and-groove joints, rabbetted joints, shiplap joints, or wool pile, vinyl or rubber weatherstripping; a rubber, wool pile, or vinyl, adjustable weatherstrip at the top and jambs; and a compressible neoprene, rubber, wool pile, or vinyl weather seal attached to the bottom of the door. On exterior doors that are electrically operated, the bottom seal shall be combination compressible weather seal and safety device for stopping and reversing door movement.

2.8 FINISHES

Concealed ferrous metal surfaces and tracks shall be hot-dip galvanized. Other ferrous metal surfaces, except rollers and lock components, shall be hot-dip galvanized and shop primed.

2.8.1 Galvanized and Shop Primed

Surfaces specified shall have a zinc coating, a phosphate treatment, and a shop prime coat of rust-inhibitive paint. The galvanized coating shall conform to ASTM A 653/A 653M, coating designation Z180 G60, for steel sheets, and ASTM A 123/A 123M for assembled steel products. The weight of coatings for assembled products shall be as designated in Table I of ASTM A 123/A 123M for the class of material to be coated. The prime coat shall be a type especially developed for materials treated by phosphates and adapted to application by dipping or spraying. Repair damaged zinc-coated surfaces with galvanizing repair paint and spot prime. At the Contractor's option,a two-part system including bonderizing, baked-on epoxy primer, and baked-on enamel topcoat may be applied in lieu of prime coat specified.

2.8.2 Aluminum

Surfaces shall receive a clear anodized finish, AA-M10-C22-A41, in accordance with NAAMM MFM. Exposed surfaces shall receive a pretreatment and a white baked-on enamel finish as standard with the manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

NFPA 70. Install doors in accordance with approved shop drawings and manufacturer's instructions. Upon completion, doors shall be weathertight and free from warp, twist, or distortion. Lubricate and adjust doors to operate freely.

3.2 ELECTRICAL WORK

NFPA 70. Conduit, wiring, and mounting of controls are as specified.

3.3 TESTING

After installation is complete, operate doors to demonstrate installation and function of operators, safety features, and controls. Correct deficiencies.

SECTION 08510

STEEL WINDOWS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B18.6.3 (1972; R 1997) Machine Screws and Machine Screw Nuts

ANSI B18.6.4 (1981; R 1997) Thread Forming and Threaded Cutting Tapping Screws and Metallic Drive Screws (Inch Series)

ASME INTERNATIONAL (ASME)

ASME A39.1 (1995) Safety Requirements for Window Cleaning

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123/A 123M	(1997; Rev. A) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 167	(1996) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 569/A 569M	(1998) Steel, Carbon (0.15 Maximum Percent), Hot Rolled Sheet and Strip Commercial
ASTM A 653/A 653M	(1998) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM D 3656	(1997) Insect Screening and Louver Cloth Woven from Vinyl-Coated Glass Yarns
ASTM E 283	(1991) Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E 330	(1997) Structural Performance of ExteriorWindows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference
ASTM E 331	(1996) Water Penetration of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80	(1995) Fire Doors and Fire Windows
NFPA 101	(2003) Life Safety Code

STEEL WINDOW INSTITUTE (SWI)

SWI SWS	(1990) Steel Window Specifications

1.2 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Windows; G.

Indicate elevations of windows, full-size sections, thicknesses and gages of metal, fastenings, proposed method of anchoring, size and spacing of anchors, details of construction, method of glazing, details of operating hardware, method and materials for weatherstripping, method of attachment of screens, metal subframes, stools, casings, sills, trim, window cleaners' bolts, other related items, and installation details.

SD-03 Product Data

Windows; G.

Manufacturer¡¯s descriptive data and catalog cut sheets. Manufacturer¡¯ preprinted installation instructions and cleaning instructions.

SD-04 Samples

Color coating; G.

Submit chart of manufacturer's color coatings if factory finish is to be provided in lieu of field painting.

SD-06 Test Reports

Air infiltration

Water infiltration

Mullion and transom bar wind load

1.3 TEST REPORT REQUIREMENTS

1.3.1 Air and Water Infiltration

ASTM E 283 and ASTM E 331. Air infiltration shall not exceed 0.05 cubic meter per minute per meter (one-half cubic foot per minute per foot) of crack length when subjected to a static pressure of 75 Pa (1.56 pounds per square foot) (equivalent to a wind velocity of 40 kilometers per hour (kph) 25 miles per hour (mph)). Water infiltration shall be "zero."

1.3.2 Mullion and Transom Bar Wind Load Tests

ASTM E 330. Members shall withstand a uniform wind load of 958 Pa (20 pounds per square foot) of window area without deflecting more than 1/175 of the span.

1.4 DELIVERY AND STORAGE

Deliver to project site in undamaged condition. Store windows and components on edge, out of contact with the ground, under weathertight covering, and arranged to avoid bending, warping, or other damage.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Steel Bars

SWI SWS.

2.1.2 Sheet Steel

ASTM A 569/A 569M.

2.1.3 Zinc-Coated Sheet Steel

ASTM A 653/A 653M.

2.1.4 Zinc Coating

ASTM A 123/A 123M.

2.1.5 Corrosion Resisting Sheet Steel

ASTM A 167.

2.1.6 Screws and Bolts

ANSI B18.6.3 or ANSI B18.6.4 as applicable.

2.2 FABRICATION OF WINDOWS

Form permanent joints by welding or mechanically fastening as specified for each type window. Use joints of strength to maintain structural value of members connected. Weld joints solid, remove excess metal, and dress smooth on exposed and contact surfaces. Closely fit joints formed with mechanical fastenings and make permanently watertight. Assemble frames and sash, including ventilators, at the plant and ship as a unit with hardware unattached. Provide the following construction:

a. Where fixed window sections adjoin ventilator sections, provide fixed sash, fabricated from similar frame members, and of manufacturer's standard type suitable for the purpose.

b. Roll weathering surfaces integrally to provide two-point parallel-surface contact with overlap at both inside and outside points of closure.

c. Provide drips and weep holes as required to return water to outside.

d. Design glazed windows and rabbets suitable for glass thickness shown on drawings or specified.

e. Use flathead, cross recessed type, exposed head screws and bolts with standard threads on windows, trim and accessories. Screw heads shall finish flush with adjoining surfaces. Self tapping sheet-metal screws are not acceptable.

f. For hot-dipped galvanized windows, use stainless steel or hot-spun galvanized steel fasteners. For windows with painted finish use cadmium plated or electro-galvanized fasteners. Finish exposed heads to match finish of windows.

2.3 FIRE RATED WINDOWS

Provide sash and frame with necessary hardware to conform to the requirements of Underwriters Laboratories Inc. (UL), for class of window indicated. Submit proof of conformance. UL label will be accepted as proof. Labeled window details take precedence over details indicated or specified for nonlabeled windows, except when sections required for nonlabeled windows are heavier than those required by UL. In lieu of UL label, written certification by approved nationally recognized testing agency may be submitted. Certification must state that complete window unit of type provided has been tested and conforms to published standards, including methods of tests, of UL.

2.4 PROVISIONS FOR GLAZING

Design sash for inside or outside glazing and for securing glass with metal beads or glazing clips and glazing compound. Where insulating glass is indicated, use rabbets of adequate weight and depth to receive and properly support glass and glazing accessories. Glass and glazing is specified in Section 08800, "Glass and Glazing."

2.5 MULLIONS AND TRANSOM BARS

Provide mullions between multiple window units designed to withstand specified wind load requirements. Secure mullions and transom bars to adjoining construction and window units in such a manner as to permit expansion and contraction and to form weathertight joint. Anchor mullions between windows requiring window cleaner's bolts to provide safe and adequate support for window cleaner. Where window cleaners' bolts are fastened to mullions, reinforce backs of mullions. Provide mullion covers of manufacturer's stock design on the interior and exterior to completely cover exposed joints and recesses between window units and for neat appearance. Provide special covers over structural supports at mullions as indicated.]

2.6 METAL-TO-METAL JOINTS

Set in mastic, using type recommended by window manufacturer to provide weathertight joints. Remove excess mastic before it hardens.

2.7 ACCESSORIES

Provide windows with hardware, clips, fins, anchors, glazing beads, and fastenings, necessary for complete installation and operation of ventilators.

2.7.1 Anchors

Use hot-dip galvanized steel anchors. Secure anchors and fastenings to heads, jambs, and sills of openings, and fasten securely to windows or frames. Use anchors recommended by window manufacturer for specific type of construction and conceal. Anchor each frame at jambs with minimum of three adjustable steel anchors. For anchorage at concrete walls and prepared openings, equip frames with manufacturer's standard bent-clips located approximately 150 mm (6 inches) from each end and at midpoint.

2.7.2 Window-Cleaners' Anchors

Provide on window frames at indicated locations. Use double-head stainless steel anchors conforming to ASME A39.1, two for each single window and each adjacent fixed glass window unit. Locate 1120 mm (44 inches) above window sill. Apply to frames at factory or ship loose for field attachment to frames before windows are set. Reinforce backs of frames to receive bolts with 6 mm (0.25 inch) thick by 150 mm (6 inch) long steel plates welded or fastened securely to frames at factory. Provide special wall anchors on backs of frames at points where bolts are located.

2.7.3   Weatherstripping

Provide on all operable windows so that, when tested before leaving factory, in accordance with ASTM E 283, air infiltration shall not exceed 0.05 cubic meter per minute per meter one half cubic foot per minute per foot of crack length when subjected to static pressure of 75 Pa (1.56 pounds) per square foot equivalent to wind velocity of 40 kmh (25 mph).

2.7.4   Hardware

Equip all operable sash with latching device which can be secured from inside. The item, type, and function of hardware required are specified under individual window type. Attach hardware securely to windows with corrosion resisting bolts or machine screws; do not use sheet metal screws. At fixed screens, adapt hardware to permit operation of ventilators. Fit and test hardware for each window at factory to ensure satisfactory operation and security.

2.7.4.1   Material and Finish

Provide non-magnetic type stainless steel exposed hardware with satin finish; white bronze with satin finish; yellow bronze with dull (oxidized) finish. Use steel or malleable iron hinges, with nonferrous pins, or with steel pins and non-ferrous bushings or washers. Finish on hinges shall match windows.

2.7.5   Fasteners

Stainless steel stainless steel or aluminum materials; zinc-coated or cadmium plated steel elsewhere. Prime exposed heads of coated or plated fasteners and finish to match adjacent material.

2.7.6   Metal Sub-frames and Stools

Manufacturer's standard type designed to suit the particular window. Exposed surfaces to match windows.

2.8   WINDOW FINISH

2.8.1   Shop Primed Finish

After fabrication, clean all surfaces of windows, fins, mullions, cover plates, and screen frames and provide a phosphate-treated and shop-primed finish or a hot-dip galvanized, phosphate-treated and shop primed finish. The methods of cleaning, chemical treatment, galvanizing, and painting shall conform to SWI SWS. Windows shall receive finish paint coats as specified in Section 09900, "Paints and Coatings."

2.8.2   Factory Finish

In lieu of shop primed finish, factory finish may be provided using the following method, in which case finish field painting will not be required:

a. Chemically clean and bonderize windows. Apply dip coat of epoxy primer baked on for not less than 15 minutes at not less than 149 degrees C (300 degrees F), followed by finish coat of alkyd-amine enamel of not less than 0.025 mm (one mil) thickness, baked on for 15 minutes at not less than 149 degrees C (300 degrees F).

b. Finish color coating to be selected from manufacturer's standard color chart.

c. Touch up abraded surfaces with enamel as specified for factory finish.

2.9 WINDOW TYPES

Conform to SWI SWS. Provide combinations, types and sizes indicated. Each window should be consist of a unit including subframe or frame sash, hardware, trim, casing, insect screen, storm units, and anchors as per drawings. Windows indicated to have screens or storm units shall be designed to accommodate items to be furnished.

2.9.1 Awning Windows

Heavy Intermediate materials in group of top-hinged or projected out-swinging ventilators:

2.9.1.1 Operators

Control shall be simultaneous by means of a rotary mechanical power unit manually operated by bronze crankhandle, providing positive adjustment and holding of vents in any position from fully open to fully closed. Operator shall securely close ventilators on both sides of window without additional locking devices. Heavy-duty worm-gear rotary operator with machine-cut case-hardened steel gears in steel housing with smooth lacquer finish.

2.9.1.2 Ventilators

Support on two hinges and two arms, or on two steel slide arms pivoted to vent and to principal frame member. Pivots shall be bronze-brushed and hinges shall have bronze pins. Design ventilators to close and weather on each other, or on independent meeting rails assembled as part of window frame. Provide for positive adjustment of individual vents to ensure positive contact between sash and frame when closed.

2.9.2 Fixed Windows

Standard Intermediate, heavy Intermediate, or Heavy Custom windows as shown on drawings.

2.9.3 Sscurity Windows

SWI SWS. Provide ventilators with manufacturer's standard hardware of iron, steel or zinc. Equip ventilators having locking rails more than 2 meters (6 feet) above floor with hardware designed for pole operation.

2.10 SCREENS

Provide one insect screen for each operable exterior sash or ventilator. Locate screen units either inside or outside, depending upon window type and method of operation. Provide full-length top-hung or half-length fixed type screens. Design screens to fit closely around entire perimeter of ventilator or opening, to be rewirable, easily removable from inside building, and interchangeable for same size ventilators of similar type windows, with minimum of exposed fasteners and latches. Provide all guides, stops, clips, bolts, and screws, as necessary, for a secure and insect-tight attachment to window. Where wickets are necessary, use sliding or hinged type, with friction catches, framed and trimmed for durability and tight fit. Provide wicket opening frames of similar material and cross-section as screen frames. Provide continuous framing bar between the two sides of screen frames.

2.10.1 Construction

Provide screen frames of steel with finish matching that of windows. Equip frames with removable splines of steel or vinyl. Form groove in frame for holding screen cloth in place with noncylindrical splines. Make spline and groove assembly so that cloth cannot be removed from groove by pressure on cloth. Make splines of such size and shape that rotation of spline in groove will be prevented and spline will tightly hold cloth in place.

2.10.2 Insect Screening

ASTM D 3656, Class 2, 18 by 14 mesh, color charcoal or grey. Install with weave parallel to frames. Stretch tight for smooth appearance. Conceal edges in spline channels.

PART 3 EXECUTION

3.1 INSTALLATION

Install in accordance with window manufacturer's printed instructions and details. Install fire rated windows in accordance with NFPA 80 and NFPA 101. Build in windows as work progresses or install without forcing into prepared window openings. Set at proper elevation, location, and reveal; plumb, square, level, and in alignment. Brace and stay to prevent distortion and misalignment. Protect ventilators and operating parts against dirt and building materials by keeping closed and locked to frame. Bed screws or bolts in sill members, joints at mullions, contacts of windows with sills, built-in fins, and subframes in mastic sealant recommended by window manufacturer. Install windows in a manner that will prevent entrance of water and wind. Fasten insect screens securely in place.

3.2 ANCHORS AND FASTENINGS

Make provision for securing units to each other and to adjoining construction. Windows installed in direct contact with masonry shall have head and jamb members designed to enter into masonry not less than 11 mm (7/16 inch). Where windows are set in prepared masonry openings, build in anchors and fastenings to jambs of openings and fasten securely to windows or frames and to adjoining construction. Space anchors not more than 450 mm (18 inches) apart on jambs and sills, and install a minimum of three anchors on each side of each opening. Anchors and fastenings shall have sufficient strength to hold member firmly in position. Where type, size, or spacing of anchors is not shown or specified, use expansion or toggle bolts or screws as best suited to construction material. Provide expansion shield and bolt assemblies of type designed to give holding power beyond tensile and shearing strength of bolt. Minimum fastener penetration shall be not less than that recommended by manufacturer for type fastener and wall material involved.

3.3 OPERATORS

Install operators before glazing. Plumb and level shaft risers and runs. Adjust ventilators for free opening and tight closing. Secure housings and adjustable supports to wall. Anchor operator parts to steel window mullions with 13 mm (1/2 inch) bolts. Couple individual lengths of shafting with steel rivets or bolts. Leave mechanical equipment and ventilators in proper operating condition.

3.4 WEATHERSTRIPPING

Use bronze, spring-brass, or stainless steel and secure with non-ferrous screws. Secure weatherstripping or rubbing-blocks to parting-strip and each end of meeting-rails. For solid bar stock windows, use manufacturer's standard weatherstripping inserted into groove.

3.5 ADJUSTMENTS AFTER INSTALLATION

After installation of windows and completion of glazing and field painting, adjust all ventilators and hardware to operate smoothly and to provide weathertight sealing when ventilators are closed and locked. Lubricate hardware and operating parts. Adjust weatherstripping to assure weathertight contact with frames when ventilators are closed and locked. Weatherstripping shall not cause binding of sash, or prevent closing and locking of ventilator.

3.6 CLEANING

Clean interior and exterior surfaces of window units of mortar, plaster, paint spattering spots, and other foreign matter to present a neat appearance and to prevent fouling of weathering surfaces and weatherstripping, or interference with operation of hardware. Clean and touch up abraded surfaces. Replace with new windows any stained, discolored, or abraded windows that cannot be restored to original condition.

SECTION 08520

ALUMINUM AND ENVIRONMENTAL CONTROL ALUMINUM WINDOWS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF-45 (1997) Designation System for Aluminum Finishes

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 101 (1997) Voluntary Specifications for Aluminum, Vinyl (PVC) and Wood Windows and Glass Doors

AAMA 603 (1998) Voluntary Performance Requirements and Test Procedures for Pigmented Organic Coatings on Extruded Aluminum

AAMA 605 (1998) voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 3656	(1997) Insect Screening and Louver Cloth Woven from Vinyl-Coated Glass Yarns
ASTM E 283	(1991) Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E 330	(1997el) Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference
ASTM E 331	(1996) Water Penetration of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference
ASTM E 547	(1996) Water Penetration of Exterior Windows, Curtain Walls, and Doors by Cyclic Static Air Pressure Differential

ASME INTERNATIONAL (ASME)

ASME A39.1	(1995; A39.1a; A39.1b) Safety Requirements for Window Cleaning

INSECT SCREENING WEAVERS ASSOCIATION (ISWA)

ISWA IWS 089	(1990) Recommended Standards and Specifications for Insect Wire Screening (Wire Fabric)

NATIONAL FENESTRATION RATING COUNCIL (NFRC)

NFRC 100	(1997) Procedure for Determing Fenestration Product U-factors
NFRC 200	(1997) Procedure for Determining Fenestration Product Solar Heat Gain Coefficients at Normal Incidence

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2003) Life Safety Code

SCREEN MANUFACTURERS ASSOCIATION (SMA)

SMA ANSI/ SMA 1004	(1987) Aluminum Tubular Frame Screens for Windows

KOREAN INDUSTRIAL STANARDS (KS)

KS D 8303	(1994) Combined Coatings of Anodic Oxide and Organic Coatings on Aluminum and Aluminum Alloys
KS F 2292	(1998) Test Method of Air Leakage of Windows and Doors
KS F 2293	(1998) Test Method of Water Penetration of Windows and Doors
KS F 3117	(1999) Window Sets

1.2 WINDOW PERFORMANCE

Aluminum windows shall meet the following performance requirements. Testing requirements shall be performed by an independent testing laboratory or agency. Exterior window having an insulating glass shall be a thermally broken aluminum window frame.

1.2.1 Structural Performance

Structural test pressures on window units shall be for positive load (inward) and negative load (outward) in accordance with ASTM E 330. After testing, there shall be no glass breakage, permanent damage to fasteners, hardware parts, support arms or actuating mechanisms or any other damage which could cause window to be inoperable. There shall be no permanent deformation of any main frame, sash or ventilator member in excess of the requirements established by AAMA 101 for the window types and classification specified in this section.

1.2.2 Air Infiltration

Air infiltration shall not exceed the amount established by AAMA 101 for each window type when tested in accordance with ASTM E 283 or KS F 2292.

1.2.3 Water Penetration

Water penetration shall not exceed the amount established by AAMA 101 for each window type when tested in accordance with ASTM E 547 or KS F 2293.

1.2.4 Thermal Performance

Thermal transmittance for thermally broken aluminum windows with insulating glass shall not exceed a U-factor of 2.0 W/m^2K (0.35 $Btu/hr\text{-}ft^2\text{-}F$) determined according to NFRC 100. Window units shall comply with the U.S. Department of Energy, Energy Star Window Program for the Northern Climate Zone.

1.2.5 Condensation Index Rating

The condensation index rating shall be 85 as determined using NFRC approved software THERM.

1.2.6 Life Safety Criteria

Windows shall conform to NFPA 101 Life Safety Code when rescue and/or second means of escape are indicated.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Aluminum Windows; G. Insect Screens; G.

Drawings indicating elevations of window, rough-opening dimensions for each type and size of window, full-size sections, thickness of metal, fastenings, methods of installation and anchorage, connections with other work, type of wall construction, size and spacing of anchors, method of glazing, types and locations of operating hardware, mullion details, weatherstripping details, screen details including method of attachment, and window schedules showing locations of each window type.

SD-03 Product Data

Aluminum Windows; G.

Manufacturer's descriptive data and catalog cut sheets. Manufacturer's preprinted installation instructions and cleaning instructions.

SD-04 Samples

Aluminum Windows; G.

Manufacturer's standard color samples of the specified finishes.

SD-06 Test Reports

Aluminum Windows; G.

Reports for each type of aluminum window attesting that identical windows have been tested and meet all performance requirements established under paragraph WINDOW PERFORMANCE.

SD-07 Certificates

Aluminum Windows;

Certificates stating that the aluminum windows are AAMA certified conforming to requirements of this section. Labels or markings permanently affixed to the window will be accepted in lieu of certificates. Product ratings determined using NFRC 100 and NFRC 200 shall be authorized for certification and properly labeled by the manufacturer.

1.4 QUALIFICATION

Window manufacturer shall specialize in designing and manufacturing the type of aluminum windows specified in this section, and shall have a minimum of 3 years of documented successful experience. Manufacturer shall have the facilities capable of meeting contract requirements, single-source responsibility and warranty.

1.5 DELIVERY AND STORAGE

Aluminum windows shall be delivered to project site and stored in accordance with manufacturer's recommendations. Damaged windows shall be replaced with new windows.

1.6 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period shall be provided.

PART 2 PRODUCTS

2.1 ALUMINUM WINDOW TYPES

Aluminum windows shall consist of complete units including sash, glass, frame, weatherstripping, and hardware. Windows shall conform to AAMA 101 or KS F 3117. Windows shall be single-glazed or thermal break type double-glazed as shown on the drawings. Thermal barrier shall be neoprene, rigid vinyl, or polyurethane and shall be resistant to weather. Window members shall be heli-arc welded or angle-reinforced and mechanically joined and sealed. Exposed welded joints shall be dressed and finished. Joints shall be permanent and weathertight. Frames shall be constructed to provide a minimum 6 mm (1/4 inch) thermal break between the exterior and interior frame surfaces. Sash corners shall be internally sealed to prevent air and water leaks. Inner sash shall be key-controlled to swing to the interior to allow maintenance and replacement of the glass. Operable windows shall permit cleaning the outside glass from inside the building.

2.1.1 Single-Hung and Double-Hung Windows

Aluminum single-hung (H) and double-hung (H) windows shall conform to AAMA 101 H-R15 (3'8"x5'0", minimum test size) type or as indicated which operate vertically with the weight of sash offset by a counterbalancing mechanism mounted in window to hold the sash stationary at any open position. Windows shall be provided with a tilt-in sash. Single-hung and double-hung windows shall be provided with locking devices to secure the sash in the closed position. Counterbalancing mechanisms shall be easily replaced after installation.

2.1.2 Fixed Windows

Aluminum fixed (F) windows shall conform to AAMA 101 F-R15 (4'0"x4'0", minimum test size) type or as indicated, non-operable glazed frame, complete with provisions for reglazing in the field.

2.1.3 Horizontal-Sliding Windows

Aluminum horizontal (HS) sliding windows shall conform to AAMA 101 HS-R15 (5'9"x4'0", minimum test size), HS-LC25 (5'9"x4'6", minimum test size) type or as indicated consisting of sliding sash and fixed lite. Sash guides shall be nylon wheels. Windows shall be provided with locking devices to secure the sash in the closed position.

2.2 WEATHERSTRIPPING

Weatherstripping for ventilating sections shall be of type designed to meet water penetration and air infiltration requirements specified in this section in accordance with AAMA 101, and shall be manufactured of material compatible with aluminum and resistant to weather. Weatherstrips shall be factory-applied and easily replaced in the field. Neoprene or polyvinylchloride weatherstripping are not acceptable where exposed to direct sunlight.

2.3 INSECT SCREENS

Insect screens shall be aluminum window manufacturer's standard design, and shall be provided where scheduled on drawings. Insect screens shall be fabricated of roll-formed tubular-shaped aluminum frames conforming to SMA ANSI/SMA 1004 and (18 x 16) aluminum mesh screening conforming with ISWA IWS 089, Type III.

2.4 ACCESSORIES

2.4.1 Fasteners

Fastening devices shall be window manufacturer's standard design made from aluminum, non-magnetic stainless steel, cadmium-plated steel, nickel/chrome-plated steel in compliance with AAMA 101. Self-tapping sheet metal screws will not be acceptable for material thicker than 2 mm (1/16 inch).

2.4.2 Hardware

Hardware shall be as specified for each window type and shall be fabricated of aluminum, stainless steel, cadmium-plated steel, zinc-plated steel or nickel/chrome-plated steel in accordance with requirements established by AAMA 101.

2.4.3 Window Anchors

Anchoring devices for installing windows shall be made of aluminum, cadmium-plated steel, stainless steel, or zinc-plated steel conforming to AAMA 101.

2.4.4 Window Cleaner Anchors

Window cleaner anchors shall be manufactured of stainless-steel conforming to ASME A39.1. Window frames shall be reinforced to receive window cleaner anchors. Locations of window cleaner anchors shall be as shown.

2.5 GLASS AND GLAZING

Aluminum windows shall be designed for inside glazing, field glazing, and for glass types scheduled on drawings and specified in Section 08810 GLASS AND GLAZING. Units shall be complete with glass and glazing provisions to meet AAMA 101. Glazing material shall be compatible with aluminum, and shall not require painting.

2.6 FINISH

2.6.1 Anodized Aluminum Finish

Exposed surfaces of aluminum windows shall be finished with anodic coating conforming to AA DAF-45: Architectural Class II, AA-M10-C22-A31, clear anodic coating, 0.01 to 0.02 mm (0.4 to 0.7 mil) thick, 204-R1 Natural Color or KS D 8303. Finish shall be free of scratches and other blemishes.

2.6.2 Baked-Acrylic Resin-Based Coating

Exposed surfaces of aluminum windows shall be finished with acrylic resin-based coating conforming to AAMA 603, total dry thickness of 0.03 mm (1.0 mil).

Finish shall be free of scratches and other blemishes.

2.6.3 High-Performance Coating

Exposed surfaces of aluminum windows shall be finished with a two-coat fluoropolymer coating system containing at least 70 percent by weight polyvinylidene fluoride, PVF2 resin, factory-applied, oven-baked, conforming to AAMA 605, with a primer coat of 0.005 to 0.008 mm (0.20 to 0.030 mils) and a color coat of minimum 0.025 mm (1.0 mils), total dry film thickness of 0.030 to 0.033 mm (1.2 to 1.3 mils). Finish shall be free of scratches and other blemishes.

2.6.4 Color

Color shall be as shown on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

Aluminum windows shall be installed in accordance with approved shop drawings and manufacturer's published instructions. Aluminum surfaces in contact with masonry, concrete, wood and dissimilar metals other than stainless steel, zinc, cadmium or small areas of white bronze, shall be protected from direct contact using protective materials recommended by AAMA 101. The completed window installation shall be watertight in accordance with Section 07900 JOINT SEALING. Glass and glazing shall be installed in accordance with requirements of this section and Section 08810 GLASS AND GLAZING.

3.2 ADJUSTMENTS AND CLEANING

3.2.1 Hardware Adjustments

Final operating adjustments shall be made after glazing work is complete. Operating sash or ventilators shall operate smoothly and shall be weathertight when in locked position.

3.2.2 Cleaning

Aluminum window finish and glass shall be cleaned on exterior and interior sides in accordance with window manufacturer's recommendations. Alkaline or abrasive agents shall not be used. Precautions shall be taken to avoid scratching or marring window finish and glass surfaces.

SECTION 08550

WOOD WINDOWS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 3117 (1999) Window Sets

1.2 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Wood windows; G.

Indicate elevations of units, full-size sections, fastenings, methods of installation and anchorage, method of glazing, locations of operating hardware, method of attaching, details of installation, and connections with other work.

SD-03 Product Data

Wood windows; G.

SD-08 Manufacturer's Instructions

Wood windows

Submit manufacturer's written instructions for installation.

1.3 DELIVERY AND STORAGE

Deliver windows to site in sealed undamaged cartons or in palletized multiple units. Protect from damage, dampness and extreme temperature or humidity changes. Store under cover in well-ventilated enclosed space. Do not store in a building under construction until concrete, masonry, and plaster are dry. Replace defective or damaged windows.

PART 2 PRODUCTS

2.1 WOOD WINDOWS

Wood windows shall consist of complete units including sash, glass, frame, and hardware. Window units shall meet the KS F 3117, provide hardware for window types as indicated below. Glass and glazing materials shall conform to Section 08810, "Glass and Glazing".

2.1.1 Horizontal-Sliding Windows for Interior

Provide latches, pulls, and corrosion resistant steel slides necessary to control and secure window. Provide for cleaning of both sides of sash from inside.

2.2 FINISHES

2.2.1 Paint

Furnish windows with factory-primed surfaces which will be exempt from first paint coat application required in Section 09900, "Paints and Coatings."

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Wood Windows

Install in accordance with the approved installation instructions. Securely anchor windows in place.

3.2 CLEANING

Clean windows in accordance with manufacturer's recommendations.

SECTION 08700

DOOR HARDWARE

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 283 (1991) Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

ASTM F 883 (1990) Padlocks

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

BHMA A156.1 (2000) Butts and Hinges (BHMA 101)

BHMA A156.2 (1996) Bored and Preassembled Locks and Latches (BHMA 601)

BHMA A156.3 (2001) Exit Devices (BHMA 701)

BHMA A156.4 (2000) Door Controls - Closers (BHMA 301)

BHMA A156.5	(2001)	Auxiliary Locks & Associated Products (BHMA 501)
BHMA A156.6	(2001)	Architectural Door Trim (BHMA 1001)
BHMA A156.7	(1988)	Template Hinge Dimensions
BHMA A156.8	(2000)	Door Controls - Overhead Holders (BHMA 311)
BHMA A156.13	(2002)	Mortise Locks & Latches (BHMA 621)
BHMA A156.15	(2001)	Closer Holder Release Devices
BHMA A156.16	(2002)	Auxiliary Hardware
BHMA A156.17	(1999)	Self Closing Hinges & Pivots
BHMA A156.18	(2000)	Materials and Finishes (BHMA 1301)
BHMA A156.21	(2001)	Thresholds
BHMA A156.22	(2003)	Door Gasketing Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80	(1999)	Fire Doors and Fire Windows
NFPA 101	(2003)	Life Safety Code

STEEL DOOR INSTITUTE (SDOI)

SDI 100	(1991)	Standard Steel Doors and Frames

UNDERWRITERS LABORATORIES (UL)

UL BMD	(1999)	Building Materials Directory
UL 14C	(1999)	Swinging Hardware for Standard Tin-Clad Fire Doors Mounted Singly and in Pairs

KOREAN INDUTRIAL STANDARDS (KS)

KS F 4519	(1997)	Hinges
KS F 4533	(1988)	Pivot Hinges

1.2 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Hardware schedule; G.

Keying system;

SD-03 Product Data

Hardware items; G.

SD-08 Manufacturer's Instructions

Installation;

SD-10 Operation and Maintenance Data

Hardware Schedule items, Data Package 1;

1.3 HARDWARE SCHEDULE

Prepare and submit hardware schedule in the following form:

Hard-ware Item	Quan-tity	Size	Reference Publi-cation Type No.	Finish	Mfr. Name and Catalog No.	Key Con-trol Symbols	UL Mark (If fire rated and listed)	ANSI/BHMA Finish Designa-tion
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1.4 KEY BITTING CHART REQUIREMENTS

Submit key bitting charts to the Contracting Officer prior to completion of the work. Include:

a. Complete listing of all keys (AA1, AA2, etc.).

b. Complete listing of all key cuts (AA1-123456, AA2-123458).

c. Tabulation showing which key fits which door.

d. Copy of floor plan showing doors and door numbers.

e. Listing of 20 percent more key cuts than are presently required in each master system.

1.5 QUALITY ASSURANCE

1.5.1 Hardware Manufacturers and Modifications

Provide, as far as feasible, locks, hinges, pivots, and closers of one lock, hinge, pivot, or closer manufacturer's make. Modify hardware as necessary to provide features indicated or specified.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver hardware in original individual containers, complete with necessary appurtenances including fasteners and instructions. Mark each individual container with item number as shown in hardware schedule. Deliver permanent keys and removable cores to the Contracting Officer, either directly or by certified mail. Deliver construction master keys with the locks.

PART 2 PRODUCTS

2.1 TEMPLATE HARDWARE

Hardware to be applied to metal or to prefinished doors shall be made to template. Promptly furnish template information or templates to door and frame manufacturers. Template hinges shall conform to BHMA A156.7. Coordinate hardware items to prevent interference with other hardware.

2.2 HARDWARE FOR FIRE DOORS AND EXIT DOORS

Provide all hardware necessary to meet the requirements of NFPA 80 for fire doors and NFPA 101 for exit doors, as well as to other requirements specified, even if such hardware is not specifically mentioned under paragraph entitled "Hardware Schedule." Such hardware shall bear the label of Underwriters Laboratories, Inc., and be listed in UL BMD or labeled and listed by another testing laboratory acceptable to the Contracting Officer.

2.3 HARDWARE ITEMS

Hinges, pivots, locks, latches, exit devices, bolts, and closers shall be clearly and permanently marked with the manufacturer's name or trademark where it will be visible after the item is installed. For closers with covers, the name or trademark may be beneath the cover.

2.3.1 Hinges

Hinges shall conform to BHMA A156.1 or KS F 4519. Hinges used on metal doors and frames shall also conform to BHMA A156.7. Except as otherwise specified, hinge sizes shall conform to the hinge manufacturer's printed recommendations and/or as shown below.

a. Doors equipped with overhead closers shall have ball bearing or other anti-friction hinges. Grade 1 hinges normally will be used on doors which are unusually heavy, subjected to unusual stress, or are very high frequency use. Grade 2 hinges normally shall be used on high frequency use doors.

b. For outswinging exterior doors and for interior doors subject to high humidity and/or corrosive conditions, nonferrous hinges or stainless steel hinges should be used. Fire rated doors should have steel hinges.

c. Hinges with loose pins on outswinging exterior doors shall be specified with nonremovable pins or safety stud.

d. Use two hinges for doors up to 1500 mm (5 feet) high, three hinges for doors from 1.5 to 2.25 mm (5 feet to 7 feet 6 inches) and one additional hinge for every additional 750 mm (30 inches) or fraction thereof in height.

See TABLE I for types of hinges to be used for various door and frame materials. When necessary to specify hinge size in the hardware set listing, see TABLE II for hinge sizes.

TABLE I. HINGE SELECTION CHART

Door and Frame	Wood Door With Wood or Hollow Metal Frame, Hollow Metal Door with Hollow Metal Frame	Hollow Metal Door with Channel Frame	Mineral Core Wood or Kalamein Door with Kalamein or Hollow Metal Frame	Mineral Core Wood or Kalamein Door With Channel Frame
Type of Hinge	Full Mortise	Half Mortise	Half Surface	Full Surface
Plain-Bearing:				
Brass, Bronze	A2133	A2233	A2433	A2333
Stainless Steel	A5133	A5233	--	--
Steel	A8133	A8233	A8433	A8333
Antifriction Bearing Standard Weight:				
Brass, Bronze	A2112	A2212	A2412	A2312
Stainless Steel	A5112	A5212	A5412	A5312
Steel	A8112	A8212	A8412	A8312
Antifriction Bearing, Heavy Weight:				
Brass, Bronze	A2111	A2211	A2411	A2311
Stainless Steel	A5111	A5211	A5411	A5311
Steel	A8111	A8211	A8411	A8311

NOTES ON THE USE OF TABLE I

a. Refer to BHMA A156.1 for listing of hinge types and options. Specify options following the designation of hinge type; e.g., A8111 w/Hospital Tips. Requirements for nonremovable pins (NRP) and template hinges have been included in the body of this specification.

b. Weight of door and frequency of use determine hinge weight and bearing structure. Frequency refers to the number of times a door is opened and closed during a set period of time.

c. This table shows types of hinges generally used with door and frame materials listed. Use appropriate designations from BHMA A156.1 if other types are required.

d. Hinges for labeled fire doors must be steel or stainless steel. Specify half-surface hinges for mineral core wood or Kalamein doors to be through-bolted to the doors. Specify back plates for attaching hinges to mineral core wood doors.

TABLE II. HINGE SIZES CHART

Thickness of Doors in mm (Inches)	Width of Doors in mm (Inches)	Height of Hinge (Length of Joint) in mm (Inches)
22 - 29 (7/8 - 1-1/8 screen)	To 915 (36)	76 (3)
35 (1-3/8)	To 815 (32)	89 (3-1/2)
35 (1-3/8)	Over 815 to 940 (32 - 37)	102 (4)
44 (1-3/4)	To 915 (36)	114 (4-1/2)
44 (1-3/4)	Over 915 to 1220 (36 - 48)	127 (5) Heavy Weight
44 (1-3/4)	Over 1220 (48)	152 (6) Heavy Weight
51 57 & 64 (2, 2-1/4 & 2-1/2)	To 1065 (42)	127 (5) Heavy Weight
51 57 & 64 (2, 2-1/4 & 2-1/2)	Over 1065 (42)	152 (6) Heavy Weight

NOTES ON THE USE OF TABLE II

a. Select and size hinges for lead-lined, unusually heavy, and high frequency doors on an individual basis. Lead lined doors may pose a problem, in that pivots may be necessary in lieu of hinges. Manufacturers weight limitations must be referred to when selecting hinges or pivots for lead lined doors.

b. The 114 by 114 mm (4-1/2 by 4-1/2 inches) specified is for 44 mm (1-3/4 inch) doors up to 915 mm (3 feet) wide and with up to 19 mm (3/4 inch) trim projection, and covers a vast majority of applications. For other doors, determine hinge width in accordance with the following formula:

(1) Twice the door thickness plus trim projection, minus 13 mm (1/2 inch), or 2(t plus p)-1/2. If answer falls between regular hinge sizes, use nearest larger size. Formula is for hinges set back 6 mm (1/4 inch) from edge of door.

(2) Pivots may be considered for extra heavy doors such as lead-lined doors. Pivots that permit vertical adjustment are preferred. Center hung pivots are used on double acting doors and generally in connection with floor closers. Offset pivots and intermediate pivots are used on single acting doors.

2.3.2 Pivots

BHMA A156.4 or KS F 4533.

2.3.3 Spring Hinges

BHMA A156.17.

2.3.4 Locks and Latches

2.3.4.1 Mortise Lock and Latchsets

Mortise lock, latchsets, and strikes shall be series 1000 and shall conform to BHMA A156.13, operational Grade 1. Strikes for security doors shall be rectangular without curved lip. Mortise type locks and latches for doors 44 mm (1-3/4 inches) thick and over shall have adjustable bevel fronts or otherwise conform to the shape of the door. Mortise locks shall have armored fronts.

2.3.4.2 Bored Lock and Latchsets

Bored lock, latchsets, and strikes shall be series 4000 and shall conform to BHMA A156.2, Grade 1. Bored type locks and latches for doors 35 mm (1-3/8 inches) thick and over shall have adjustable bevel fronts or otherwise conform to the shape of the door.

2.3.4.3 Electro-Mechanical Locks

Electro-mechanical locks shall allow for locking or unlocking of doors from a remote location by means of push buttons or card reader. Locks shall be fail safe mode (unlocked when power is off) or fail secured mode (exterior side only locked when power is off). Locks shall be mortise series conforming to BHMA A156.13 and bored series conforming to BHMA A156.2 with factory installed electric lock modification or manufactured electro-mechanical locks conforming to BHMA A156.13 or BHMA A156.2 test standards. In hazardous locations, products shall use safe power supplies or be pneumatic.

2.3.4.4 Auxiliary Locks and Associated Products

Bored and mortise dead locks and dead latches, narrow style dead locks and dead latches, rim latches, dead latches, and dead bolts, and electric strikes shall conform to BHMA A156.5. Bolt and latch retraction shall be dead bolt style. Strike boxes shall be furnished with dead bolt and latch strikes for Grade 1. Electric strikes shall be locked or unlocked from a remote location in fail safe or fail secured mode. Electric strike for rated openings shall be fail secured.

2.3.4.5 Lock Cylinders (Mortise, Rim and Bored)

Lock cylinders shall comply with BHMA A156.5.

2.3.4.5.1 Conventional

Lock cylinder shall have not less than six (general-purpose construction) or seven pins (master keyed systems). Cylinders shall have key removable type cores. A construction master keying system or construction interchangeable cores shall be provided as indicated. Disassembly of knob or lockset shall not be required to remove core from lockset. All locksets, lockable exit devices, and padlocks shall accept same interchangeable cores.

2.3.4.5.2 Mechanical Coded

Lock cylinder shall have not less than 35 magnetic pins, each pin having a North and South Pole. Each cylinder shall have anti-rap magnets on the opposite sides of the core. Pins shall operate mechanically with out the use of electrical power. Lock cylinders shall have a construction code setting for use during construction and shall be capable of being reset from outside of the locked room after construction is completed. Lock cylinders shall be changeable on-site without removal or disassembly of the cylinder. Each cylinder shall be capable of accepting a minimum of sixteen (16) different code changes as sub-codes to the basic cylinder.

2.3.4.6 Hospital Latches

Push-pull latchset similar and equal to Glynn-Johnson HL6, 13 mm (1/2 inch) throw, 70 mm (2 3/4 inch) or 127 mm (5 inch) backset, to fit 161 cutout. Cover approximately 64 by 140 mm (2 1/2 by 5 1/2 inches), handle approximately 38 by 114 mm (1 1/2 by 4 1/2 inches), projection approximately 64 mm (2 1/2 inches), covers and handles of stainless steel, BHMA 630 finish, engraved "PUSH" and "PULL" on handles, push handle pointing up, pull handle pointing down.

2.3.4.7 Auxiliary Locks

BHMA A156.5, Grade 1.

2.3.4.8 Combination Locks

Heavy-duty, mechanical combination lockset with five pushbuttons, standard-sized knobs, 20 mm (3/4 inch) deadlocking latch, 70 mm (2 3/4 inch) backset. Lock shall be operated by pressing two or more of the buttons in unison or individually in the proper sequence. Inside knob shall always operate the latch. Provide a keyed cylinder on the interior to permit setting the combination.

2.3.5 Exit Devices

BHMA A156.3, Grade 1. Provide adjustable strikes for rim type and vertical rod devices. Provide open back strikes for pairs of doors with mortise and vertical rod devices. Touch bars may be provided in lieu of conventional crossbars and arms. Provide escutcheons, not less than 178 by 57 mm (7 by 2 1/4 inches).

2.3.5.1 Door Coordinator

Door coordinator with carry bar shall be Type 21 and shall be provided for each pair of doors equipped with an overlapping astragal. The coordinator may be gravity or mechanically operated and shall be capable of holding the active door of a pair open until the inactive door has preceded it in the closing cycle. When used as fire exit hardware, the coordinator and carry bar shall be listed or labeled by a nationally recognized independent testing laboratory.

2.3.5.2 Removable Mullions

Removable mullions shall be Type 22 of the box type and shall be used only with those exit devices for which the mullions were manufactured. Mullions shall be furnished with mullion stabilizers of the same manufacturer.

2.3.5.3 Electric Exit Devices

Electric exit devices shall conform to BHMA A156.3 with factory installed electric lock modification having the capability to lock or unlock from remote location by means of push button or card reader. Exit devices shall comply with life safety requirements of NFPA 101. In hazardous locations, products shall use safe power supplies or be pneumatic.

2.3.5.4 Automatic Flush Bolts

Automatic flush bolts shall be Type 25 in accordance with BHMA A156.3, and shall be installed at the top and bottom of the inactive leaf of pairs of fire rated doors where specified in the hardware sets. Flush bolts shall be mortised in the strike edge of the door.

2.3.6 Exit Locks With Alarm

BHMA A156.5, Type E0431 (with full-width horizontal actuating bar) for single doors; Type E0431 (with actuating bar) or E0471 (with actuating bar and top and bottom bolts, both leaves active) for pairs of doors, unless otherwise specified.

2.3.7 Keying System

Provide a construction master keying system as specified when drawing is required.

2.3.8 Lock Trim

Cast, forged, or heavy wrought construction and commercial plain design.

2.3.8.1 Knobs and Roses

In addition to meeting test requirements of BHMA A156.2 and BHMA A156.13, knobs, roses, and escutcheons shall be 1.25 mm (0.050 inch) thick if unreinforced. If reinforced, outer shell shall be 0.89 mm (0.035 inch) thick and combined thickness shall be 1.78 mm (0.070 inch), except knob shanks shall be 1.52 mm (0.060 inch) thick.

2.3.8.2 Lever Handles

Provide lever handles in lieu of knobs where specified in paragraph entitled "Hardware Schedule or drawings". Lever handles for exit devices shall meet the test requirements of BHMA A156.13 for mortise locks. Lever handle locks shall have a breakaway feature (such as a weakened spindle or a shear key) to prevent irreparable damage to the lock when a force in excess of that specified in BHMA A156.13 is applied to the lever handle. Lever handles shall return to within 13 mm (1/2 inch) of the door face.

2.3.8.3 Texture

Provide knurled or abrasive coated knobs or lever handles where specified in paragraph entitled "Hardware Schedule" or drawings for doors which are accessible to blind persons and which lead to dangerous areas.

2.3.9 Keys

2.3.9.1 Conventional

Locks shall be keyed in sets or subsets as scheduled. Locks shall be furnished with the manufacturer's standard construction key system. Change keys for locks shall be stamped with change number and the inscription "U.S. Property - Do Not Duplicate." Keys shall be supplied as follows:

Locks:	3 change keys each lock.
Master keyed sets:	3 keys each set.
Grand master keys:	3 keys each set.
Control keys:	3 keys each set.
Construction keys:	3 keys each set.
Blank keys:	5% of total or 30 keys which ever greater.

The keys shall be furnished to the Contracting Officer arranged in a container in sets or subsets as scheduled. Control keys shall be specified whenever lock cylinders with removable cores are specified.

2.3.9.2 Mechanical Coded

Keys shall be fabricated of stainless steel with magnetic insert and keying hole reinforced with an eyelet. Key size shall be approximately 1-1/2 by 2-3/4 inches with radius top and bottom edges, approximately .05 inches thick. The correct position for key insertion to be marked on the key with an arrow. Keys shall be capable of accepting coding for unlocking and locking the cylinders provided. Master keys shall be capable of being encoded to operate multiple cylinders in a master keying security system. Keys shall be capable of being erased and recoded as often as desired. Key codes shall be invisible. Keys shall be obtainable in bulk, uncoded, or precoded for on-site additional encoding or they may be factory-coded. Identification of keys shall be by serial number. Stainless steel keys to be guaranteed recodable for ten (10) years. The entire cylinder system shall be capable of being re-mastered, including the highest master up to fifteen (15) times by the user and including on-site recoding of existing valid keys to the new combination. Initial coding shall be by the supplier. Each differently coded cylinder shall be supplied with four (4) working keys. Also, two (2) master keys for each different level of the initial system shall be provided. Spare blank keys shall be supplied 5 % of total or 30 keys whichever greater and shall be pre-coded for on-site additional encoding.

2.3.10 Door Bolts

BHMA A156.16. Provide dustproof strikes for bottom bolts, except for doors having metal thresholds. Automatic latching flush bolts: BHMA A156.3, Type 25.

2.3.11 Closers

BHMA A156.4, Series C02000, Grade 1, with PT 4C. Provide with brackets, arms, mounting devices, fasteners, full size covers, except at storefront mounting, pivots, and other features necessary for the particular application. Size closers in accordance with manufacturer's recommendations, or provide multi-size closers, Sizes 1 through 6, and list sizes in the Hardware Schedule.

2.3.11.1 Identification Marking

Engrave each closer with manufacturer's name or trademark, date of manufacture, and manufacturer's size designation located to be visible after installation.

2.3.12 Overhead Holders

BHMA A156.8.

2.3.13 Closer Holder-Release Devices

BHMA A156.15. For fire doors, which shall be held open, use electromagnetic holder-release devices.

2.3.14 Door Protection Plates

BHMA A156.6.

2.3.14.1 Sizes of Armor, Mop and Kick Plates

Width for single doors shall be 50 mm (2 inches) less than door width; width for pairs of doors shall be 25 mm (1 inch) less than door width. Height of kick plates shall be 250 mm (10 inches) for flush doors and 25 mm (1 inch) less than height of bottom rail for panel doors. Height of armor plates shall be not less than 1200 mm (48 inches) for flush doors and shall completely cover lower panels of panel doors, except that armor plates on fire doors shall be 400 mm (16 inches) high. Height of mop plates shall be 100 mm (4 inches).

2.3.15 Edge Guards

BHMA A156.6, stainless steel, of same height as armor plates. Apply to hinge stile, lock stile or meeting stiles as indicated.

2.3.16 Door Stops and Silencers

BHMA A156.16. Silencers Type L03011. Provide three silencers for each single door, two for each pair.

2.3.17 Padlocks

ASTM F 883.

2.3.18 Thresholds

BHMA A156.21. Use J35100, with vinyl or silicone rubber insert in face of stop, for exterior doors opening out, unless specified otherwise.

2.3.19 Weather Stripping

A set shall include head and jamb seals, sweep strips, and, for pairs of doors, astragals. Air leakage of weather stripped doors shall not exceed 2.19 x 10-5 cms (0.5 cfm) for residential swinging doors and 5.48 x 10-5 cms (1.25 cfm) for non-residential swinging doors of air per square meter (foot) of door area when tested in accordance with ASTM E 283. Weather stripping shall be one of the following:

2.3.19.1   Extruded Aluminum Retainers

Extruded aluminum retainers not less than 1.25 mm (0.050 inch) wall thickness with vinyl, neoprene, silicone rubber, or polyurethane inserts. Aluminum shall be clear (natural) or bronze anodized.

2.3.19.2   Interlocking Type

Zinc or bronze not less than 0.45 mm (0.018 inch) thick.

2.3.19.3   Spring Tension Type

Spring bronze or stainless steel not less than 0.20 mm (0.008 inch) thick.

2.3.20   Lightproofing and Soundproofing

A set shall include adjustable doorstops at head and jambs and an automatic door bottom, both of extruded aluminum, clear (natural) or bronze anodized, surface applied, with vinyl fin seals between plunger and housing. Doorstops shall have solid neoprene tube, silicone rubber, or closed-cell sponge gasket. Door bottoms shall have adjustable operating rod and silicone rubber or closed-cell sponge neoprene gasket. Doorstops shall be mitered at corners. Zero "Sound Stop 1" (No. 770 and No. 361); Pemko No. 350ASN and No. 430AS; National Guard No. 1038N and No. 420; or equal.

2.3.21   Rain Drips

Extruded aluminum, not less than 2.03 mm (0.08 inch) thick, clear or bronze anodized. Set drips in sealant conforming to Section 07900, "Joint Sealing" and fasten with stainless steel screws.

2.3.21.1   Door Rain Drips

Approximately 38 mm high by 16 mm (1 1/2 inches high by 5/8 inch) projection. Align bottom with bottom edge of door.

2.3.21.2   Overhead Rain Drips

Approximately 38 mm high by 64 mm (1 1/2 inches high by 2 1/2 inches) projection, with length equal to overall width of door frame. Align bottom with door frame rabbet.

2.3.22   Special Tools

Provide special tools, such as spanner and socket wrenches and dogging keys, required to service and adjust hardware items.

2.4   FASTENERS

Provide fasteners of proper type, quality, size, quantity, and finish with hardware. Fasteners exposed to weather shall be of nonferrous metal or stainless steel. Provide fasteners of type necessary to accomplish a permanent installation.

2.5 FINISHES

BHMA A156.18. Hardware shall have BHMA 630 finish (satin stainless steel), unless specified otherwise. Provide items not manufactured in stainless steel in BHMA 626 finish (satin chromium plated) over brass or bronze, except surface door closers which shall have aluminum paint finish, and except steel hinges which shall have BHMA 652 finish (satin chromium plated). Hinges for exterior doors shall be stainless steel with BHMA 630 finish or chromium plated brass or bronze with BHMA 626 finish. Exit devices may be provided in BHMA 626 finish in lieu of BHMA 630 finish except where BHMA 630 is specified under paragraph entitled "Hardware Sets". Exposed parts of concealed closers shall have finish to match lock and door trim. Hardware for aluminum doors shall be finished to match the doors. BHMA A156.18. Hardware shall have BHMA 612 finish (satin bronze), unless specified otherwise. Surface door closers shall have bronze paint or aluminum paint. Steel hinges shall have BHMA 600 finish (primed for painting). Hardware showing on interior of bathrooms, shower rooms, toilet rooms, washrooms, laundry rooms and kitchens shall have BHMA 629 finish (bright stainless steel) or BHMA 625 finish (bright chromium plated).

2.6 KEY CABINET AND CONTROL SYSTEM

2.6.1 Conventional

BHMA A156.5, Type E8331 (25 hooks), E8341 (125 hooks), E8351 (150 hooks), E8311 (600 hooks) or E8321 (700 hooks) as shown on drawings. Type required to yield a capacity (number of hooks) 50 percent greater than the number of key changes used for door locks.

2.6.2 Mechanical Coded

Reserve key storage of coded key shall be manufacturer¡¯s standard and as a minimum shall be plastic sheets with pockets into which keys can be placed. Sheets shall be sized to fit a fifteen (15) inch wide file cabinet.

2.6.3 Encoding and Rekeying Equipment Kit

Encoding and rekeying equipment kit shall include fixtures and spare parts necessary for rekeying and servicing of lock cylinders and erasing and recoding of stainless steel keys. Equipment kit shall be provided in a lockable carrying case with cushioned interior designed specifically for storage and transport of the encoding and rekeying equipment furnished.

2.6.4 Mechanical Coded Switch Locks

Mechanical coded switch locks shall be tamperproof and may be surface or flush mounted type. Mechanical coded switch locks shall activate an internal electrical contact only (no other material shall operate the switch lock) when coded key is inserted.

PART 3 EXECUTION

3.1 INSTALLATION

Install hardware in accordance with manufacturers' printed instructions. Fasten hardware to wood surfaces with full-threaded wood screws or sheet metal screws. Provide machine screws set in expansion shields for fastening hardware to solid concrete and masonry surfaces. Provide toggle bolts where required for fastening to hollow core construction. Provide through bolts where necessary for satisfactory installation.

3.1.1 Weather Stripping Installation

Handle and install weather stripping so as to prevent damage. Provide full contact, weather-tight seals. Doors shall operate without binding.

3.1.1.1 Stop-Applied Weather Stripping

Fasten in place with color-matched sheet metal screws not more than 225 mm (9 inches) o.c. after doors and frames have been finish painted.

3.1.1.2 Interlocking Type Weather Stripping

Provide interlocking, self-adjusting type on heads and jambs and flexible hook type at sills. Nail weather stripping to door 25 mm (1 inch) o.c. and to heads and jambs at 100 mm (4 inches) o.c.

3.1.1.3 Spring Tension Type Weather Stripping

Provide spring tension type on heads and jambs. Provide bronze nails with bronze, stainless steel nails with stainless steel. Space nails not more than 38 mm (1 1/2 inches) o.c.

3.1.2 Lightproofing and Soundproofing Installation

Install as specified for stop-applied weather stripping.

3.1.3 Threshold Installation

Extend thresholds the full width of the opening and notch end for jamb stops. Set thresholds in a full bed of sealant and anchor to floor with cadmium-plated, countersunk, steel screws in expansion sleeves.

3.2 FIRE DOORS AND EXIT DOORS

Install hardware in accordance with NFPA 80 for fire doors, NFPA 101 for exit doors, and UL 14C for swinging tin-clad fire doors.

3.3 HARDWARE LOCATIONS

SDI 100, unless indicated or specified otherwise.

a. Kick and Armor Plates: Push side of single-acting doors. Both sides of double-acting doors.

b. Mop Plates: Bottom flush with bottom of door.

3.4 KEY CABINET AND CONTROL SYSTEM

Locate where indicated. Tag one set of file keys and one set of duplicate keys. Place other keys in appropriately marked envelopes, or tag each key. Furnish complete instructions for setup and use of key control system. On tags and envelopes, indicate door and room numbers or master or grand master key.

3.5   FIELD QUALITY CONTROL

After installation, protect hardware from paint, stains, blemishes, and other damage until acceptance of work. Submit notice of testing 15 days before scheduled, so that testing can be witnessed by the Contracting Officer. Adjust hinges, locks, latches, bolts, holders, closers, and other items to operate properly. Demonstrate that permanent keys operate respective locks, and give keys to the Contracting Officer. Correct, repair, and finish, as directed, errors in cutting and fitting and damage to adjoining work.

SECTION 08810

GLASS AND GLAZING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z97.1 (1984; R 1994) Safety Performance Specifications and Methods of Test for Safety Glazing Materials Used in Buildings

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 509 (1994) Elastomeric Cellular Preformed Gasket and Sealing Material

ASTM C 669 (1995) Glazing Compounds for Back Bedding and Face Glazing of Metal Sash

ASTM C 864 (1999) Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers

ASTM C 920 (1998) Elastomeric Joint Sealants

ASTM C 1036 (1991; R 1997) Flat Glass

ASTM C 1048 (1997b) Heat-Treated Flat Glass - Kind HS, Kind FT Coated and Uncoated Glass

ASTM C 1172 (1996el) Laminated Architectural Flat Glass

ASTM C 1349 (1996) Architectural Flat Glass Clad Polycarbonate

ASTM D 395 (1998) Rubber Property - Compression Set

ASTM E 773 (1997) Accelerated Weathering of Sealed Insulating Glass Units

ASTM E 774 (1997) Classification of the Durability of Sealed Insulating Glass Units

ASTM E 1300 (1998) Determining the Minimum Thickness and Type of Glass Required to Resist a Specified Load

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

16 CFR 1201 Safety Standard for Architectural Glazing Materials

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-378 (Basic) Putty Linseed Oil Type, (for Wood-Sash-Glazing)

GLASS ASSOCIATION OF NORTH AMERICA (GANA)

GANA Glazing Manual (1997) Glazing Manual

GANA Standards Manual (1995) Engineering Standards Manual

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80 (1999) Fire Doors and Fire Windows

NFPA 252 (1995) Fire Tests of Door Assemblies

NFPA 257 (1996) Fire Tests for Window and Glass Block Assemblies

KOREAN INDUSTRIAL STANDARDS (KS)

KS L 2001 (1997) Sheet Glass

KS L 2002 (1997) Tempered Glass

KS L 2003 (1997) Sealed Insulating Glass

KS L 2004 (1997) Laminated Glass

KS L 2005 (1997) Figured Glass

KS L 2006 (1997) Wired Glass

KS L 2008 (1997) Heat Absorbing Glass

KS L 2015 (2001) Heat-Strengthened Glass

KS L 2104 (1999) Glass Mirror

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation; G.

Drawings showing complete details of the proposed setting methods, mullion details, edge blocking, size of openings, frame details, materials, and types and thickness of glass.

Drawings showing complete details of the proposed setting methods, mullion details, edge blocking, size of openings, frame details, materials, and types and thickness of glass.

SD-03 Product Data

Insulating Glass; G. Glazing Accessories; G.

Manufacturer's descriptive product data, handling and storage recommendations, installation instructions, and cleaning instructions.

SD-04 Samples

Insulating Glass; G.

Two 203 x 254 mm (8 x 10 inch) samples of each of the following: tinted glass, patterned glass, heat-absorbing glass, and insulating glass units.

SD-07 Certificates

Insulating Glass;

Certificates stating that the glass meets the specified requirements. Labels or manufacturers marking affixed to the glass will be accepted in lieu of certificates.

Glazing Accessories;

Certificates from the manufacturer attesting that the units meet the luminous and solar radiant transmission requirements for heat absorbing glass.

1.3 SYSTEM DESCRIPTION

Glazing systems shall be fabricated and installed watertight and airtight to withstand thermal movement and wind loading without glass breakage, gasket failure, deterioration of glazing accessories, and defects in the work. Glazed panels shall comply with the safety standards, as indicated in accordance with ANSI Z97.1. Glazed panels shall comply with indicated wind/snow loading in accordance with ASTM E 1300.

1.4 DELIVERY, STORAGE AND HANDLING

Glazing compounds shall be delivered to the site in the manufacturer's unopened containers. Glass shall be stored indoors in a safe, well ventilated dry location in accordance with manufacturer's instructions, and shall not be unpacked until needed for installation. Glass shall not be stored on site over 1 month.

1.5 PROJECT/SITE CONDITIONS

Glazing work shall not be started until outdoor temperature is above 5 degrees C (40 degrees F) and rising, unless procedures recommended by glass manufacturer and approved by Contracting Officer are made to warm the glass and rabbet surfaces. Ventilation shall be provided to prevent condensation of moisture on glazing work during installation. Glazing work shall not be performed during damp or raining weather.

1.6 WARRANTY

1.6.1 Insulating Glass

Manufacturer shall warrant the insulating glass to be free of fogging or film formation on the internal glass surfaces caused by failure of the hermetic seal for a period of 10 years from Date of Substantial Completion. Warranty shall be signed by manufacturer.

PART 2 PRODUCTS

2.1 FLOAT GLASS

2.1.1 Annealed Glass

Annealed glass shall be Type I transparent flat type, Class 1 ? clear or tinted, Quality q3 - glazing select, conforming to ASTM C 1036 or KS L 2001. Light transmittance, shading coefficient and color shall be as indicated.

2.1.2 Heat-Absorbing Glass

Heat-absorbing glass shall be Type I transparent flat type, Class 2-tinted, Quality q3 - glazing select, conforming to ASTM C 1036 or KS L 2008. Light transmittance, shading coefficient and color shall be as indicated.

2.1.3 Tinted (Light-Reducing) Glass

Tinted (light-reducing) glass shall be Type I transparent flat type, Class 3-tinted, Quality q3 - glazing select, conforming to ASTM C 1036 or KS L 2008. Light transmittance, shading coefficient and color shall be as indicated.

2.2 ROLLED GLASS

2.2.1 Patterned Glass

Patterned glass shall be Type II flat type. Class 1 ? translucent, Class 2 - tinted heat absorbing or Class 3 - tinted heat reducing, Finish f1 ? patterned one side or Finish f2 - patterned both sides, Quality q7 ? decorative or Quality q8 - glazing, conforming to ASTM C 1036 or KS L 2005. Light transmittance, coefficient and color shall be as indicated.

2.2.2 Wired Glass

Wired glass shall be Type II flat type, Class 1 ? translucent, Class 2 - tinted, heat-absorbing or Class 3 - tinted, light-reducing, Quality q7 ? decorative or Quality q8 - glazing, Form 1 - wired and polished both sides or Form 2 - patterned and wired, light transmittance and shading coefficient as indicated, conforming to ASTM C 1036 or KS L 2006. Wire mesh shall be polished stainless steel Mesh 1 ? diamond, Mesh 2 ? square or Mesh 3 - parallel. Wired glass for fire-rated windows shall bear an identifying UL label or the label of a nationally recognized testing agency, and shall be rated for 20, 30 or 45 minutes when tested in accordance with NFPA 257. Wired glass for fire-rated doors shall be tested as part of a door assembly in accordance with NFPA 252. Color shall be as indicated.

2.3 INSULATING GLASS

Insulating glass shall be Class A preassembled units of dual-seal construction consisting of lites of glass separated by an aluminum, steel, or stainless steel, spacer and dehydrated space conforming to ASTM E 773 and ASTM E 774. Spacer shall be roll-formed, with bent or tightly welded or keyed and sealed joints to completely seal the spacer periphery and eliminate moisture and hydrocarbon vapor transmission into airspace through the corners. Primary seal shall be compressed polyisobutylene and the secondary seal shall be a specially formulated silicone. Glass types shall be as follows:

2.3.1 Clear Insulating Glass

Glass for two-pane insulating units shall be Type I annealed glass, Class 1 - clear, Quality q3 - glazing select, conforming to ASTM C 1036 or KS L 2003. Glass performance shall be K-Value/Winter Nighttime 2.98 Kcal/m-h-?C (R-Value /Winter Nighttime 0.61 Btu/f-h-?F).

2.3.2 Heat-Absorbing Insulating Glass

Interior and exterior glass panes for heat-absorbing insulating units shall be Type I annealed flat glass, Class 2-tinted, Quality q3 - glazing select, conforming with ASTM C 1036. Glass performance shall be K-Value/Winter Nighttime 3.57 Kcal/m-h-?C (R-Value /Winter Nighttime 0.73 Btu/f-h-?F). Shading coefficient and color shall be as indicated.

2.4 HEAT-TREATED GLASS

Heat-treated glass shall conform to the following requirements.

2.4.1 Tempered Glass

Tempered glass shall be kind FT fully tempered transparent flat type, Class 1-clear or Class 2-tinted, Condition A uncoated surface, Quality q3 ? glazing select, conforming to ASTM C 1048 or KS L 2002 and GANA Standards Manual. Light transmittance, shading coefficient and color shall be as indicated.

2.4.2 Heat-Strengthened Glass

Heat-strengthened glass shall be kind HS heat-strengthened transparent flat type, Class 1-clear or Class 2-tinted, Condition A uncoated surface, Quality q3 - glazing select, conforming to ASTM C 1048 or KS L 2015. Color shall be clear, bronze, gray or as indicated.

2.5 LAMINATED GLASS

Laminated glass shall consist of minimum two layers of Type I transparent float glass, Class 1-clear or Class 2-tinted, Quality q3 - glazing select, conforming to ASTM C 1036 or KS L 2004. Glass shall be bonded together with 0.76 or 1.52 mm (0.030 or 0.060 inch) thick PVB interlayer under pressure, or alternatives such as resin laminates, conforming to requirements of 16 CFR 1201, ASTM C 1172 or KS L 2004. Color shall be clear, gray, bronze or as indicated.

2.6 MIRRORS

2.6.1 Glass Mirrors

Glass for mirrors shall be Type I transparent flat type, Class 1-clear, Glazing Quality q1 6 mm (1/4 inch) thick conforming to ASTM C 1036 or KS L 2104. Glass color shall be clear or as indicated. Glass shall be coated on one surface with silver coating, copper protective coating, and mirror backing paint. Silver coating shall be highly adhesive pure silver coating of a thickness which shall provide reflectivity of 83 percent or more of incident light when viewed through 6 mm (1/4 inch) thick glass, and shall be free of pinholes or other defects. Copper protective coating shall be pure bright reflective copper, homogeneous without sludge, pinholes or other defects, and shall be of proper thickness to prevent "adhesion pull" by mirror backing paint. Mirror backing paint shall consist of two coats of special scratch and abrasion-resistant paint, and shall be baked in uniform thickness to provide a protection for silver and copper coatings which will permit normal cutting and edge fabrication.

2.6.2 One-Way Mirrors

Glass for one-way mirrors shall be Type I transparent flat type, Class 1 clear, Glazing Quality q1, 6 mm (1/4 inch) thick conforming to ASTM C 1036 or KS L 2104. Glass shall be coated on one face with a hard adherent film of chromium or other approved coating of proven equivalent durability. Glass shall transmit not less than 5 percent nor more than 11 percent of total incident light in visible region, and shall reflect from front surface of coating not less than 45 percent of total incident light in visible region.

2.6.3 Mirror Accessories

2.6.3.1 Mastic

Mastic for setting mirrors shall be a polymer type mirror mastic resistant to water, shock, cracking, vibration and thermal expansion. Mastic shall be compatible with mirror backing paint, and shall be approved by mirror manufacturer.

2.6.3.2 Mirror Frames

Mirrors shall be provided with mirror frames (J-mold channels) fabricated of one-piece roll-formed Type 304 stainless steel with No. 4 brushed satin finish and concealed fasteners which will keep mirrors snug to wall. Frames shall be 32 x 6 x 6 mm (1-1/4 x 1/4 x 1/4 inch) continuous at top and bottom of mirrors. Concealed fasteners of type to suit wall construction material shall be provided with mirror frames.

2.6.3.3 Mirror Clips

Concealed fasteners of type to suit wall construction material shall be provided with clips.

2.7 GLAZING ACCESSORIES

2.7.1 Preformed Tape

Preformed tape shall be elastomeric rubber extruded into a ribbon of a width and thickness suitable for specific application. Tape shall be of type which will remain resilient, have excellent adhesion, and be chemically compatible to glass, metal, or wood.

2.7.2 Sealant

Sealant shall be elastomeric conforming to ASTM C 920, Type S or M, Grade NS, Class 12.5, Use G, of type chemically compatible with setting blocks, preformed sealing tape and sealants used in manufacturing insulating glass. Color of sealant shall be as selected.

2.7.3 Glazing Gaskets

Glazing gaskets shall be extruded with continuous integral locking projection designed to engage into metal glass holding members to provide a watertight seal during dynamic loading, building movements and thermal movements. Glazing gaskets for a single glazed opening shall be continuous one-piece units with factory-fabricated injection-molded corners free of flashing and burrs. Glazing gaskets shall be in lengths or units recommended by manufacturer to ensure against pull-back at corners. Glazing gasket profiles shall be as indicated on drawings.

2.7.3.1 Fixed Glazing Gaskets

Fixed glazing gaskets shall be closed-cell (sponge) smooth extruded compression gaskets of cured elastomeric virgin neoprene compounds conforming to ASTM C 509, Type 2, Option 1.

2.7.3.2 Wedge Glazing Gaskets

Wedge glazing gaskets shall be high-quality extrusions of cured elastomeric virgin neoprene compounds, ozone resistant, conforming to ASTM C 864, Option 1, Shore A durometer between 65 and 75.

2.7.3.3 Aluminum Framing Glazing Gaskets

Glazing gaskets for aluminum framing shall be permanent, elastic, non-shrinking, non-migrating, watertight and weathertight.

2.7.4 Putty and Glazing Compound

Glazing compound shall conform to ASTM C 669 for face-glazing metal sash. Putty shall be linseed oil type conforming to CID A-A-378for face-glazing primed wood sash. Putty and glazing compounds shall not be used with insulating glass or laminated glass.

2.7.5 Setting and Edge Blocking

Neoprene setting blocks shall be dense extruded type conforming to ASTM D 395, Method B, Shore A durometer between 70 and 90. Edge blocking shall be Shore A durometer of 50 (+ or - 5). Silicone setting blocks shall be required when blocks are in contact with silicone sealant. Profiles, lengths and locations shall be as required and recommended in writing by glass manufacturer.

PART 3 EXECUTION

3.1 PREPARATION

Openings and framing systems scheduled to receive glass shall be examined for compliance with approved shop drawings, GANA Glazing Manual and glass manufacturer's recommendations including size, squareness, offsets at corners, presence and function of weep system, face and edge clearance requirements and effective sealing between joints of glass-framing members. Detrimental materials shall be removed from glazing rabbet and glass surfaces and wiped dry with solvent. Glazing surfaces shall be dry and free of frost.

3.2 INSTALLATION

Glass and glazing work shall be performed in accordance with approved shop drawings, GANA Glazing Manual, glass manufacturer's instructions and warranty requirements. Glass shall be installed with factory labels intact and removed only when instructed. Wired glass and fire/safety rated glass shall be installed in accordance with NFPA 80. Edges and corners shall not be ground, nipped or cut after leaving factory. Springing, forcing or twisting of units during installation will not be permitted.

3.3 CLEANING

Upon completion of project, outside surfaces of glass shall be washed clean and the inside surfaces of glass shall be washed and polished in accordance with glass manufacturer's recommendations.

3.4 PROTECTION

Glass work shall be protected immediately after installation. Glazed openings shall be identified with suitable warning tapes, cloth or paper flags, attached with non-staining adhesives. Reflective glass shall be protected with a protective material to eliminate any contamination of the reflective coating. Protective material shall be placed far enough away from the coated glass to allow air to circulate to reduce heat buildup and moisture accumulation on the glass. Glass units which are broken, chipped, cracked, abraded, or otherwise damaged during construction activities shall be removed and replaced with new units.

SECTION 08840

PLASTIC GLAZING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z97.1 (1984; R 1994) Safety Performance Specifications and Methods of Test for Safety Glazing Materials Used in Buildings

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 669 (1995) Glazing Compounds for Back Bedding and Face Glazing of Metal Sash

ASTM C 920 (1998) Elastomeric Joint Sealants

1.2 GENERAL REQUIREMENTS

Plastic glazing shall be provided in the locations indicated. Glazing may be performed in the shop or in the field using plastic sheets of the thickness specified.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Materials; G. Cleaning; G.

Data composed of catalog cuts, brochures, cleaning directions, and compatible cleaning agents.

Installation;

Manufacturer's installation instructions.

SD-04 Samples

Plastic Sheets; G.

Sample of plastic sheets shall be minimum 125 by 175 mm (5 by 7 inches).

SD-07 Certificates

Materials;

Certificates stating that the plastic sheets and glazing material meet the specified requirements.

1.4 DELIVERY AND STORAGE

Glazing compounds, sealants and primers shall be delivered to the site in the manufacturer's unopened containers. Plastic sheets shall be stored in safe, dry locations and shall not be unpacked until needed for installation.

1.5 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period shall be provided.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Plastic Sheets

2.1.1.1 Acrylic Plastic Sheets

Acrylic plastic commercial-grade sheets shall conform to ANSI Z97.1, clear and smooth on both sides, translucent, textured on both sides, gray tint, or bronze tint, ultraviolet stabilized, scratch resistant, 6 mm (0.236 in.) thick or as shown on the drawings.

2.1.1.2 Polycarbonate Plastic Sheets

Polycarbonate plastic sheets shall conform to ANSI Z97.1, clear and smooth on both sides, translucent, textured on both sides, gray tint or bronze tint, ultraviolet stabilized, scratch resistant, 6 mm (0.236in.) thick or as shown on the drawings.

2.1.2 Glazing Compound

Nonhardening glazing compound shall conform to ASTM C 669, gray or neutral color for glazing in wood, steel, or color finished aluminum, and aluminum color for glazing in natural colored aluminum.

2.1.3 Glazing Tape

Glazing tape shall be fully-cured synthetic rubber, or plastic composition; and shall be unreinforced, 100 percent solid, resilient, nonsagging, nonstaining, and noncrazing. The tape shall be pressure sensitive. The tape shall be capable of sealing out moisture, air, and dust when compressed to the extent recommended by the glazing tape manufacturer for the extensibility requirements of the joint. The tape shall be furnished in the proper width and depth for the particular application in order to obtain the required degree of compression when installed in the joint. The tape shall withstand temperatures of minus 40 degrees C (minus 40 degrees F) up to 71 degrees C (160 degrees F) without bleeding, cracking, flowing, or showing signs of deterioration. Tape color shall be as shown on the drawings.

2.1.4 Sealant

Sealant shall conform to ASTM C 920, Grade NS, Class 25 or Class 12-1\2; Use G. Sealant shall be gray or neutral color for glazing in wood, steel, or color finished aluminum, and aluminum color for glazing in natural color aluminum.

2.1.5 Sealant Backstop Material

Sealant backstop shall be a material that will not adversely affect or bond with sealant. Shape and dimensions shall be as recommended by the plastic sheet manufacturer for the particular application.

2.1.6 Sealant Primer

Sealant primer shall be as recommended by the sealant manufacturer.

2.1.7 Glazing Accessories

Glazing accessories shall be as required to supplement the items to be glazed including glazing points and spacer shims. Ferrous metal accessories shall have a finish that will not stain or corrode while in service. Spacer shims shall be of material and of dimensions recommended by the plastic sheet manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

Glazing shall be performed in accordance with the approved installation instructions of the plastic sheet manufacturer.

3.2 CLEANING

The plastic surfaces shall be clean and free of smears, spatters, scratches, and other defacement at the time the work is accepted. Cleaning shall be in accordance with the plastic sheet manufacturer's recommendation.

DIVISION 09 FINISHES

SECTION 09200

LATHING AND PLASTERING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 580(M)	(1998) Stainless Steel Wire
ASTM A 853	(1993; R 1998) Steel Wire, Carbon, for General Use
ASTM B 164	(1998) Nickel-Copper Alloy Rod, Bar, and Wire
ASTM C 28	(1996el) Gypsum Plasters
ASTM C 29(M)	(1997) Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C 35	(1995) Inorganic Aggregates For Use in Gypsum Plaster
ASTM C 37(M)	(1999) Gypsum Lath
ASTM C 61	(1995) Gypsum Keene's cement
ASTM C 150	(1999a) Portland Cement
ASTM C 206	(1984; R 1997) Finishing Hydrated Lime
ASTM C 472	(1999) Physical Testing of Gypsum, Gypsum Plasters and Gypsum Concrete
ASTM C 587	(1997) Gypsum Veneer Plaster
ASTM C 588(M)	(1999) Gypsum Base for Veneer Plasters
ASTM C 645	(2000) Nonstructural Steel Framing Members
ASTM C 754	(1999a) Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products
ASTM C 841	(1999) Installation of Interior Lathing and Furring
ASTM C 842	(1999) Application of Interior Gypsum Plaster
ASTM C 843	(1999) Application of Gypsum Veneer Plaster
ASTM C 844	(1999) Application of Gypsum Base to Receive Gypsum Veneer Plaster
ASTM C 847	(1995) Metal Lath
ASTM C 897	(1996) Aggregate for Job-Mixed Portland Cement-Based Plasters
ASTM C 926	(1998a) Application of Portland Cement-Based Plaster
ASTM C 933	(1996a) Welded Wire Lath

ASTM C 955	(1998) Load-Bearing (Transverse and Axial) Steel Studs, Runners (Tracks), and Bracing or Bridging for Screw Application of Gypsum Panel Products and Metal Plaster Bases
ASTM C 1002	(1998) Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases
ASTM C 1032	(1996) Woven Wire Plaster Base

KOREAN INDUTRIAL STANDARDS (KS)

KS D 3552	(1996) Iron Wire
KS D 3609	(2000) Steel Furrings for Wall and Ceiling in Buildings
KS D 3703	(1997) Stainless Steel Wire
KS F 3507	(1997) Gypsum Plaster
KS F 4551	(2000) Wire Lath
KS F 4552	(2000) Metal Lath
KS L 5201	(1989) Portland Cement
KS L 9007	(2001) Decorated Quicklime and Hydrated Lime

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings; G.

Drawings including installation details, ceiling framing, and furring.

SD-03 Product Data

Lathing Installation; G.

Manufacturer's pre-printed descriptive data, catalog cuts, and installation instructions for plastering materials and accessories.

SD-07 Certificates

Qualifications;

Manufacturer's experience in specified work.

Gypsum Plaster;

Certification indicating that factory-mixed plaster provides a minimum compressive strength of not less than 6.9 MPa (1000 psi) when tested in accordance with ASTM C 472.

1.3 QUALIFICATIONS

Manufacturer shall specialize in manufacturing the types of material specified, and shall have a minimum of 5 years of documented successful experience. Applicator shall specialize in the type of lath and plaster work required to meet requirements, with a minimum of 3 years of documented experience.

1.4 DELIVERY, STORAGE AND HANDLING

Materials shall be delivered to project site in the original containers bearing the name of manufacturer, contents, and brand name. Plaster, cement, and lime shall be stored off the ground under weathertight cover and away from sweating walls and other damp surfaces until ready for use. Accessories shall be stored off the ground in a weathertight structure for protection. Damaged or deteriorated materials shall be removed from project site.

1.5 ENVIRONMENTAL CONDITIONS

A temperature between 4 degrees C (40 degrees F) and 27 degrees C (80 degrees F) shall be evenly maintained in the building for a period of not less than 1 week prior to application of plaster, and for a period of at least 1 week after the gypsum plaster is set, in accordance with ASTM C 842. Interior spaces shall be ventilated in accordance with ASTM C 842 immediately after applying plaster.

PART 2 PRODUCTS

2.1 NON-LOADBEARING WALLS

2.1.1 Studs

Studs for non-loadbearing walls shall conform to ASTM C 645 or KS D 3609. Studs shall be C-shaped, roll-formed steel with minimum uncoated design thickness of 0.45 mm (0.0179 in) made from G40 hot-dip galvanized coated sheet.

2.1.2 Runner Tracks

Prefabricated floor and ceiling runner tracks shall conform to ASTM C 645 or KS D 3609. Tracks shall be prefabricated, U-shaped, unpunched web, thickness to match studs, made from G40 hot-dip galvanized coated sheet.

2.2 LOADBEARING STUD WALLS

2.2.1 Studs

Studs for loadbearing walls shall conform to ASTM C 955. Studs shall be C-shaped, roll-formed steel made from minimum G60 hot-dip galvanized coated sheet. Stud sizes and base metal design thickness shall be as shown.

2.2.2 Runner Tracks

Floor and ceiling runner tracks shall conform to ASTM C 955. Tracks shall be prefabricated, U-shaped with minimum 19 mm (3/4 inch) flanges, unpunched web, made from G60 hot-dip galvanized coated sheet.

2.2.3 Bridging

Bridging in loadbearing walls shall conform to ASTM C 955. Bridging shall be minimum 19 mm (3/4 inch) wide x 11 mm (7/16 inch) deep cold-rolled steel channel with weld attachment clips at each stud location or V-bar type weld or screw attached to each stud flange. Bridging shall be adequate to provide lateral support for the stud.

2.3 METAL WALL FURRING

Metal wall furring channels shall conform to ASTM C 645 or KS D 3609. Furring channels shall be formed from cold-rolled steel, 19 mm (3/4 inch) wide x 11 mm (7/16 inch) deep, made from G40 hot-dip galvanized coated sheet.

2.4 SUSPENDED CEILING FRAMING

Suspended ceiling framing system shall have the capability to support the finished ceiling, light fixtures, air diffusers, and accessories, as shown. The suspension system shall have a maximum deflection of L/240. Carrying channels shall be formed from minimum 1.40 mm thick (0.0548 in) cold-rolled steel, 38 mm (1-1/2 inch) wide x 11 mm (7/16 inch) deep. Cross furring members shall conform to ASTM C 645, and shall be formed from cold-rolled steel, 19 mm (3/4 inch) wide x 11 mm (7/16 inch) deep. Carrying channels and furring members shall be made from hot-dip galvanized coated sheet.

2.5 TRIM, MOLDINGS, AND ACCESSORIES

2.5.1 Hangers

Suspended ceiling runner channel hangers shall be soft, annealed steel wire not less than No. 8 SWG nominal diameter, conforming to ASTM A 853 or KS D 3552, or flat iron or steel straps, at least 2 x 22 mm 3/32 x 7/8 inch size, coated with zinc, cadmium, or rust-inhibiting paint.

2.5.2 Fastenings

Tie wire, rings, and other fastenings shall be corrosion-resisting steel conforming to ASTM A 580(M) or KS D 3703, composition 302, 304, or 316, Condition A, or nickel-copper alloy conforming to ASTM B 164, annealed condition. Walls, partitions, and other vertical surfaces not incorporated in ceiling construction may be erected with soft, annealed steel conforming to ASTM A 853 or KS D 3552.

2.5.2.1 Tie Wire

Tie wire for constructing partitions and vertical furring, for securing metal lath to supports, and for lacing shall be not less than No. 18 SWG diameter. Tie wire for all other applications shall be not less than No. 16 SWG diameter.

2.5.2.2 Clips

Clips used in lieu of tie wire for securing furring channels to the runner channels in ceiling construction shall be made from strips not less than 3 mm (1/8 inch) thick or shall be hairpin clip formed of No. 8 SWG wire. Other clips and rings or fastenings of similar materials shall be equivalent in holding power to that provided by tie wire for the specific application.

2.5.3 Arch, Flexible Corner Beads

Flexible corner beads shall be fabricated of aluminum, vinyl or 0.50 mm thick (0.0210 in) in galvanized steel, with minimum 32 mm (1-1/4 inch) wide flanges and 3 mm (1/8 inch) thick bead, designed to bend without buckles, kinks, or breaks in the nose.

2.5.4 Expanded Flange Corner Beads

Expanded flange corner beads shall be fabricated of vinyl or aluminum 0.50 mm thick (0.0210 in) galvanized steel, with 64 mm (2-1/2 inch) wide flanges and 3 mm (1/8 inch) wide bead.

2.5.5 Bullnose Corner Beads

Bullnose corner beads shall be fabricated of vinyl or aluminum 0.50 mm thick (0.0210 in) galvanized steel, with 64 mm (2-1/2 inch) wide flanges and 20 mm (3/4 inch) bead.

2.5.6 Cornerites

Cornerites shall conform to ASTM C 847. Cornerites shall be fabricated of galvanized expanded metal lath to form an angle of at least 100 degrees, with outstanding legs of not less than 50 mm (2 inches).

2.5.7 Striplath

Striplath shall conform to ASTM C 847. Striplath shall be fabricated of galvanized steel sheet, 1.4 kg per square meter (2.5 pounds per square yard).

2.5.8 Base or Parting Screed

Base screeds shall be fabricated of 0.50 mm thick (0.0210 in) galvanized steel, 13 mm (1/2 inch) depth, with not less than 50 mm (2 inch) wide expansion flanges.

2.5.9 Casing Beads

Casing beads shall be fabricated of vinyl or galvanized 0.70 mm (0.0276 inch) thick steel 13 mm (1/2 inch) depth, 25 mm (1 inch) wide expansion wings, front edge of face flange shaved for intended use, back slightly arched to provide a spring effect.

2.5.10 Control Joints

Control joints shall be designed for expansion and contraction of plaster work due to thermal exposure. Control joints shall be fabricated of vinyl or 0.55 mm (0.0217 inch) thick galvanized steel for interior applications or 0.76 mm

(0.030 inch) thick zinc alloy for exterior applications, with perforated or expanded-metal wings.

2.5.11 Reveal Molding

Reveal moldings shall be fabricated of aluminum, vinyl, galvanized steel or zinc. Reveal molding shall be size and shape as shown.

2.5.12 Raidused Column Trim

Raidused column moldings shall be fabricated of aluminum and shall be shape and sizes as shown.

2.5.13 Screws

Self-drill steel screws shall conform to ASTM C 1002. Screws shall be Type S for use with steel framing and Type W for use with wood members.

2.6 METAL LATH

2.6.1 Expanded Metal Lath

Expanded metal lath shall conform to ASTM C 847. Lath shall be flat base lath, self-furring lath, flat rib lath or rib lath, expanded from cold-rolled carbon sheet steel of commercial quality, coated with rust-inhibitive paint after fabrication, 1.8 kg per square meter (3.4 pounds per square yard), with backing.

2.6.2 Welded Wire Lath

Welded wire lath shall conform to ASTM C 933. Lath shall be flat base or self-furring type, fabricated from not less than 1.6 mm (0.0625 inch) copper-bearing, cold-drawn, galvanized steel wire, with backing.

2.6.3 Woven Wire Lath

Woven wire lath shall conform to ASTM C 1032 or KS F 4551. Lath shall be flat base or self-furring type with backing fabricated from copper-bearing, cold-drawn, galvanized steel wire not less than 1.40 mm (0.0548 in), thick with openings not to exceed 50 x 50 mm (2 x 2 inch) welded.

2.7 GYPSUM LATH AND VENEER PLASTER BASE

2.7.1 Gypsum Lath

Gypsum lath shall conform to ASTM C 37(M). Lath shall be plain, aluminum foil backed, or lead-backed for control of X-ray transmission designed to be used as a base for gypsum plaster.

2.7.2 Veneer Plaster Base

Veneer plaster base shall conform to ASTM C 588(M). Base shall be aluminum foil backed, and shall be designed to be used as a base for gypsum veneer plaster.

2.8 GYPSUM PLASTER

2.8.1 Ready-Mixed Gypsum Plaster

Ready-mixed plaster for use over gypsum or metal lath shall conform to ASTM C 28 or KS F 3507 for the following: ready-mixed plaster with vermiculite aggregate, ready-mixed plaster with perlite aggregates or ready-mixed plaster with sand aggregate as shown. Ready-mixed gypsum plaster for use over masonry bases shall conform to ASTM C 28 or KS F 3507 for plaster with vermiculite aggregate. Ready-mixed plaster for use over veneer plaster bases shall conform to ASTM C 587.

2.8.2 Gypsum Neat Plaster

Gypsum neat plaster shall conform to ASTM C 28.

2.8.3 Gypsum Wood-Fibered Plaster

Gypsum wood-fibered plaster shall conform to ASTM C 28.

2.8.4 Gypsum Gauging Plaster for Finish Coats

Gypsum gauging plaster shall conform to ASTM C 28. Keene's quick-set cement for finish coats shall conform to ASTM C 61.

2.9 CEMENT PLASTER MATERIALS

2.9.1 Portland Cement

Portland cement shall conform to ASTM C 150, gray portland cement Type II or white portland cement Type II or KS L 5201, Class I with 13 mm (1/2 inch) chopped alkali-resistant fiberglass strands or polypropylene fibers, minimum 680 g (1-1/2 pounds) per sack of cement.

2.9.2 Aggregates

The unit weight of aggregates shall be determined in accordance with ASTM C 29(M). Gypsum aggregates shall conform to ASTM C 35. Portland cement based plaster aggregates shall conform to ASTM C 897, except that the gradation of natural or manufactured sand for portland-cement plaster shall be as follows:

	Sand, Percentage by Weight Retained on Each Sieve	
Sieve Size (mm)	Maximum	Minimum
4.75	0	--
2.36	8	2
1.18	38	22
0.60	78	52
0.30	97	65
0.15	100	97

Sieve Size (inches)	Sand, Percentage by Weight Retained on Each Sieve Maximum	Minimum
4	0	--
8	8	2
16	38	22
30	78	52
50	97	65
100	100	97

2.9.3 Water

Water shall be clean, fresh, potable, and free from injurious amounts of oils, acids, alkalis and organic matter injurious to the plaster and to any metal in the system.

2.9.4 Lime

Lime shall conform to ASTM C 206 or KS L 9007, Type N-Normal hydrated finishing lime or Type S-Special hydrated finishing lime suitable for use in scratch brown and finish coats of portland-cement plaster.

2.10 WALL OPENING FRAMES

Steel frames for wall openings for doors, pass-through openings, and access panels shall be as specified in Section 08110 STEEL DOORS AND FRAMES or Section 05500 MISCELLANEOUS METAL. Wood frames, wood bucks, and blocking for wall openings for doors, pass-through openings, and access panels shall be as specified in Section 06100 ROUGH CARPENTRY.

PART 3 EXECUTION

3.1 PREPARATION

Project conditions shall be verified as ready to receive the work. Field measurements shall be verified for compliance with approved detail drawings and manufacturer's published recommendations. Beginning of installation means installer accepts existing conditions.

3.2 SUSPENDED CEILING FRAMING INSTALLATION

Suspended system shall be installed in accordance with ASTM C 841. Where channels are spliced, the ends shall be overlapped not less than 300 mm (12 inches) for 38 mm (1-1/2 inch) channels and not less than 200 mm (8 inches) for 20 mm (3/4 inch) channels with flanges of channels interlocked and securely tied near each end of the splice with two loops of the tie wire. Splices shall be staggered.

3.2.1 Hangers

Wire or strap hangers shall be attached to structural members in accordance with ASTM C 841, except hangers shall be spaced not more than 1220 mm (48 inches) along runner channels and 900 mm (36 inches) in the other direction or 1050 mm (42 inches) in both directions unless otherwise indicated or approved. Locations of hangers shall be coordinated with other work. Hangers at ends of runner channels shall be located not more than 150 mm (6 inches) from wall. Hanger wire shall be looped around bottom chord of open-web steel joist or secured to structural elements with suitable fasteners. Sags or twists in the suspended system shall be adjusted. Damaged or faulty parts shall be replaced.

3.2.2 Main Runners

Main runner channels shall be installed in accordance with ASTM C 841. Hanger wire shall be saddle-tied to runner channels, and the end of hanger wires shall be twisted three times around itself. Main runners shall not come in contact with abutting masonry or concrete walls and partitions. Main runners shall be located within 150 mm (6 inches) of the paralleling wall to support the ends of cross furring.

3.2.3 Furring Channels

Furring channels shall be spaced in accordance with ASTM C 841 for the type of lath used. Furring channels shall be securely saddle-tied to the runner channels and to structural supports at each crossing with tie wire, hairpin clips, or equivalent clips or fastenings. Furring channels shall be located within 50 mm (2 inches) of parallel walls and beams, and 15 mm (1/2 inch) from abutting walls. When gypsum lath is used on ceilings, hat-shaped sheetmetal furring channels may be used in lieu of 19 mm (3/4 inch) rolled steel furring channels. Gypsum lath shall be screw-applied at 200 mm (8 inches) on centers along supports and not less than 10 mm (3/8 inch) from edges of lath.

3.2.4 Light Fixtures and Air Diffusers

Light fixtures and air diffusers shall be supported directly from suspended ceiling runners. Wires shall be provided at appropriate locations to carry the weight of recessed or surface mounted light fixtures and air diffusers.

3.3 FURRED CEILING FRAMING INSTALLATION

Ceiling runners at continuous furred ceilings shall be applied directly to furring channels and secured thereto with tie wire, bolts, or screws at not more than 600 mm (24 inch) centers.

3.4 WALL FRAMING INSTALLATION

3.4.1 Loadbearing Wall Framing

Load-bearing steel studs shall be spaced for the type of lath used at external corners, partition ends, and approximately 50 mm (2 inches) each side of internal corners. Floor and ceiling runners shall be firmly secured to structural members with screws or bolts in expansion shields, hard-tempered stub nails, powder-actuated anchors, or by other approved methods at not more than 600 mm (24 inch) centers. Studs shall be attached to runner tracks with rivets or screws. Runner to tracks shall be aligned to partition layout at floor and ceiling, and shall be secured to concrete slabs with minimum 22 mm (7/8 inch) powder-driven pins or 19 mm (3/4 inch) concrete stub nails at no more than 1200 mm (48 inches) on centers. Each stud shall be aligned, plumb and true to top and bottom runner tracks.

3.4.2 Non-Loadbearing Wall Framing

Nonload-bearing steel studs shall be installed in accordance with ASTM C 754 with spacings as indicated in ASTM C 841 for the type of lath used. Studs shall be aligned and secure in top and bottom runners at spacings indicated on drawings. One or two beads of acoustic sealant shall be placed between runners and substrate to achieve the required air seal. Stud splicing is not acceptable. Corners shall be constructed with a minimum of three studs. Stud framing system shall be braced and made rigid.

3.4.3 Adjoining Walls and Columns

Studs which adjoin walls or columns shall be secured near the top and bottom, and at least one intermediate point, but not more than 1.5 m (5 feet) on centers, with wire inserts, dovetail anchors, toggle bolts, or bolts set in expansion shields.

3.4.4 Wall Bracing

Partitions more than 3 m (10 feet) long or 2.7 m (9 feet) high shall be braced with 19 mm (3/4 inch) steel channel stiffeners concealed horizontally. Stiffeners shall be spaced vertically not more than 2 m (6 feet) and shall be secured to each stud. Unsupported partitions 6 m (20 feet) or more in height shall be braced with 40 mm (1-1/2 inch) channel type horizontal stiffeners.

3.4.5 Corners and Intersection

Corners and intersections of partitions shall be formed of three studs. Studs at internal corners shall be placed not more than 50 mm (2 inches) from partition intersection.

3.4.6 Wall Openings

One loadbearing metal stud shall be installed at each jamb of door openings continuous from floor to ceiling, and shall be welded to jamb anchors and runner tracks. Jack studs shall be attached to runner track on interior of head of frame, and to runner track or 19 mm (3/4 inch) channel at ceiling. A 19 mm (3/4 inch) channel reinforcement shall be placed inside the partition 150 to 200 mm (6 to 8 inches) above door openings continuously through two stud spaces on each side of jambs, and welded to the flange. Studs shall be doubled at wall openings, with not more than 50 mm (2 inches) each side of openings. Stud placement shall be coordinated with supports and attachments. Intermediate studs above and below openings shall be secured at same spacing as wall studs. Stud framing shall extend to ceiling or through ceiling as indicated on drawings. Clearance shall be maintained between partition and structure to avoid deflection transfer to studs of partitions which extend through ceiling to structure. Placement of insulation in stud spaces shall be made inaccessible after studs are installed.

3.4.7 Bucks, Anchors and Blocking

Installation of bucks, anchors, and blocking shall be coordinated with electrical and mechanical work to be placed in or behind stud framing, and shall be coordinated with blocking requirements for support of plumbing fixtures, toilet partitions, wall cabinets, toilet accessories, hardware and similar items scheduled for installation.

3.5 WALL FURRING INSTALLATION

Metal furring shall be installed in accordance with ASTM C 754 and ASTM C 841.

3.6 SINGLE/DOUBLE CHANNEL, AND STUDLESS SOLID PARTITION INSTALLATION

Channel studs for single channel and double channel stud partitions shall be spaced 400 mm (16 inches) on centers and shall be secured to ceiling runners and to floor runners or base clips with wire ties or sheet-metal screws. Studs on each side of door openings shall be doubled and stiffened with a 6 x 25 mm (1/4 x l inch) flat steel strut, shop-coated with rust-inhibiting paint. Ends of struts shall be bent and punched for bolting to floor and ceiling construction. Where rib metal lath is the plaster base in continuous lengths from ceiling runners to floor runners for partitions less than 3 m (10 feet) in height, steel channel studs may be excluded from the partition except at locations previously specified for door openings. Rib lath shall be firmly attached to ceiling runner tracks or cornerite and to floor runner track or base by wire ties located not more than 200 mm (8 inches) on centers. Studless rib lath partitions shall be limited to not less than 50 mm (2 inches) thick. Partitions shall be as shown.

3.7 LATHING INSTALLATION

3.7.1 Metal Lath on Vertical Surfaces

Metal lath shall be applied with the long dimension across the supports, with true even surfaces, and without sags or buckles in accordance with ASTM C 841. Metal lath on vertical surfaces shall be oriented to provide maximum mechanical bond with plaster and the upper sheet shall be attached to overlap the lower sheet. When paper-backed lath is used, the upper sheet shall be attached to overlap the lower sheet. The lath shall be secured to supports at intervals not exceeding 150 mm (6 inches). Nails or staples shall be used for securing lath to wood supports. Tie wires, rings, clips, or other approved fasteners having equivalent holding power of the tie wires shall be used for securing the plaster base to metal supports and to concrete or masonry. Side-laps or junction of sides of plaster base shall be tied or otherwise secured at intervals not exceeding 225 mm (9 inches) between supports, in addition to being secured to supports.

3.7.2 Metal Lath on Ceilings

Lath on restrained ceilings shall be turned down at junction with wall, or shall be applied to cornerite or corner bead. Control joints in plasterwork shall be installed to continue control joints in structural frame and to divide plastered areas into not more than 13 square meters (144 square feet) for portland-cement plaster and 230 square meters (2500 square feet) for gypsum. Interval between joints shall be no more than 4 meters (12 feet) for portland-cement plaster and 15 meters (50 feet) for gypsum plaster.

3.7.3 Side and End Laps

Side and end laps of metal plaster bases shall be performed in accordance with ASTM C 841 for flat lath and ribbed lath.

3.7.4 Chases and Recesses

Chases and recesses shall be lathed for plastering. Openings over 300 mm (12 inches) wide shall be bridged with furring channels spaced 300 mm (12 inches) on centers. Openings 300 mm (12 inches) wide and less do not need to be bridged. Lath shall extend 75 mm (3 inches) beyond the edges of opening. Lath shall be securely fastened by nailing or tying. Lath shall be securely fastened with nails, screws or wire ties.

3.7.5 Installation of Gypsum Lath

Gypsum lath shall be installed in accordance with ASTM C 841. Spring clips or floating-wall-type attachment may be used in lieu of nails. Lath shall be cut and fitted to allow slight clearance around openings. Horizontal or vertical joints are not acceptable at corners of openings. End joints shall be made over supports. Where clip systems are approved, end joints shall be staggered in alternate courses. End joints shall not coincide with ceiling joints, and shall not occur in the same course on opposite side of support. Internal corners shall be reinforced with cornerites, and external corners shall be reinforced with corner beads. Internal corners of unrestrained ceilings shall not be reinforced with cornerites.

3.8 INSTALLATION OF GYPSUM BASE TO RECEIVE VENEER PLASTER

Gypsum base shall be installed in accordance with ASTM C 844. Base shall be cut and fitted to allow slight clearance around openings. Horizontal or vertical joints are not acceptable at corners of openings. End joints shall be made over supports. Where clip systems are approved, end joints shall be staggered in alternate courses. End joints shall not coincide with ceiling joints, and shall not occur in the same course on opposite side of support. Internal corners shall be reinforced with cornerites, and external corners shall be reinforced with corner beads. Internal corners of unrestrained ceilings shall not be reinforced with cornerites.

3.9 OPENINGS

Reinforcement shall be provided at corners of openings in plastered areas extending 300 mm (12 inches) or more in any dimension by securing striplath diagonally at corners. Striplath shall be at least 150 mm (6 inches) wide by 400 mm (16 inches) long. Shorter lengths shall be used to preclude lapping striplath. Striplath shall be secured to lathing without extending fastenings into or around supporting members. Where plaster is applied directly to concrete or masonry surfaces, striplath shall be secured to the concrete or masonry.

3.9.1 Steel Frames

Steel frames shall be securely attached through built-in anchors to the nearest stud on each side of opening with tie wire, bolts, screws, or welding or bracing where bracing is specified. Steel frames shall be grouted solid with plaster grout and a groove shall be formed within the frame returns to receive lath and plaster.

3.9.2 Wood Frames

Wood frames shall be securely attached to the nearest stud in frame partitions and to wood bucks built into the solid partition. Sizes shall be as indicated for each type and size of wall or partition.

3.9.3 Ceiling Openings

Framing shall be provided for ceiling openings and supplemental supporting members for items mounted in ceiling or attached to ceiling suspension system. Frames for openings shall be secured to lath support members. Frames provided with expanded metal flanges shall be secured to lath. Intermediate structural members shall be provided for attachment or suspension of support members.

3.9.4 Openings in Hollow Partitions

Hollow partition door openings shall be additionally braced by tying together each set of double-jamb studs with not less than four solid metal column clips evenly spaced along each jamb.

3.9.5 Openings in Partitions Not To Structure

Partitions not extending to the structural ceiling or structural supports or frame shall be strengthened at openings with angle bracing from each jamb location anchored to the structural ceiling or supports.

3.9.6 Cross Bracing

Cross bracing between partitions or similar bracing may be substituted for angle bracing as approved. Minor frames such as those required for access panels may be provided with expanded metal flanges which shall be attached to lath.

3.10 INSTALLATION OF TRIM, MOLDINGS, AND ACCESSORIES

Trim, moldings, and accessories shall be installed in standard lengths level and plumb to straight lines and as indicated on drawings. Fastenings shall be spaced not over 300 mm (12 inches) on centers for single-flanged accessories and not over 600 mm (24 inches) on centers on each flange of double-flanged accessories. Items shall be mitered or coped at corners, or prefabricated corners shall be used. Joints in straight runs shall be formed with splice or tie plates.

3.10.1 Base Screeds

Base screeds shall be installed approximately 75 mm (3 inches) above finished floor elevation unless indicated otherwise.

3.10.2 Corner Beads

Corner beads shall be installed in standard lengths at external plastered corners, and shall be secured to furring members or supports.

3.10.3 Cornerites

Cornerites shall be installed at internal angles formed by abutting surfaces of gypsum lath or metal lath not turned down at horizontal corners or returned around vertical corners. Cornerites shall be secured to lathed surfaces. Cornerites shall be secured to concrete or masonry where plaster is applied directly to concrete or masonry surfaces. Cornerites shall not be installed at unrestrained ceilings.

3.10.4 Casing Beads

Casing beads shall be installed at the joints of dissimilar base materials in the same plane and at exposed edges of plaster including junctions of walls and ceilings except that beads shall not be installed at restrained ceilings abutting plastered surfaces. At the perimeter of unrestrained suspended ceilings, the casing bead shall be secured to the ceiling to provide a 10 mm (3/8 inch) opening between the abutting surfaces. The opening shall be sealed prior to plastering with sealant as specified in Section 07900 JOINT SEALING.

3.10.5 Expansion and Control Joint Beads

Expansion joint beads shall be installed as control joints in plasterwork at the locations indicated. Plaster base shall not be run continuous through control joints. Additional supports shall be installed as required to support the beads.

3.10.6 Trim

Trim shall be installed where indicated and as required to complete the plaster work.

3.11 PLASTER THICKNESS AND SURFACE EVENNESS

Plaster thickness and surface evenness shall be controlled by grounds or screeds of metal, wood, or plaster. Wood grounds are specified under Section 06100 ROUGH CARPENTRY. Plaster thickness shall be as shown.

3.11.1 Grounds and Screeds

Grounds shall be used for securing trim items, and for finished corners and terminations. Screeds shall be installed for base screeds when wood or metal grounds are not required. Temporary screeds shall be installed when permanent screeds or grounds cannot be used. On completion of approved base coats, temporary screeds shall be removed and voids immediately filled with plaster.

3.11.2 Plaster Screeds

Plaster screeds shall be used within the plastered areas to supplement wood and metal grounds and screeds.

3.12 PLASTER GROUT

Plaster grout shall be scratch-coat material mixed to a non-fluid consistency. Plaster grout shall be used to fill steel door frames and partition bases. Grout shall be placed and grooved prior to gypsum lathing operations. Heads and jambs of frames shall be filled solid with grout, and 13 mm (1/2 inch) deep grooves shall be formed in the grout, while plastic, to receive gypsum lath.

3.13 PROPORTIONS AND MIXING

3.13.1 Portland Cement Plaster Base Coat

Base coat shall be proportioned and mixed in accordance with ASTM C 926 coat L for general use or coat C for optimum impact resistance.

3.13.2 Lime-Putty Finish

Lime-putty finish shall be mixed in the proportion of 1 part of gypsum gauging plaster, calcined gypsum, to 3 parts of lime putty by volume. The mix shall be approximately equivalent to one 45 kg (100 pound) bag of gypsum plaster to four 23 kg (50 pound) bags of hydrated lime or 0.13 cubic meters (4.5 cubic feet) of lime putty or 0.13 cubic meters (35 gallons) of lime putty. Perlite or vermiculite aggregated base coats shall have 23 kg (50 pounds) of fine white sand or 0.014 cubic meters (1/2 cubic foot) of perlite fines added for each 45 kg (100 pounds) of gauging plaster.

3.13.3 Prepared-Gypsum Finish

Prepared-gypsum finish shall be mixed with water to the proper consistency in accordance with manufacturer's published instructions. Prepared-gypsum finish shall have a minimum compressive strength of not less than 2 MPa (300 psi) when tested in accordance with ASTM C 472. Prepared gypsum finish shall be used only over sanded base coats.

3.13.4 Keene's Cement Finish

Keene's cement finish shall be mixed in the proportions of 45 kg (100 pounds) of Keene's cement to 11 kg (25 pounds), dry weight, of hydrated lime. The mix shall be approximately equivalent to one 45 kg (100 pound) bag of Keene's cement to one-half 23 kg (50 pound) bag of hydrated lime or 23 kg (50 pounds) lime putty or 0.017 cubic meters (4-1/2 gallons) lime putty. Subject to approval, 5 kg (10 pounds) of fine white sand may be added to the above mix. When mixing mechanically, the water shall be put into the mixer first, then the lime, the white sand if used, and finally the Keene's cement.

3.13.5 High-Strength Gypsum Finish

High-strength gypsum finish shall be mixed by dry weights in proportions of 45kg (100 pounds) of high-strength gypsum gauging plaster to 45 kg (100 pounds) of hydrated lime or 90 kg (200 pounds) of lime putty. Gypsum gauging plaster for high-strength finish coat shall be mixed with lime putty in accordance with ASTM C 28. Gauging plaster shall have a compressive strength not less than 21 MPa (3000 psi) when tested in accordance with ASTM C 472. Factory-mixed gypsum finishing plasters shall equal or exceed the performance requirements of job-mixed finishing plasters.

3.13.6 Portland Cement-Plaster Finish

The finish coat shall be proportioned and mixed in accordance with ASTM C926, coat FL for general use or coat F for abrasion resistance.

3.14 MACHINE APPLICATION

A plastering machine may be used for the application of scratch and brown coats. Plaster for machine application shall be a special plaster compounded and packaged by the manufacturer for this purpose. Slump cone equipment shall be present on the jobsite when base-coat plastering begins, and until completion. Testing of the mix shall be the responsibility of the Contractor, but equipment shall be available for use by the Government. Additional water shall not be added to the mix to allow pumping through extended hose lines to the plastering nozzle. The amount of water added to each batch of plaster shall be that quantity which results in a plaster slump of not more than 75 mm (3 inches) for gypsum and 65 mm (2-1/2 inches) for portland cement using a standard plaster slump cone or 150 mm (6 inches) for gypsum and 125 mm (5 inches) for portland cement using a concrete slump cone. Application of plaster shall conform to the provisions of ASTM C 842.

3.15 QUALITY CONTROL

Fluidity or stiffness of plaster shall be tested with a standard 50x100x150 mm (2x4x6 inch) plaster slump testing cone or by a 100x200x300 mm (4x8x12 inch) concrete slump testing cone. Method of making slump test shall be as follows:

a. Place cone on center of dry base plate located on a level, firm surface. Hold cone tightly against plate.

b. Fill the cone with plaster obtained from the hose or nozzle, without air on the nozzle, puddling with tamping rod during the operation to eliminate air bubbles or voids.

c. Screed plaster level with top of cone.

d. Lift cone straight up from base plate in a slow and uniform motion, and place it on the base plate next to plaster sample.

e. Lay a straightedge across top of cone, being careful not to disturb or jostle the plate, and measure the slump in millimeters inches from the bottom of the straightedge to the top of the plaster sample.

3.16 APPLICATION OF FINISHES

The finish coat may be omitted back of projecting bases, wainscots, structural-glass wall finish, cabinets, chalkboards, tackboards, bulletin boards, acoustic treatments, fixed equipment, and other locations where indicated. Finish coats shall not be applied above wainscots until wainscots have been installed. Plaster shall have a smooth-trowel or texture finish as shown.

3.16.1 Interior Gypsum Plaster

Application of interior gypsum plaster (full thick) shall be in accordance with ASTM C 842. Nominal plaster thickness shall be as shown.

3.16.2 Gypsum Veneer Plaster

Application of gypsum veneer plaster shall be in accordance with ASTM C 843. Plaster shall be one-component system or two-component system as shown.

3.16.3 Lime-Putty Finish

Lime-putty finish shall be applied over gypsum plaster base coats in accordance with ASTM C 842. The finish coat shall be 1.5 to 3 mm (1/16 to 1/8 inch) thick and troweled smooth and free from blemishes.

3.16.4 Prepared-Gypsum Finish

Prepared-gypsum finish may be used in lieu of lime-putty finish, and shall be applied in accordance with the manufacturer's printed directions.

3.16.5 Keene's Cement Finish and High Strength Gypsum-Plaster Finish

Keene's cement finish and high-strength gypsum-plaster finish shall be applied in accordance with ASTM C 842. Where indicated on the finish schedule, either may be used at the Contractor's option. Neither finish shall be used over lightweight-aggregate-plaster or portland-cement-plaster base coats. The finish coat shall be 1.5 to 3 mm (1/16 to 1/8 inch) thick, and troweled smooth and free from blemishes and irregularities.

3.16.6 Portland Cement-Based Plaster

Two-coat or Three-coat portland cement-based plaster shall be applied in accordance with ASTM C 926. The final coat shall be finished to a true and even surface free from rough areas, checks, or blemishes. Nominal plaster finish thickness shall be as shown.

3.17 PATCHING

Plaster showing oversanding, cracks, blisters, pits, checks, discoloration or other defects is not acceptable. Defective plaster work shall be removed and replaced with new plaster at the expense of Contractor. Patching of defective work will be permitted only when approved by the Contracting Officer. Patching shall match existing work in texture and color.

3.18 SAMPLES OF COMPLETED WORK

Samples of completed work may be taken by the Contracting Officer at any time for laboratory inspection and tests to determine conformance.

SECTION 09250

GYPSUM BOARD

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A108.11	(1992) Interior Installation of Cementitious Backer Units
ANSI A118.9	(1992) Cementitious Backer Units

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 36/C 36M	(1999) Gypsum Wallboard
ASTM C 79/C 79M	(2001) Standard Specification for Treated Core and Nontreated Core Gypsum Sheathing Board
ASTM C 442/C 442M	(1999; Rev. A) Gypsum Backing Board and Coreboard
ASTM C 475	(1994) Joint Compound and Joint Tape for Finishing Gypsum Board
ASTM C 514	(1996) Nails for the Application of Gypsum Board

ASTM C 557	(1999) Adhesives for Fastening Gypsum Wallboard to Wood Framing
ASTM C 630/C 630M	(2001) Water-Resistant Gypsum Backing Board
ASTM C 840	(2001) Application and Finishing of Gypsum Board
ASTM C 954	(2000) Steel Drill Screws for the Application of Gypsum Board or Metal Plaster Bases to Steel Studs from 0.84 mm (0.033 in.) to 2.84 mm (0.112 in.) in Thickness
ASTM C 1002	(2000) Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases
ASTM C 1047	(1999) Accessories for Gypsum Wallboard and Gypsum Veneer Base
ASTM C 1177/C 1177M	(1999) Standard Specification for Glass Mat Gypsum Substrate for use as Sheathing
ASTM C 1178/C 1178M	(1999) Glass Mat Water-Resistant Gypsum Backing Board
ASTM C 1396/C 1396M	(2000) Standard Specification for Gypsum Board
ASTM D 226 `	(1997) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D 412	(1998) Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension
ASTM D 624	(2000) Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D 1037	(1999) Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials
ASTM D 1149	(1999) Standard Test Method for Rubber Deterioration-Surface Ozone Cracking in a Chamber
ASTM D 2394	(1999) Standard Method for Simulated Service Testing of Wood and Wood-Base Finish Flooring
ASTM D 5420	(1998) Standard Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker Impacted by a Falling Weight (Gardner Impact)
ASTM E 84	(2001) Surface Burning Characteristics of Building Materials
ASTM E 695	(1997) Standard Method for Measure Relative Resistance of Wall, Floor and Roof Construction to Impact Loads

GYPSUM ASSOCIATION (GA)

GA 214	(1996) Recommended Levels of Gypsum Board Finish
GA 216	(2000) Application and Finishing of Gypsum Board
GA 253	(1999) Application of Gypsum Sheathing
GA 600	(2000) Fire Resistance and Sound Control Design Manual

UNDERWRITERS LABORATORIES (UL)

UL Fire Resist Dir	(2000) Fire Resistance Directory

KOREAN INDUSTRIAL STANDARD (KS) PUBLICATIONS

KS F 3504	(1996) Gypsum Boards
KS F 3514	(2001) Gypsum Board Nails

1.2 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-03 Product Data

Cementitious backer units; G.

Glass Mat Water-Resistant Gypsum Tile Backing Board; G.

Water-Resistant Gypsum Backing Board; G.

Glass Mat Covered or Reinforced Gypsum Sheathing; G.

Glass Mat Covered or Reinforced Gypsum Sheathing Sealant; G.

Impact Resistant Gypsum Board; G.

Accessories; G.

Submit for each type of gypsum board and for cementitious backer units.

SD-07 Certificates

Asbestos Free Materials; G.

Certify that gypsum board types, gypsum backing board types, cementitious backer units, and joint treating materials do not contain asbestos.

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery

Deliver materials in the original packages, containers, or bundles with each bearing the brand name, applicable standard designation, and name of manufacturer, or supplier.

1.3.2 Storage

Keep materials dry by storing inside a sheltered building. Where necessary to store gypsum board and cementitious backer units outside, store off the ground, properly supported on a level platform, and protected from direct exposure to rain, snow, sunlight, and other extreme weather conditions. Provide adequate ventilation to prevent condensation.

1.3.3 Handling

Neatly stack gypsum board and cementitious backer units flat to prevent sagging or damage to the edges, ends, and surfaces.

1.4 ENVIRONMENTAL CONDITIONS

1.4.1 Temperature

Maintain a uniform temperature of not less than 10 degrees C (50 degrees F) in the structure for at least 48 hours prior to, during, and following the application of gypsum board, cementitious backer units, and joint treatment materials, or the bonding of adhesives.

1.4.2 Exposure to Weather

Protect gypsum board and cementitious backer unit products from direct exposure to rain, snow, sunlight, and other extreme weather conditions.

1.5 QUALIFICATIONS

Manufacturer shall specialize in manufacturing the types of material specified and shall have a minimum of 5 years of documented successful experience. Installer shall specialize in the type of gypsum board work required and shall have a minimum of 3 years of documented successful experience.

PART 2 PRODUCTS

2.1 MATERIALS

Conform to specifications, standards and requirements specified herein. Provide gypsum board types, gypsum backing board types, cementitious backing units, and joint treating materials manufactured from asbestos free materials only.

2.1.1 Gypsum Board

ASTM C 36/C 36M and ASTM C 1396/C 1396M, or KS F 3504 (GB-R) regular gypsum board only.

2.1.1.1 Regular

1200 mm (48 inches) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated, tapered edges.

2.1.1.2 Foil-Backed

1200 mm (48 inches) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated, tapered edges.

2.1.1.3 Type X (Special Fire-Resistant)

1200 mm (48 inches) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated, tapered edges.

2.1.2 Gypsum Backing Board

ASTM C 442/C 442M, gypsum backing board shall be used as a base in a multilayer system.

2.1.2.1 Regular

1200 mm (48 inches) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated, square edges.

2.1.2.2 Foil-Backed

1200 mm (48 inches) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated, square edges.

2.1.2.3 Gypsum Coreboard Type X (Special Fire-Resistant)

1200 mm (48 inches) wide, 19.05 or 25.4 mm (3/4 or 1 inch) thick as indicated, square edges.

2.1.3 Regular Water-Resistant Gypsum Backing Board

ASTM C 630/C 630M

2.1.3.1 Regular

1200 mm (48 inches) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated, tapered edges.

2.1.3.2 Type X (Special Fire-Resistant)

1200 mm (48 inches) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated, tapered edges.

2.1.4 Glass Mat Water-Resistant Gypsum Tile Backing Board

ASTM C 1178/C 1178M

2.1.4.1 Regular

1200 mm (48 inches) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated, square edges.

2.1.4.2 Type X (Special Fire-Resistant)

1200 mm (48 inches) wide, 12.7 or 15.9 mm (1/2 or 5/8 inch) thick as indicated, square edges.

2.1.5 Glass Mat Covered or Reinforced Gypsum Sheathing

Exceeds physical properties of ASTM C 79/C 79M and ASTM C 1177/C 1177M. Provide 12.7 or 15.9 mm (1/2 or 5/8 inch) as indicated, gypsum sheathing. Gypsum board shall consist of a noncombustible water-resistant core, with a glass mat surfaces embedded to the gypsum core or reinforcing embedded throughout the gypsum core. Gypsum sheathing board shall be warranted for at least 6 months against delamination due to direct weather exposure. Provide continuous, asphalt impregnated, building felt to cover exterior face of sheathing. All joints, seams and penetrations shall be sealed with compatible sealant.

2.1.5.1 Glass Mat Covered or Reinforced Gypsum Sheathing Sealant

Sealant shall be compatible with gypsum sheathing, rubber washers for masonry veneer anchors,and other associated cavity wall components such as anchors and through wall flashing. Sealants for gypsum sheathing board edge seams and veneer anchor penetrations shall be the type recommended by the gypsum sheathing manufacturer and have the following performance requirements:

a. ASTM D 412: Tensile Strength - 551 kilopascals (80 psi)

b. ASTM D 412: Ultimate Tensile Strength (maximum elongation) ? 1172 kilopascals (170 psi)

c. ASTM D 624: Tear Strength, dieB, - 4.7 kN/m 27 ppi

d. ASTM D 1149: Joint Movement Capability after 14 Days cure - percent + 50

2.1.6 Impact Resistant Gypsum Board

1200 mm (48 inch) wide, 15.9 mm (5/8 inch) thick, tapered edges. Reinforced gypsum panel with imbedded fiber mesh or lexan backing testing in accordance with the following tests. Provide fasteners that meet manufacturer requirements and specifications stated within this section. Impact resistant gypsum board, when tested in accordance with ASTM E 84, shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less.

2.1.6.1 Structural Failure Test

ASTM E 695 or ASTM D 2394 for structural failure (drop penetration). ASTM E 695using a 27.2 kg (60 lb) sand filled leather bag, resisting no less than 407 N-m (300 ft. lb.) cumulative impact energy before failure or ASTM D 2394 using 139.7 mm (5.5 inches) hemispherical projectile resisting no less than 357 N-m (264 ft. lb.) before failure. Test specimen stud spacing shall be 406 mm (16 inch) or greater on center.

2.1.6.2 Indentation Test

ASTM D 5420 or ASTM D 1037 for indentation resistance. ASTM D 5420 using a 0.907 kg (32 oz) weight with a 16 mm (5/8 inch) hemispherical impacting head dropped once 915 mm (3 feet) creating not more than 3.5 mm (0.137 inch) indentation or ASTM D 1037 using no less than 213 kg (470 lb) weight applied to the 11.13 mm (0.438 inch) diameter ball to create not more than a 0.5 mm (0.0197 inch) indentation depth.

2.1.7 Cementitious Backer Units

ANSI A118.9.

2.1.8 Joint Treatment Materials

ASTM C 475.

2.1.8.1 Embedding Compound

Specifically formulated and manufactured for use in embedding tape at gypsum board joints and compatible with tape, substrate and fasteners.

2.1.8.2 Finishing or Topping Compound

Specifically formulated and manufactured for use as a finishing compound.

2.1.8.3 All-Purpose Compound

Specifically formulated and manufactured to serve as both a taping and a finishing compound and compatible with tape, substrate and fasteners.

2.1.8.4 Setting or Hardening Type Compound

Specifically formulated and manufactured for use with fiber glass mesh tape.

2.1.8.5 Joint Tape

Cross-laminated, tapered edge, reinforced paper, or fiber glass mesh tape recommended by the manufacturer.

2.1.9 Fasteners

2.1.9.1 Nails

ASTM C 514 or KS F 3514.

2.1.9.2 Screws

ASTM C 1002, Type "G", Type "S" or Type "W" steel drill screws for fastening gypsum board to gypsum board, wood framing members and steel framing members less than 0.84 mm (0.033 inch) thick. ASTM C 954 steel drill screws for fastening gypsum board to steel framing members 0.84 to 2.84 mm (0.033 to 0.112 inch) thick. Provide cementitious backer unit screws with a polymer coating.

2.1.9.3 Staples

1.5 mm thick (No. 16 USS gage) flattened galvanized wire staples with 11.1 mm (7/16 inch) wide crown outside measurement and divergent point for base ply of two-ply gypsum board application. Use as follows:

Length of Legs (mm)	Thickness of Gypsum Board (mm)
28.6	12.7
31.8	15.9

Length of Legs (inch)	Thickness of Gypsum Board (inch)
1 1/8	1/2
1 1/4	5/8

2.1.10   Adhesives

Do not use adhesive containing benzene, carbon tetrachloride, or trichloroethylene.

2.1.10.1   Adhesive for Fastening Gypsum Board to Metal Framing

Type recommended by gypsum board manufacturer.

2.1.10.2   Adhesive for Fastening Gypsum Board to Wood Framing

ASTM C 557.

2.1.10.3   Adhesive for Laminating

For laminating two-ply gypsum board systems and gypsum studs to face panels, provide adhesive recommended by gypsum board manufacturer.

2.1.11   Gypsum Studs

25 mm (One inch) minimum thickness and 150 mm (6 inch) minimum width. Studs may be of 25 mm (one inch) thick gypsum board or multilayers laminated to required thickness. Conform to ASTM C 36/C 36M or ASTM C 442/C 442M for material.

2.1.12   Shaftwall Liner Panel

ASTM C 442/C 442M. Shaftwall liner panel shall conform to UL Fire Resist Dir for the Design Number(s) indicated. Liner Panel shall be specifically manufactured for cavity shaftwall system, with water-resistant paper faces, bevel edges, single lengths to fit required conditions, 25.4 mm or 19.05 mm (1" or 3/4") thick as indicated, by 610 mm (24") wide.

2.1.13   Accessories

ASTM C 1047. Fabricate from corrosion protected steel or plastic designed for intended use. Accessories manufactured with paper flanges are not acceptable. Flanges shall be free of dirt, grease, and other materials that may adversely affect bond of joint treatment.

2.1.14   Asphalt Impregnated Building Felt

The moisture barrier over gypsum sheathing shall be 6.7 kg (15-lb) asphalt impregnated felt conforming to ASTM D 226 Type I (No. 15).

2.1.15 Water

Clean, fresh, and potable.

PART 3 EXECUTION

3.1 EXAMINATION

3.1.1 Framing and Furring

Verify that framing and furring are securely attached and of sizes and spacing to provide a suitable substrate to receive gypsum board and cementitious backer units. Verify that all blocking, headers and supports are in place to support plumbing fixtures and to receive soap dishes, grab bars, towel racks, and similar items. Do not proceed with work until framing and furring are acceptable for application of gypsum board and cementitious backer units.

3.1.2 Gypsum Board and Framing

Verify that surfaces of gypsum board and framing to be bonded with an adhesive are free of dust, dirt, grease, and any other foreign matter. Do not proceed with work until surfaces are acceptable for application of gypsum board with adhesive.

3.1.3 Masonry and Concrete Walls

Verify that surfaces of masonry and concrete walls to receive gypsum board applied with adhesive are dry, free of dust, oil, form release agents, protrusions and voids, and any other foreign matter. Do not proceed with work until surfaces are acceptable for application of gypsum board with adhesive.

3.2 APPLICATION OF GYPSUM BOARD

Apply gypsum board to framing and furring members in accordance with ASTM C 840 or GA 216 and the requirements specified herein. Apply gypsum board with separate panels in moderate contact; do not force in place. Stagger end joints of adjoining panels. Neatly fit abutting end and edge joints. Use gypsum board of maximum practical length. Cut out gypsum board as required to make neat close joints around openings. In vertical application of gypsum board, provide panels in lengths required to reach full height of vertical surfaces in one continuous piece. Surfaces of gypsum board and substrate members may be bonded together with an adhesive, except where prohibited by fire rating(s). Treat edges of cutouts for plumbing pipes, screwheads, and joints with water-resistant compound as recommended by the gypsum board manufacturer. Provide type of gypsum board for use in each system specified herein as indicated.

3.2.1 Application of Single-Ply Gypsum Board to Wood Framing

Apply in accordance with ASTM C 840, System I or GA 216.

3.2.2 Application of Two-Ply Gypsum Board to Wood Framing

Apply in accordance with ASTM C 840, System II or GA 216.

3.2.3 Adhesive Nail-On Application to Wood Framing

Apply in accordance with ASTM C 840, System III or GA 216. This method may be used in lieu of ASTM C 840, System I at the option of the Contractor.

3.2.4 Semi-Solid Gypsum Board Partitions

Provide in accordance with ASTM C 840, System IV or GA 216 .

3.2.5 Solid Gypsum Board Partitions

Provide in accordance with ASTM C 840, System V or GA 216.

3.2.6 Adhesive Application to Interior Masonry or Concrete Walls

Apply in accordance with ASTM C 840, System VI or GA 216.

3.2.7 Application of Gypsum Board to Steel Framing and Furring

Apply in accordance with ASTM C 840, System VIII or GA 216.

3.2.8 Arches and Bending Radii

Apply gypsum board in accordance with ASTM C 840, System IX or GA 216.

3.2.9 Gypsum Board for Wall Tile or Tile Base Applied with Adhesive

In dry areas (areas other than tubs, shower enclosures, saunas, steam rooms, gang shower rooms), apply glass matt water-resistant gypsum tile backing board or water-resistant gypsum backing board in accordance with ASTM C 840, System X or GA 216.

3.2.10 Exterior Application

Apply exterior gypsum board (such as at soffits) in accordance with ASTM C 840, System XI or GA 216.

3.2.11 Glass Mat Covered or Fiber Reinforced Gypsum Sheathing

Apply gypsum sheathing in accordance to gypsum association publication GA 253. Design details for joints and fasteners shall follow gypsum sheathing manufacturer's requirements and be properly installed to protect the substrate from moisture intrusion. Exposed surfaces of the gypsum sheathing shall not be left exposed beyond the manufacture's recommendation without a weather barrier cladding. Provide continuous asphalt impregnated building felt over sheathing surface in shingle fashion with edges and ends lapped a minimum of 150 mm (6 inch). Openings shall be properly flashed. All joints, seams and penetrations shall be sealed with compatible silicone sealant.

3.2.12 Floating Interior Angles

Locate the attachment fasteners adjacent to ceiling and wall intersections in accordance with ASTM C 840, System XII or GA 216, for single-ply and two-ply applications of gypsum board to wood framing.

3.2.13 Control Joints

Install expansion and contraction joints in ceilings and walls in accordance with ASTM C 840, System XIII or GA 216, unless indicated otherwise. Control joints between studs in fire-rated construction shall be filled with firesafing insulation to match the fire-rating of construction.

3.2.14 Application of Foil-Backed Gypsum Board

Apply foil-backed gypsum board in accordance with ASTM C 840, System XIV or GA 216.

3.2.15 Application of Impact Resistant Gypsum Board

Apply in accordance with applicable system of ASTM C 840 as specified or GA 216. Follow manufacturers written instructions on how to cut, drill and attach board.

3.3 APPLICATION OF CEMENTITIOUS BACKER UNITS

3.3.1 Application

In wet areas (tubs, shower enclosures, saunas, steam rooms, gang shower rooms), apply cementitious backer units in accordance with ANSI A108.11. A 7.6 kg (15 lb) asphalt impregnated, continuous felt paper membrane shall be placed behind cementitious backer units, between backer units and studs or base layer of gypsum board. Membrane shall be placed with a minimum 150 mm (6 inch) overlap of sheets laid shingle style.

3.3.2 Joint Treatment

ANSI A108.11.

3.4 FINISHING OF GYPSUM BOARD

Tape and finish gypsum board in accordance with ASTM C 840, GA 214 and GA 216. Plenum areas above ceilings shall be finished to Level 1 in accordance with GA 214. Water resistant gypsum backing board, ASTM C 630/C 630M, to receive ceramic tile shall be finished to Level 2 in accordance with GA 214. Walls and ceilings to receive a heavy-grade wall covering or heave textured finish before painting shall be finished to Level 3 in accordance with GA 214. Walls and ceilings without critical lighting to receive flat paints, light textures, or wall coverings shall be finished to Level 4 in accordance with GA 214. Unless otherwise specified, all gypsum board walls, partitions and ceilings shall be finished to Level 5 in accordance with GA 214. Provide joint, fastener depression, and corner treatment. Do not use fiber glass mesh tape with conventional drying type joint compounds; use setting or hardening type compounds only. Provide treatment for water-resistant gypsum board as recommended by the gypsum board manufacturer.

3.4.1 Uniform Surface

Wherever gypsum board is to receive eggshell, semigloss or gloss paint finish, or where severe, up or down lighting conditions occur, finish gypsum wall surface in accordance to GA 214 Level 5. In accordance with GA 214 Level 5, apply a thin skim coat of joint compound to the entire gypsum board surface, after the two-coat joint and fastener treatment is complete and dry.

3.5 SEALING

Seal openings around pipes, fixtures, and other items projecting through gypsum board and cementitious backer units as specified in Section 07900a "Joint Sealing." Apply material with exposed surface flush with gypsum board or cementitious backer units.

3.5.1 Sealing for Glass Mat or Reinforced Gypsum Board Sheathing

Apply silicone sealant in a 9.5 mm (3/8 inch) bead to all joints and trowel flat. Apply enough of the same sealant to all fasteners penetrating through the glass mat gypsum board surface to completely cover the penetration when troweled flat. Construction and materials shall not be placed behind sheathing until a visual inspection of sealed joints during daylight hours has been completed by Contracting Officer.

3.6 FIRE-RESISTANT ASSEMBLIES

Wherever fire-rated construction is indicated, provide materials and application methods, including types and spacing of fasteners, wall and ceiling framing in accordance with the specifications contained in UL Fire Resist Dir for the Design Number(s) indicated or GA 600 for the File Number(s) indicated. Joints of fire-rated gypsum board enclosures shall be closed and sealed in accordance with UL test requirements or GA requirements. Penetrations through rated partitions and ceilings shall be sealed tight in accordance with tested systems. Fire ratings shall be as indicated.

3.7 PATCHING

Patch surface defects in gypsum board to a smooth, uniform appearance, ready to receive finish as specified.

3.8 SHAFT WALL FRAMING

The shaft wall system shall be installed in accordance with the system manufacturer's published instructions. Bucks, anchors, blocking and other items placed in or behind shaft wall framing shall be coordinated with electrical and mechanical work. Fireproofing materials which are damaged or removed during shaft wall construction shall be patched or replaced.

SECTION 09310

CERAMIC TILE, QUARRY TILE, AND PAVER TILE

SECTION TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A108.1A (1992) Installation of Ceramic Tile in the Wet-Set Method, with Portland Cement Mortar

ANSI A108.1B (1992) Installation of Ceramic Tile on a Cured Portland Cement Mortar Setting Bed with Dry-Set or Latex Portland Cement Mortar

ANSI A108.4 (1992) Installation of Ceramic Tile with Organic Adhesives or Water Cleanable Tile Setting Epoxy Adhesive

ANSI A108.5 (1992) Installation of Ceramic Tile with Dry-Set Portland Cement Mortar or Latex-Portland Cement Mortar

ANSI A108.6 (1992) Installation of Ceramic Tile with Chemical Resistant, Water Cleanable Tile-Setting and Grouting Epoxy

ANSI A108.7 (1992) Electrically Conductive Ceramic Tile Installed with Conductive Dry-Set Portland Cement Mortar

ANSI A108.8 (1992) Installation of Ceramic Tile with Chemical Resistant Furan Mortar and Grout

ANSI A108.10 (1992) Installation of Grout in Tilework

ANSI A118.1 (1992) Dry-Set Portland Cement Mortar

ANSI A118.2 (1992) Conductive Dry-Set Portland Cement Mortar

ANSI A118.3 (1992) Chemical Resistant, Water Cleanable Tile Setting and Grouting Epoxy and Water Cleanable Tile Setting Epoxy Adhesive

ANSI A118.4 (1992) Latex-Portland Cement Mortar

ANSI A118.5 (1992) Chemical Resistant Furan Mortars and Grouts for Tile

ANSI A118.6 (1992) Ceramic Tile Grouts

ANSI A118.9 (1992) Test Methods and Specifications for Cementitious Backer Units

ANSI A136.1 (1992) Organic Adhesives for Installation of Ceramic Tile

ANSI A137.1 (1988) Ceramic Tile

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 185 (1997) Steel Welded Wire Fabric, Plain, for Concrete Reinforcement

ASTM C 33 (1999ae1) Concrete Aggregates

ASTM C 144 (1999) Aggregate for Masonry Mortar

ASTM C 150 (1999a) Portland Cement

ASTM C 206 (1984; R 1997) Finishing Hydrated Lime

ASTM C 207 (1991; R 1997) Hydrated Lime for Masonry Purposes

ASTM C 241 (1997) Abrasion Resistance of Stone Subjected to Foot Traffic

ASTM C 373 (1988; R 1994) Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products

ASTM C 482 (1981; R 1996) Bond Strength of Ceramic Tile to Portland

	Cement
ASTM C 501	(1984; R 1996) Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser
ASTM C 648	(1998) Breaking Strength of Ceramic Tile
ASTM C 847	(1995) Metal Lath
ASTM C 1026	(1987; R 1996) Measuring the Resistance of Ceramic Tile to Freeze-Thaw Cycling
ASTM C 1027	(1999) Determining Visible Abrasion Resistance of Glazed Ceramic Tile
ASTM C 1028	(1996) Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method
ASTM F 446	(1985; R 1993) Grab Bars and Accessories Installed in Bathing Area

MARBLE INSTITUTE OF AMERICA (MIA)

MIA Design Manual	(1991) Design Manual IV Dimensional Stone

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 99	(1999) Health Care Facilities

TILE COUNCIL OF AMERICA (TCA)

TCA Hdbk	(1997) Handbook for Ceramic Tile Installation

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

36 CFR 1191	Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities

KOREAN INDUSTRIAL STANDARD (KS) PUBLICATIONS

KS F 4552	(1980) Metal Lath
KS L 5201	(1989) Portland Cement
KS L 9007	(1996) Decorated Quicklime and Hydrated Lime

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Tile; G.

Setting-Bed; G.

Mortar, Grout, and Adhesive; G.

Manufacturer's catalog data and preprinted installation and cleaning instructions.

SD-04 Samples

Tile; G.

Accessories; G.

Marble Thresholds; G.

Samples of sufficient size to show color range, pattern, type and joints.

SD-07 Certificates

Tile; G.

Mortar, Grout, and Adhesive; G.

Certificates indicating conformance with specified requirements. A master grade certificate shall be furnished for tile.

1.3 DELIVERY AND STORAGE

Materials shall be delivered to the project site in manufacturer's original unopened containers with seals unbroken and labels and hallmarks intact. Materials shall be kept dry, protected from weather, and stored under cover in accordance with manufacturer's instructions.

1.4 ENVIRONMENTAL REQUIREMENTS

Ceramic tile work shall not be performed unless the substrate and ambient temperature is at least 10 degrees C (50 degrees F) and rising. Temperature shall be maintained above 10 degrees C (50 degrees F) while the work is being performed and for at least 7 days after completion of the work. When temporary heaters are used they shall be vented to the outside to avoid carbon dioxide damage to new tilework.

1.5 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a 1-year period shall be provided.

1.6 EXTRA STOCK

Supply an extra two percent of each type tile used in clean and marked cartons.

PART 2 PRODUCTS

2.1 TILE

Tile shall be standard grade conforming to ANSI A137.1. Containers shall be grade sealed. Seals shall be marked to correspond with the marks on the signed master grade certificate. Tile shall be impact resistant with a minimum breaking strength for wall tile of 41 kg (90 lbs) and 113 kg (250 lbs) for floor tile in accordance with ASTM C 648. Tile for cold climate projects shall be rated frost resistant by the manufacturer as determined by ASTM C 1026. Water absorption shall be 0.50 maximum percent in accordance with ASTM C 373. Floor tile shall have a minimum coefficient of friction of 0.60 (wet and dry) and 0.80 (wet and dry) for ramps in accordance with ASTM C 1028. Floor tile shall be Class III - Medium-Heavy Traffic for all residential applications, and Class IV-Heavy Traffic for commercial applications such as public areas of exhibition halls, shops, and schools, and Class IV Plus-Extra Heavy Traffic for walkways, food service, etc., durability classification as rated by the manufacturer when tested in accordance with ASTM C 1027 for abrasion resistance as related to foot traffic. Color shall be as indicated.

2.1.1 Mosaic Tile

Ceramic mosaic tile and trim shall be unglazed natural clay or conductive with cushion edges, or porcelain unpolished or polished with sharply formed face as indicated. Tile size shall be 25 x 25 mm (1 x 1 inch), 50 x 50 mm (2 x 2 inches) or as indicated. Color shall be as indicated.

2.1.2 Quarry Tile

Quarry tile and trim shall be unglazed with abrasive surface. Tile shall be 150 x 150 x 13 mm (6 x 6 x 1/2inch). Color shall be as indicated.

2.1.3 PAVER TILE

Paver tile shall be glazed or unglazed, size 100 x 100 x 13 mm (4 x 4 x 3/8 inch) or 150 x 150 x 13 mm (6 x 6 x 3/8 inch), or 100 x 200 x 13 mm (4 x 8 x 3/8 inch) as indicated. Color shall be as indicated.

2.1.3 Detectable Warning Tile

Detectable warning tile shall be unglazed with raised truncated domes with a diameter of nominal 23 mm (0.9 inch) at a height of nominal 5 mm (0.2 inch) and a center-to-center spacing of nominal 60 mm (2.35 inches) and shall contrast visually with adjoining surfaces. Tile shall be 150 x 150 x 13 mm (6 x 6 x 1/2 inch). Color shall be as indicated.

2.1.4 Porcelain Tile

Porcelain tile and trim shall be unglazed with the color extending uniformly through the body of the tile. Tile size shall be nominal 305 by 305 mm by 8 mm (12 by 12 inches by 5/16 inch) thick. Tile shall meet or exceed the following criteria: Abrasive wear in accordance with ASTM C 501 and bonding strength in accordance with ASTM C 482. Tile shall comply with 36 CFR 1191 for coefficient of friction for interior floors. Color shall be as indicated.

2.1.5 Glazed Wall Tile

Glazed wall tile and trim shall be cushion edged with matte glaze. Tile shall be 106 x 106 or 150 x 150 mm (4-1/4 x 4-1/4 or 6 x 6 inches) or as indicated. Color shall be as indicated.

2.1.6 Accessories

Accessories shall be the built-in type of the same materials and finish as the wall tile. Quantity and location for accessories shall be provided as shown on the drawings:

a. Recessed soap holders

b. Tumbler holders

c. Combination tumbler and toothbrush holders

d. Towel bars, stainless steel or ceramic 600 or 750 mm (24 or 30 inches) long, two towel posts

e. Robe hooks

f. Roll paper holder

g. Recessed soap holder and hand hold combination: support static load in compliance with ASTM F 446

2.2 SETTING-BED

The setting-bed shall be composed of the following:

2.2.1 Aggregate for Concrete Fill

Aggregate shall conform to ASTM C 33. Maximum size of coarse aggregate shall not be greater than one-half the thickness of concrete fill.

2.2.2 Portland Cement

Cement shall conform to ASTM C 150, Type I, or KS L 5201, white for wall mortar and gray for other uses.

2.2.3 Sand

Sand shall conform to ASTM C 144.

2.2.4 Hydrated Lime

Hydrated lime shall conform to ASTM C 206, Type S or ASTM C 207, Type S, or KS L 9007.

2.2.5 Metal Lath

Metal lath shall be flat expanded type conforming to ASTM C 847 or KS F 4552, and weighing not less than 1.4 kg/square meter (2.5 pounds per square yard).

2.2.6 Reinforcing Wire Fabric

Wire fabric shall conform to ASTM A 185. Wire shall be either 50 x 50 mm (2 x 2 inch) mesh, 16/16 wire or 38 x 50 mm (1-1/2 x 2 inch) mesh, 16/13 wire.

2.3 WATER

Water shall be potable.

2.4 MORTAR, GROUT, AND ADHESIVE

Mortar, grout, and adhesive shall conform to the following:

2.4.1 Dry-Set Portland Cement Mortar

ANSI A118.1.

2.4.2 Conductive Dry-Set Mortar

ANSI A118.2.

2.4.3 Latex-Portland Cement Mortar

ANSI A118.4.

2.4.4 Ceramic Tile Grout

ANSI A118.6; dry-set grout, latex-portland cement grout or commercial portland cement grout.

2.4.5 Organic Adhesive

ANSI A136.1, Type I.

2.4.6 Epoxy Resin Grout

ANSI A118.3.

2.4.7 Furan Resin Grout

ANSI A118.5 and consist of an intimate mixture of furfuryl-alcohol resin with carbon filler and catalyst.

2.4.8 Cementitious Backer Board

Cementitious backer units, for use as tile substrate over wood sub-floors, shall be in accordance with ANSI A118.9. Cementitious backer units shall be 6.35 or 12.7 mm (1/4 or 1/2 inch) thick as indicated.

2.5 MARBLE THRESHOLDS

Marble thresholds shall be of size required by drawings or conditions. Marble shall be Group A as classified by MIA Design Manual. Marble shall have a fine sand-rubbed finish and shall be white or gray in color as approved by the

Contracting Officer. Marble abrasion shall be not less than 12.0 when tested in accordance with ASTM C 241.

PART 3 EXECUTION

3.1 PREPARATORY WORK AND WORKMANSHIP

Surface to receive tile shall be inspected and shall conform to the requirements of ANSI A108.1A or ANSI A108.1B for surface conditions for the type setting bed specified and for workmanship. Variations of surface to be tiled shall fall within maximum values shown below:

TYPE	WALLS	FLOORS
Dry-Set Mortar	3 mm in 2.4 meters	3.0 mm in 3 meters
Organic Adhesives	3 mm in 2.4 meters	1.5 mm in 1 meters
Latex portland cement mortar	3 mm in 2.4 meters	3.0 mm in 3 meters
Epoxy	3 mm in 2.4 meters	3.0 mm in 3 meters

TYPE	WALLS	FLOORS
Dry-Set Mortar	1/8 inch in 8 ft.	1/8 inch in 10 ft.
Organic Adhesives	1/8 inch in 8 ft.	1/16 inch in 3 ft.
Latex portland cement mortar	1/8 inch in 8 ft.	1/8 inch in 10 ft.
Epoxy	1/8 inch in 8 ft.	1/8 inch in 10 ft.

3.2 GENERAL INSTALLATION REQUIREMENTS

Tile work shall not be started until roughing in for mechanical and electrical work has been completed and tested, and built-in items requiring membrane waterproofing have been installed and tested. Floor tile installation shall not be started in spaces requiring wall tile until after wall tile has been installed. Tile in colors and patterns indicated shall be applied in the area shown on the drawings. Tile shall be installed with the respective surfaces in true even planes to the elevations and grades shown. Special shapes shall be provided as required for sills, jambs, recesses, offsets, external corners, and other conditions to provide a complete and neatly finished installation. Tile bases and coves shall be solidly backed with mortar.

3.3 INSTALLATION OF WALL TILE

This paragraph covers three different methods of installing tile on walls: the mortar bed method W211, W221, W222, W231, and W241; direct to masonry with dry-set mortar W202; and the organic adhesive method W223, and W242, 243 or 244. See TCA Hdbk for detailed guidance.

General guidance is as follows:

a. The mortar bed method or cementitious backer board method shall be used for all prolonged wet areas such as showers. Ceramic tile over gypsum board shall be used only in dry areas.

b. Dry-set mortar applied direct to masonry is suitable for all but prolonged wet areas such as showers.

c. The organic adhesive method shall be limited to dry areas and shall generally be used over gypsum wallboard.

3.3.1 Workable or Cured Mortar Bed

Tile shall be installed over a workable mortar bed or a cured mortar bed at the option of the Contractor. A 0.102 mm (4 mil) polyethylene membrane, metal lath, and scratch coat shall also be installed. Workable mortar bed, materials, and installation of tile shall conform to ANSI A108.1A. Cured mortar bed and materials shall conform to ANSI A108.1B.

3.3.2 Dry-Set Mortar and Latex-Portland Cement Mortar

Dry-set or Latex-portland cement shall be used to install tile in accordance with ANSI A108.5. Latex portland cement shall be used when installing porcelain ceramic tile.

3.3.3 Organic Adhesive

Organic adhesive installation of ceramic tile shall conform to ANSI A108.4.

3.3.4 Furan Mortar and Grout

Furan mortar and grout installation shall conform to ANSI A108.8.

3.4 INSTALLATION OF FLOOR TILE

This paragraph covers two different methods of installing tile on floors. The mortar bed method F111, F112, F114, and F121 and direct to concrete with dry-set mortar method F113 and F115. See TCA Hdbk for detailed guidance.

General guidance is as follows:

a. The mortar bed method will be used for areas having a floor drain.

b. Dry-set mortar direct to concrete is suitable for areas without a floor drain or when it is not practical to recess the slab.

Shower receptors shall be installed in accordance with TCA Hdbk, method B414 or B415.

3.4.1 Workable or Cured Mortar Bed

Floor tile shall be installed over a workable mortar bed or a cured mortar bed at the option of the Contractor. Workable mortar bed materials and installation shall conform to ANSI A108.1A. Cured mortar bed and materials shall conform to ANSI A108.1B. Joints between quarry tile shall be between 6.35 mm (1/4 inch) and 9.53 mm (3/8 inch) in width and shall be uniform in width.

3.4.2 Dry-Set and Latex-Portland Cement

Dry-set or Latex-portland cement mortar shall be used to install tile directly over properly cured, plane, clean concrete slabs in accordance with ANSI A108.5. Latex portland cement shall be used when installing porcelain ceramic tile.

3.4.3 Resinous Grout

When resinous grout is indicated, quarry tile shall be grouted with either furan or epoxy resin grout. Joints shall be raked and cleaned to the full depth of the tile and neutralized when recommended by the resin manufacturer. Epoxy resin grout shall be installed in conformance with ANSI A108.6. Furan resin grout shall be installed in accordance with manufacturer's instructions. Tile installed with furan resin shall be coated with wax by the tile manufacturer. Installation of resin grout shall be in strict accordance with manufacturer's instructions for proportioning, mixing, installing, and curing. Recommended temperature shall be maintained in the area and on the surface to be grouted. After grouting, tile shall be left free of grout stain.

3.4.4 Ceramic Tile Grout

Ceramic Tile grout shall be prepared and installed in accordance with ANSI A108.10.

3.4.5 Waterproofing

Shower pans are specified in Section 15400 PLUMBING, GENERAL PURPOSE. Waterproofing under concrete fill shall conform to the requirements of Section 07132 BITUMINOUS WATERPROOFING.

3.4.6 Concrete Fill

Concrete fill shall be composed by volume of 1 part portland cement to 3 parts fine aggregate to 4 parts coarse aggregate, and mixed with water to as dry a consistency as practicable. The fill shall be spread, tamped, and screeded to a true plane, and pitched to drains or leveled as shown. Concrete fill shall be thoroughly damp cured before application of setting-bed material. Concrete fill shall be reinforced with one layer of reinforcement, with the uncut edges lapped the width of one mesh and the cut ends and edges lapped not less than 50 mm (2 inches). Laps shall be tied together with 1.3 mm (18 gauge) wire every 250 mm (10 inches) along the finished edges and every 150 mm (6 inches) along the cut ends and edges. The reinforcement shall be supported and secured in the centers of concrete fills. The mesh shall be continuous; except where expansion joints occur, mesh shall be cut and discontinued across such joints. Reinforced concrete fill shall be provided under the setting-bed where the distance between the under-floor surface and the finished tile floor surface is 50 mm (2 inches) or greater, and shall be of such thickness that the mortar setting-bed over the concrete fill shall be not less nor more than the thickness required in the specified TCA Hdbk methods.

3.5 INSTALLATION OF CONDUCTIVE FLOORING

Conductive ceramic mosaic tile floors shall be installed in accordance with ANSI A108.7.

3.6 INSTALLATION OF MARBLE THRESHOLDS

Thresholds shall be installed where indicated in a manner similar to that of the ceramic tile floor. Thresholds shall be the full width of the opening. Head joints at ends shall not exceed 6 mm (1/4 inch) in width and shall be grouted full as specified for ceramic tile.

3.7 TESTING

Electrical resistance tests shall be performed on conductive flooring in the presence of the Contracting Officer by a technician experienced in such work and a copy of the test results shall be furnished. Test procedures, testing apparatus, and test results shall be in accordance with the provisions for Conductive Flooring in NFPA 99.

3.8 EXPANSION JOINTS

Joints shall be formed as indicated and sealed as specified in Section 07900 JOINT SEALING.

3.8.1 Walls

Expansion joints shall be provided at control joints in backing material. Wherever backing material changes, an expansion joint shall be installed to separate the different materials.

3.8.2 Floors

Expansion joints shall be provided over construction joints, control joints, and expansion joints in concrete slabs. Expansion joints shall be provided where tile abuts restraining surfaces such as perimeter walls, curbs and columns and at intervals of 7.2 to 10.8 m (24 to 36 feet) each way in large interior floor areas and 3.6 to 4.8 m (12 to 16 feet) each way in large exterior areas or areas exposed to direct sunlight or moisture. Expansion joints shall extend through setting-beds and fill.

3.9 CLEANING AND PROTECTING

Upon completion, tile surfaces shall be thoroughly cleaned in accordance with manufacturer's approved cleaning instructions. Acid shall not be used for cleaning glazed tile. Floor tile with resinous grout or with factory mixed grout shall be cleaned in accordance with instructions of the grout manufacturer. After the grout has set, tile wall surfaces shall be given a protective coat of a noncorrosive soap or other approved method of protection. Tiled floor areas shall be covered with building paper before foot traffic is permitted over the finished tile floors. Board walkways shall be laid on tiled floors that are to be continuously used as passageways by workmen. Damaged or defective tiles shall be replaced.

SECTION 09510

ACOUSTICAL CEILINGS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 167	(1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plates, Sheet and Strip
ASTM A 366/A 366M	(1997e1) Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality
ASTM A 580/A 580M	(1998) Stainless Steel Wire
ASTM A 641/A 641M	(1998) Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A 653/A 653M	(2001a) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM B 633	(1998e1) Electrodeposited Coatings of Zinc on Iron and Steel
ASTM C 423	(2001) Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
ASTM C 635	(2000) Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings
ASTM C 636	(1996) Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels
ASTM C 834	(2000e1) Latex Sealants
ASTM E 84	(2001) Surface Burning Characteristics of Building Materials
ASTM E 119	(2000a) Fire Tests of Building Construction and Materials
ASTM E 580	(2000) Application of Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels in Areas Requiring Moderate Seismic Restraint
ASTM E 795	(2000) Mounting Test Specimens During Sound Absorption Tests
ASTM E 1264	(1998) Acoustical Ceiling Products
ASTM E 1414	(2000a) Airborne Sound Attenuation Between Rooms Sharing a Common Ceiling Plenum
ASTM E 1477	(1998a) Luminous Reflectance Factor of Acoustical Materials by Use of Integrating-Sphere Reflectometers

U.S. ARMY CORPS OF ENGINEERS (USACE)

TI 809-04	(1998) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL Fire Resist Dir	(1999) Fire Resistance Directory (2 Vol.)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Acoustical Ceiling Systems; G.

Manufacturer's descriptive data, catalog cuts, and installation instructions. Submittals which do not provide adequate data for the product evaluation will be rejected.

SD-04 Samples

Acoustical Units; G.

Two samples of each type of acoustical unit and each type of suspension grid tee section showing texture, finish, and color.

SD-06 Test Reports

Fire Resistive Ceilings; G.

Ceiling Attenuation Class and Test; G.

Reports by an independent testing laboratory attesting that acoustical ceiling systems meet specified fire endurance and sound transmission requirements. Data attesting to conformance of the proposed system to Underwriters Laboratories requirements for the fire endurance rating listed in UL Fire Resist Dir may be submitted in lieu of test reports.

SD-07 Certificates

Acoustical Units

Certificate attesting that the mineral based acoustical units furnished for the project contain recycled material and showing an estimated percent of such material.

1.3 GENERAL REQUIREMENTS

Acoustical treatment shall consist of sound controlling units mechanically mounted on a ceiling suspension system. The unit size, texture, finish, and color shall be as specified. The Contractor has the option to substitute inch-pound (I-P) Recessed Light Fixtures (RLF) for metric RLF. If the Contractor opts to furnish I-P RLF, other ceiling elements like acoustical ceiling tiles, air diffusers, air registers and grills, shall also be I-P products. The Contractor shall coordinate the whole ceiling system with other details, like the location of access panels and ceiling penetrations, etc., shown on the drawings. If I-P products are used, the Contractor shall be responsible for all associated labor and materials and for the final assembly and performance of the specified work and products. The location and extent of acoustical treatment shall be as shown on the approved detail drawings. Reclamation of mineral fiber acoustical ceiling panels to be removed from the job site shall be in accordance with paragraph RECLAMATION PROCEDURES.

1.3.1 Fire Resistive Ceilings

Acoustical ceiling systems indicated as fire resistant shall be rated for fire endurance as indicated when tested in accordance with ASTM E 119. Suspended ceiling shall have been tested with a specimen floor assembly representative of the indicated construction, including mechanical and electrical work within ceiling space openings for light fixtures, and air outlets, and access panels. Ceiling assembly rating shall be as shown on drawings. Flame spread of acoustical units shall be 25 or less and smoke development shall be 50 or less when tested in accordance with ASTM E 84.

1.3.2 Ceiling Attenuation Class and Test

The ceiling attenuation class (CAC) of the ceiling system shall be 35 - 39 and 40 - 44 for speech privacy rooms, or as shown on the drawings when determined in accordance with ASTM E 1414. Provide fixture attenuators over light fixtures and other ceiling penetrations, and provide acoustical blanket insulation adjacent to partitions, as required to achieve the specified CAC. Test ceiling shall be continuous at the partition and shall be assembled in the suspension system in the same manner that the ceiling will be installed on the project.

1.3.3 Ceiling Sound Absorption

Determine the NRC in accordance with ASTM C 423 Method of Test.

1.3.4 Light Reflectance

Determine light reflectance factor in accordance with ASTM E 1477 Test Method.

1.4 DELIVERY AND STORAGE

Materials shall be delivered to the site in the manufacturer's original unopened containers with brand name and type clearly marked. Materials shall be carefully handled and stored in dry, watertight enclosures. Immediately before installation, acoustical units shall be stored for not less than 24 hours at the same temperature and relative humidity as the space where they will be installed in order to assure proper temperature and moisture acclimation.

1.5 ENVIRONMENTAL REQUIREMENTS

A uniform temperature of not less than 16 degrees C (60 degrees F) nor more than 29 degrees C (85 degrees F) and a relative humidity of not more than 70 percent shall be maintained for 24 hours before, during, and 24 hours after installation of acoustical units.

1.6 SCHEDULING

Interior finish work such as plastering, concrete and terrazzo work shall be complete and dry before installation. Mechanical, electrical, and other work above the ceiling line shall be completed and heating, ventilating, and air conditioning systems shall be installed and operating in order to maintain temperature and humidity requirements.

1.7 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a one year period shall be provided. Standard performance guarantee or warranty shall contain an agreement to repair or replace acoustical panels that fail within the warranty period. Failures include, but are not limited to, sagging and warping of panels; rusting and manufacturers defects of grid system.

1.8 EXTRA MATERIALS

Spare tiles of each color shall be furnished at the rate of 5 tiles for each 1000 tiles installed. Tiles shall be from the same lot as those installed.

PART 2 PRODUCTS

2.1 ACOUSTICAL UNITS

Acoustical units shall conform to ASTM E 1264, Class A, and the following requirements:

2.1.1 Units for Exposed-Grid System

Type:	III (non-asbestos mineral fiber with painted finish), or IV (non-asbestos mineral fiber with membrane-faced overlay) as indicated.
Minimum NRC:	0.75 in open office areas; 0.60 in conference rooms, executive offices, teleconferencing rooms, and other rooms as designated; 0.50 in all other rooms and areas when tested on mounting Type E-400 of ASTM E 795.
Pattern:	A, B, C, D, E or F as indicated.
Nominal size:	600 by 1200 mm (24 by 48 inches) or 600 by 600 mm (24 by 24 inches) as indicated.
Edge detail:	Square, Reveal, Trimmed or butt as indicated.
Finish:	Factory-applied standard finish or color finish.
Minimum LR coefficient:	LR-1, 0.75 or greater.
Minimum CAC:	35.
Flame Spread:	Class A, 25 or less

2.1.2 Units for Concealed-Grid System

Type:	III (non-asbestos mineral fiber with painted finish) or IV (non-asbestos mineral fiber with membrane-faced overlay) as indicated.
Minimum NRC:	0.50 when tested on mounting Type B or Type E-400 of ASTM E 795.
Pattern:	A, B, C, D, E, F or as indicated.
Nominal size:	300 by 300 mm (12 by 12 inches).
Edge detail:	beveled or square.
Joint detail:	kerfed and rabbeted, or tongue and grooved as indicated.
Finish:	Factory-applied standard finish or color finish .
Minimum LR coefficient:	LR-1, 0.75 or greater.
Minimum CAC:	35.
Flame Spread:	Class A, 25 or less.

2.1.3 Metal Pans

Type:	V, steel, VI, ASTM A 167 stainless steel, or VII, aluminum perforated pans with acoustical, non-asbestos, insulation backing as indicated.
Minimum NRC:	0.75 in open office areas; 0.60 in conference rooms, executive offices, teleconferencing rooms, and other rooms as designated; 0.50 in all other rooms and

	areas when tested on mounting Type E-400 of ASTM E 795.
Pattern:	A, C or I as indicated.
Nominal size:	600 by 600 mm (24 by 24 inches).
Edge detail:	Manufacturer's standard.
Joint detail:	Beveled.
Finish:	Factory-applied standard finish.
Pads:	Completely enclosed, of material and thickness required for acoustical and fire test ratings.
Minimum LR coefficient:	LR-1, 0.75 or greater.
Flame Spread:	Class A, 25 or less.

2.1.4 Impact/Abrasion Resistant Units

a. Type: Non-asbestos mineral composition with a hardened mineral surface and factory applied white paint finish. Surface shall be resistant to impact and abrasion.

b. Class: A, flame spread 25 or less.

c. Pattern: As shown on the drawings.

d. NRC Grade: Minimum 0.50 when tested on Mounting Type E-400 of ASTM E 795.

e. Light Reflectance: LR-1, 0.75 or greater.

f. Nominal Size: 300 by 300, 600 by 600, or 600 by 1200 mm (12 by 12, 24 by 24, or 24 by 48 inches).

g. Edge Detail: Square or Beveled.

h. Joint Detail: Trimmed and butted or Kerfed and rabbeted.

2.1.5 Humidity Resistant Composition Units

a. Type: Non-asbestos mineral or glass fibers bonded with ceramic, moisture resistant thermo-setting resin, or other moisture resistant material and having a factory applied white paint finish. Panels shall not sag or warp under conditions of heat, high humidity or chemical fumes.

b. Class: A, flame spread 25 or less.

c. Pattern: As shown on the drawings.

d. NRC Grade: Minimum 0.50 when tested on Mounting Type E-400 of ASTM E 795.

e. Light Reflectance: LR-1, 0.75 or greater.

f. Nominal Size: 600 by 1200 mm (24 by 48 inches).

g. Edge Detail: Square.

2.1.6 Metal Faced Composition Units

a. Type V (Steel facings with non-asbestos mineral composition absorbent backing), Type VI (Stainless steel facings with non-asbestos mineral composition absorbent backing), or Type VII (Aluminum facings with non-asbestos mineral composition absorbent backing) with anodized, baked enamel or acrylic finish as indicated, color white or as indicated.

b. Class: A, flame spread 25 or less.

c. Pattern: As shown on the drawings.

d. Noise Reduction Coefficient (NRC) Grade: Minimum 0.75 in open office areas. Minimum 0.60 in conference rooms, executive offices, teleconferencing rooms, and other rooms as designated. Minimum 0.50 in all other rooms and areas. Base the tested NRC value on Mounting Type E-400 of ASTM E 795.

e. Light Reflectance: LR-1, 0.75 or greater.

f. Nominal Size: 600 by 600 or 600 by 1200 mm (24 by 24, 24 by 48 inches).

g. Edge Detail: Square.

h. Joint Detail: Trimmed and butted.

2.1.7 Unit Acoustical Absorbers

Unit acoustical absorbers should be used in high noise areas such as bowling alleys, industrial areas or in other locations when recommended by an acoustical consultant. Absorbers shall be individually mounted sound absorbing plaques composed of glass fibers or non-asbestos mineral fibers and having a NRC range of not less than 0.60 - 0.70 when tested in accordance with ASTM C 423 and reported as a 4 frequency average.

2.2 SUSPENSION SYSTEM

Suspension system shall be as shown on drawings], and shall conform to ASTM C 635 for intermediate-duty systems or heavy-duty systems. Surfaces exposed to view shall be aluminum or steel with a factory-applied white color baked-enamel finish or a clear anodized finish. Wall molding shall have a flange of not less than 23 mm (15/16 inch). Inside and outside corner caps shall be provided. Suspended ceiling framing system shall have the capability to support the finished ceiling, light fixtures, air diffusers, and accessories, as shown. The suspension system shall have a maximum deflection of 1/360 of span length. Seismic details shall conform to the guidance in TI 809-04 and ASTM E 580 as shown on the drawings.

2.3 HANGERS

Hangers and attachment shall support a minimum 1330 N (300 pound) ultimate vertical load without failure of supporting material or attachment.

2.3.1 Wires

Wires shall conform to ASTM A 641/A 641M, Class 1, 2.7 mm (0.106 inches) in diameter. ASTM A 580/A 580M, composition 302 or 304, condition annealed stainless steel, 2.7 mm (0.1055 inches) in diameter.

2.3.2 Straps

Straps shall be 25 by 5 mm (1 by 3/16 inch) galvanized steel conforming to ASTM A 653/A 653M, with a light commercial zinc coating or ASTM A 366/A 366M with an electrodeposited zinc coating conforming to ASTM B 633, Type RS.

2.3.3 Rods

Rods shall be 5 mm (3/16 inch) diameter threaded steel rods, zinc or cadmium coated.

2.4 ACCESS PANELS

Access panels shall match adjacent acoustical units and shall be designed and equipped with suitable framing and fastenings for removal and replacement without damage. Panel shall be not less than 300 by 300 mm (12 by 12 inches) or more than 300 by 600 mm (12 by 24 inches).

a. An identification plate of 0.8 mm (0.032 inch) thick aluminum, 19 mm (3/4 inch) in diameter, stamped with the letters "AP" and finished the same as the unit, shall be attached near one corner on the face of each access panel.

b. Identify ceiling access panel by a number utilizing white identification plates or plastic buttons with contrasting numerals. The plates or buttons shall be of minimum 25 mm (1 inch) diameter and securely attached to one corner of each access unit. Provide a typewritten card framed under glass listing the code identification numbers and corresponding system descriptions listed above. Mount the framed card where directed and furnish a duplicate card to the Contracting Officer. Code identification system shall be as follows:

1 Fire detection/alarm system
2 Air conditioning controls
3 Plumbing system
4 Heating and steam systems
5 Air conditioning duct system
6 Sprinkler system
7 Intercommunication system
8 Nurse's call system
9 Pneumatic tube system
10 Medical piping system
11 Program entertainment
12 Telephone junction boxes
13 Detector X-ray

2.5 ADHESIVE

Adhesive shall be as recommended by tile manufacturer.

2.6 FINISHES

Acoustical units and suspension system members shall have manufacturer's standard textures, patterns and finishes as specified. Ceiling suspension system components shall be treated to inhibit corrosion.

2.7 COLORS AND PATTERNS

Colors and patterns for acoustical units and suspension system components shall be as shown on the drawings.

2.8 ACOUSTICAL SEALANT

Acoustical sealant shall conform to ASTM C 834, nonstaining.

PART 3 EXECUTION

3.1 INSTALLATION

Examine surfaces to receive directly attached acoustical units for uneveness, irregularities, and dampness that would affect quality and execution of the work. Areas where acoustical units will be cemented shall be free of oils, form residue, or other materials that reduce bonding capabilities of the adhesive. Interior finish work such as plastering, concrete, and terrazzo work shall be completed and dry before installation. Mechanical, electrical, and other work above the ceiling line shall be completed and approved prior to the start of acoustical ceiling installation. Acoustical work shall be provided complete with necessary fastenings, clips, and other accessories required for a complete installation. Mechanical fastenings shall not be exposed in the finished work. Hangers shall be laid out for each individual room or space. Hangers shall be placed to support framing around beams, ducts, columns, grilles, and other penetrations through ceilings. Main runners and carrying channels shall be kept clear of abutting walls and partitions. At least two main runners shall be provided for each ceiling span. Wherever required to bypass an object with the hanger wires, a subsuspension system shall be installed, so that all hanger wires will be plumb.

3.1.1 Suspension System

Suspension system shall be installed in accordance with ASTM C 636 and as specified herein. There shall be no hanger wires or other loads suspended from underside of steel decking.

3.1.1.1 Plumb Hangers

Hangers shall be plumb and shall not press against insulation covering ducts and pipes. Where lighting fixtures are supported from the suspended ceiling system, hangers shall be provided at a minimum of four hangers per fixture and located not more than 150 mm (6 inches) from each corner of each fixture.

3.1.1.2 Splayed Hangers

Where hangers must be splayed (sloped or slanted) around obstructions, the resulting horizontal force shall be offset by bracing, countersplaying, or other acceptable means.

3.1.2 Wall Molding

Wall molding shall be provided where ceilings abut vertical surfaces. Miter corners where wall moldings intersect or install corner caps. Wall molding shall be secured not more than 75 mm (3 inches) from ends of each length and not more than 400 mm (16 inches) on centers between end fastenings. Wall molding springs shall be provided at each acoustical unit in semi-exposed or concealed systems.

3.1.3 Acoustical Units

Acoustical units shall be installed in accordance with the approved installation instructions of the manufacturer. Edges of acoustical units shall be in close contact with metal supports, with each other, and in true alignment. Acoustical units shall be arranged so that units less than one-half width are minimized. Units in exposed-grid system shall be held in place with manufacturer's standard hold-down clips, if units weigh less than 5 kg per square m (1 psf) or if required for fire resistance rating.

3.1.4 Caulking

Seal all joints around pipes, ducts or electrical outlets penetrating the ceiling. Apply a continuous ribbon of acoustical sealant on vertical web of wall or edge moldings. See Section 07900 JOINT SEALING.

3.1.5 Adhesive Application

Wipe back of tile to remove accumulated dust. Daub acoustical units on back side with four equal daubs of adhesive. Apply daubs near corners of tiles. Contact area of each daub shall be at least 50 mm (2 inches) diameter in final position. Press units into place, aligning joints and abutting units tight and uniform without differences in joint widths.

3.2 CEILING ACCESS PANELS

Ceiling access panels shall be located directly under the items which require access.

3.3 CLEANING

Following installation, dirty or discolored surfaces of acoustical units shall be cleaned and left free from defects. Units that are damaged or improperly installed shall be removed and new units provided as directed.

SECTION 09620

RESILIENT ATHLETIC FLOORING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 920	(1998) Elastomeric Joint Sealants
ASTM D 395	(1998) Rubber Property - Compression Set
ASTM D 412	(1998a) Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension
ASTM D 624	(1991; R 1998) Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D 1054	(1991) Rubber Property - Resilience Using a Rebound Pendulum

ASTM D 1242	(1995a) Resistance of Plastic Materials to Abrasion
ASTM D 1894	(1999) Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting
ASTM D 2240	(1997el) Rubber Property ? Durometer Hardness
ASTM D 2632	(1996) Rubber Property-Resilience by Vertical Rebound
ASTM F 1303	(1999) Sheet Vinyl Floor Covering with Backing
ASTM G 21	(1996) Determining Resistance of Synthetic Polymeric Materials to Fungi

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings; G.

Drawings showing game lines, location of anchor plate assemblies, floor outlets, and under-floor conduit or raceways.

SD-03 Product Data

Installation; G.

Manufacturer's descriptive data and catalog cuts indicating materials of construction and physical characteristics.

Installation, cleaning and maintenance instructions shall be included.

SD-04 Samples

Flooring; G.

Three samples minimum 225 x 275 mm (9 x 11 inches) of each color of flooring material required.

SD-07 Certificates

Materials

Manufacturer's certificates stating that the resilient athletic flooring materials conform to the specified requirements. Labels or markings affixed to manufacturer's products attesting that products meet requirements specified herein will be accepted in lieu of certificates.

1.3 QUALIFICATIONS

Adhesive applied and poured-in-place flooring shall be installed by an experienced floor applicator approved by the manufacturer.

1.4 DELIVERY, STORAGE, AND HANDLING

Materials shall be delivered in manufacturer's original unopened containers with labels intact. Materials shall not be delivered to the installation area or installed before all work that may damage the materials or the finished floor, such as overhead work, is completed. Materials shall be stored in a clean, dry area. Materials in storage shall be maintained at temperatures recommended by the manufacturer. Protection boards shall be stored flat and off the ground.

1.5 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a one year period shall be provided.

1.6 EXTRA MATERIALS

1.6.1 Floor Tiles

Spare tiles of each color shall be furnished at the rate of 5 tiles for each 1000 tiles installed. Tiles shall be from the same lot as those installed.

1.6.2 Carpeting

Extra material from same dye lot consisting of full width continuous broadloom shall be provided for maintenance. A minimum of 1 percent of total square meters (square yards) of each carpet type, pattern, and color shall be provided.

PART 2 PRODUCTS

2.1 INDOOR-OUTDOOR CARPETING

Carpet-type flooring shall be spike proof ribbed or berber pattern consisting of a top layer of rugged polypropylene or nylon fibers combined with an inorganic cut-resistant non-skid. Minimum total thickness shall be 13 mm (0.5 inches). Finished surface pile yarn weight (face weight) shall be minimum 1.7 kg per square meter (50 ounces per square yard). Test results for resistance to soil bacteria or fungi shall show no sustained growth or discoloration after 21 days when tested in accordance with ASTM G 21.

2.2 RUBBER COMPOSITION TILE TYPE

Rubber tiles shall be interlocked 600 x 600 mm (24 x 24 inches) square, of solid first quality rubber, uniformly resilient material designed to be applied without adhesive. Tiles shall be approximately 13 mm (1/2 inch) thick, shall be traction texture, and shall be reversible or non-reversible as indicated. Flooring shall be able to withstand 75 percent compression for 22 hours at 70 degrees C (158 degrees F) without residual deformation when tested in accordance with ASTM D 395. Flooring shall have a durometer hardness Shore-A of 50-60 when tested in accordance with ASTM D 2240.

2.3 SHEET RUBBER COMPOSITION FLOORING

Sheet rubber flooring shall be prefabricated, homogeneous, natural and synthetic rubbers, and shall be minimum 5 mm (3/16 inch) thick, and shall have smooth gymnasium and textured all-purpose finish. Flooring shall be roll type not less than 1500 mm (60 inches) wide. Flooring shall have a minimum tensile stress at 100 percent elongation of 1500 kPa (220 psi) and a minimum ultimate elongation of 250 percent when tested in accordance with ASTM D 412. Flooring shall be able to withstand 50 percent compression for 72 hours at 22 degrees C (72 degrees F) with a residual deformation of less than 10 percent when tested in accordance with ASTM D 395. Flooring shall provide a 55 plus or minus 5 percent rebound when tested in accordance with ASTM D 1054.

2.4 ADHESIVES

Adhesive shall be as recommended by the flooring manufacturer and must correspond to the specified flooring product and to the substrate.

2.5 CRACK FILLER/LEVELER FOR CONCRETE SURFACES

Crack filler/leveler for concrete floor surfaces shall be as recommended by flooring manufacturer.

2.6 EDGING STRIPS

Strips shall be of the same material and design as recommended by flooring manufacturer.

2.7 PRIMER

Concrete primer shall be as recommended by flooring manufacturer and must correspond to the specified flooring product and to the substrate.

2.8 GAME LINE MATERIAL

Game line material shall as recommended by the flooring manufacturer and must correspond to the specified flooring product.

2.9 WALL BASE

Base shall be rubber or vinyl type and coved style. Base shall be 100 mm (4 inches) high and minimum 3 mm (1/8 inch) thick.

2.10 SEALANTS

Sealants shall be in accordance with Section 07900 JOINT SEALING.

2.11 MANUFACTURERS COLOR

Color shall be as shown on the drawings.

PART 3 EXECUTION

3.1 PREPARATION

Concrete surfaces shall be completely cured and dry. No curing agents, sealers, or hardeners shall be used to aid in the curing of the concrete slab. Surfaces shall be free of paint spots, and other foreign materials. Surfaces shall be ground down or leveled with an approved leveling compound to a tolerance of plus or minus 3 mm (1/8 inch) within a 3 meters (10 foot) radius. Cracks, construction joints, or damaged portions of floor shall be filled with crack filler for concrete surfaces. Expansion joints shall be filled and sealed in accordance with the approved installation instructions of the manufacturer. All sealants shall be in accordance with ASTM C 920. Expansion joints shall not be filled with a material that will make them inoperable.

3.2 MOISTURE TEST

The suitability of the concrete subfloor for receiving the resilient flooring with regard to moisture content shall be determined by a moisture test as recommended by the flooring manufacturer.

3.3 INSTALLATION

3.3.1 General Requirements

Installation shall be in accordance with the approved installation instructions. Tile or sheet flooring shall be rolled with a medium-sized roller in both directions to release entrapped air.

3.3.2 Molded Rubber Base

Base shall be installed in accordance with the approved installation instructions of the manufacturer of the base.

3.3.3 Indoor-Outdoor Carpeting

Application of flooring shall be as recommended by the manufacturer.

3.3.4 Sheet Rubber Composition Flooring

Sheet flooring shall be dry cut and layed out flat a minimum of 24 hours prior to adhering to the substrate. End seams shall be single cut. Edge seams shall be cut through overlapping sheets, then snapped into place to ensure tight seams. Seams shall be weighted as required.

3.3.5 Rubber Composition Tile Flooring

3.3.5.1 Application With Adhesive

Tiles shall be layed on adhesive surface in pattern according to approved detail drawings. Joints of tiles shall be even and tight. Tiles shall be cut to fit tightly against the wall.

3.3.5.2 Application Without Adhesive

Tiles shall be joined together using interlocking ears or other mechanical locking techniques. The ears shall interlock into the adjoining tile 40 mm (1-1/2 inches) and shall provide at least five interlocks for each 600 mm (24 inch) edge. Where required, a beveled transfer border shall be supplied to interlock with the flooring tiles. The borders shall be 150 mm (6 inches) wide and 600 mm (24 inches) long and the same thickness as the matching tiles.

3.3.6 Line Marking and Finishing

After installation is complete, the floor surface shall be cleaned in accordance with installation instructions. Line marking shall be layed out, masked, and painted according to approved detail drawings and approved installation instructions. Finishing shall be in accordance with the manufacturer's recommendations.

3.4 PROTECTION

The installed flooring shall be protected from soiling and damage with heavy reinforced, nonstaining kraft paper, plywood, or hardboard sheets as required. Edges of kraft paper protection shall be lapped and secured to provide a continuous cover. Protective covering shall be removed when directed by the Contracting Officer.

SECTION 09640

WOOD STRIP FLOORING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

MAPLE FLOORING MANUFACTURERS ASSOCIATION (MFMA)

MFMA GS (1997)(DATE N/A) Spec Data Sheet; Wood Flooring, Maple

NATIONAL OAK FLOORING MANUFACTURERS ASSOCIATION (NOFMA)

NOFMA Grading Rules (1997) Flooring Grading Rules, Oak, Beech, Birch, Hard Maple, Pecan

1.2 SYSTEM DESCRIPTION

This specification is written to allow the Contractor to build wood strip floorings for gymnasiums, handball and squash courts, and other special purpose applications but does not preclude the installation of competitive, manufacturer standard, integrated systems.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Squash and Handball Court Walls; G.

Expansion joint details.

SD-03 Product Data

Installation; G.

Manufacturer's descriptive data and installation instructions.

SD-04 Samples

Strip Flooring; G.

Two samples of each type of strip flooring.

1.4 DELIVERY AND STORAGE

Materials shall be delivered to the site in original unopened packages, bundles or containers and with all labels intact. Flooring shall be stored in fully covered, well ventilated areas and protected from extreme changes in temperature and humidity. Flooring shall be maintained at an average moisture content of 6 to 9 percent. Temperature and humidity in the storage area shall closely approximate the temperature and humidity of the rooms in which the flooring is to be installed.

1.5 ENVIRONMENTAL CONDITIONS

Rooms where wood flooring is to be installed shall have permanent heating and air conditioning installed and working or adequate arrangements for ventilation and temperature controls. The temperature shall be maintained at 14 to 27 degrees C (55 to 80 degrees F) and the humidity shall be maintained as recommended by the manufacturer starting not less than 3 days prior to beginning the installation of flooring and continuing throughout the remainder of the contract period.

1.6 SCHEDULING

Strip flooring work shall be scheduled after any other work which would raise the moisture content of the flooring or damage the finished surface of the flooring.

PART 2 PRODUCTS

2.1 STRIP FLOORING

Strip flooring shall be 25 mm (33/32 inch) thick by 55 mm (2-1/4 inches) face width, kiln dried, continuous tongue and groove and of standard lengths. Beech and birch shall be second grade in accordance with NOFMA Grading Rules. Hard maple shall be second and better in accordance with MFMA GS. Red and white oak shall be select grade in accordance with NOFMA Grading Rules. Strip flooring shall be marked with the trademark of the grading agency.

2.2 NAILS

Nails shall be in accordance with strip flooring manufacturer's recommendations.

2.3 RESILIENT PADS

Resilient pads shall be pneumatic rubber, PVC, or polyurethane resilient mounts to fit the selected floor system.

2.4 WALL BASE

Wall base shall be wood molding or vented cove with premolded outside corners and mitered inside corners.

2.5 MOISTURE BARRIER

Moisture barrier shall be 0.15 mm (6 mil) minimum thickness polyethylene.

2.6 CLIPS, ANCHOR CHANNELS AND INSULATION

Galvanized steel clips for steel channel anchorage systems shall be in accordance with steel channel anchorage system manufacturer's recommendations. Clips shall be designed to provide holding at least equal to the nailing specified and shall function without splitting the assembled boards or otherwise reducing the performance of the floor. Anchor channels shall be as recommended by the flooring manufacturer. Anchor channels shall be galvanized, complete with all pads, anchors and other components required for channel installation. Underfloor insulation shall be asphalt impregnated fiberboard or closed-cell polyethylene foam.

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

Concrete slab shall be level, steel troweled to a tolerance of 3 mm (1/8 inch) plus or minus in a 3 meters (10 foot) radius. Slab surface shall be clean, dry, and approved prior to start of installation. The slab shall be depressed as required by the floor specified.

3.2 INSTALLATION

Flooring shall be installed in accordance with the approved installation instructions of the manufacturer. Wood nailers are specified in Section 06100 ROUGH CARPENTRY. Unless otherwise approved, flooring shall be laid parallel to the length of the area to be floored. Strips shall be laid to allow for intermediate expansion in accordance with humidity conditions expected during the life of the of the flooring. End joints shall be so alternated that there will be at least two boards between end joints in the same plane and at least 150 mm (6 inches) between end joints in adjacent boards. Space for expansion shall be left along perimeter walls and around fixed projections through the floor surface. Unless otherwise shown or permitted by the approved installation instructions, expansion space shall be 5 mm per meter (1/16 inch per foot) of distance between opposite walls, with one half the space provided at each wall and with a minimum space of 25 mm (1 inch) at each wall.

3.2.1 Gymnasium Floors

3.2.1.1 Wood Sleepers

For wood sleeper supported floors, the slab shall be vapor-sealed with a two-ply membrane and hot-poured, steep-slope asphalt to a minimum depth of 6 mm (1/4 inch) above bottom of sleepers. Anchored, treated wood sleepers shall be spaced at 400 mm (16 inches) on center with wood or plywood subfloor or, if required by design considerations, wood sleepers at 300 mm (12 inches) on centers without subfloor and with 25 mm (33/32 inch) thick flooring. Space between rows of wood sleepers shall be left vacant. Expansion joints shall be 50 mm (2 inches) maximum.

3.2.1.2 Steel Channels

Galvanized steel channel system shall be placed on manufacturer's standard grooved foam or grooved resilient insulation board. Expansion joints shall be in accordance with manufacturer's recommendations.

3.2.2 Handball Court Floor and Walls

Strip flooring used for floors and walls in handball courts shall be laid out to provide an overall light appearance; contrast from one board to the next shall be gradual in order to avoid dark streaks.

3.2.3 Squash and Handball Court Walls

Maximum space for expansion shall be 50 mm (2 inches) at each wall. Expansion joints over 25 mm (1 inch) and expansion joints for steel channel-strip flooring application shall be detailed and the drawings, showing the method of covering, submitted for approval.

3.2.3.1 Wood Supports

Anchored wood supports shall be used to keep the treated wood sleepers shimmed away from the wall to provide ventilation. Wood sleepers shall be spaced at 400 mm (16 inches) on center. Exterior grade plywood 15 mm (5/8 inch) thick, with two coats of aluminum enamel on the back side in accordance with Section 06100 ROUGH CARPENTRY, shall be used for vapor seal and sound deadener.

3.2.3.2 Steel Supports

Anchored, galvanized, steel channel supports shall be used with steel channel system; steel channels shall be spaced at 300 mm (12 inches) on center. The space between the supporting wall and the back of the finished wall shall be filled to within 300 mm (12 inches) of the ceiling with an approved hot-poured, steep-slope asphalt as the construction of the wall progresses. As an option to the asphalt-backed wall construction when 25 mm (33/32 inch) thick flooring is used, the wall shall be vapor sealed with a 0.15 mm (6 mil) thickness of polyethylene sheeting prior to application to steel channels and the space between the supporting wall and the back of the finished wall shall be filled with insulation as used for the floor.

3.3 SANDING

Flooring shall be sanded to a smooth, even, uniform finish without burns. A minimum of three sanding cuts, each with a finer sandpaper, shall be made. A heavy drum-type sander shall be used for floors, except a disc-type sander will be permitted for the final cut on strip flooring. Either the first pass or the second pass of the drum-type sander shall be at an angle of 45 degrees to the grain; other passes of the drum-type sander shall be in the direction of the grain of strip flooring. Edges not reached by the sander shall be finished with an edger or by hand methods. The final sanding shall be performed at a time and in a manner that will permit application of the first seal coat as specified in Section 09900 PAINTING, GENERAL to be completed within 8 hours after completion of sanding. The flooring shall be left clean and ready to receive the finishing materials.

3.4 PROTECTION

From the time of installation until final acceptance, flooring shall be protected from damage.

SECTION 09650

RESILIENT FLOORING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 2240 (2002) Rubber Property - Durometer Hardness

ASTM D 4078 (1992; R 1996) Water Emulsion Floor Polish

ASTM E 648	(2000) Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source
ASTM E 662	(2001) Specific Optical Density of Smoke Generated by Solid Materials
ASTM F 510	(1993; R 1999) Resistance to Abrasion of Resilient Floor Coverings Using an Abrader with a Grit Feed Method
ASTM F 1066	(1999) Vinyl Composition Floor Tile
ASTM F 1303	(1999) Sheet Vinyl Floor Covering with Backing
ASTM F 1344	(2000) Rubber Floor Tile
ASTM F 1700	(1999) Solid Vinyl Floor Tile
ASTM F 1913	(1998) Vinyl Sheet Floor Covering Without Backing

1.2 FIRE RESISTANCE REQUIREMENTS

Critical radiant flux shall be a minimum average of 0.45 watts per square centimeter when used in corridors in bachelor enlisted quarters, bachelor officer quarters, hospital, child care centers, temporary lodging facilities, and new construction detention and correctional facilities. Generally the critical radiant flux shall be a minimum of 0.22 watts per square centimeter for corridors of other type facilities. Where an approved automatic sprinkler system is installed, Class II interior floor finish may be used where Class I floor finish is required, and where Class II is required, no critical radiant flux rating is required. Critical radiant flux shall be tested in accordance with ASTM E 648. The smoke density rating shall be less than 450 when tested in accordance with ASTM E 662.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Tile Flooring; G.

Sheet Flooring; G.

Accessories for Sheet Vinyl; G.

Integral Coved Base; G.

Adhesive for Sheet Vinyl; G.

Adhesive for Vinyl Composition Tile; G.

Adhesive for Wall Base; G.

Manufacturer's descriptive data and installation instructions including cleaning and maintenance instructions.

SD-04 Samples

Tile Flooring; G.

Sheet Flooring; G.

Seaming Bead; G.

Wall Base; G.

Two samples of each indicated color and type of flooring and base. Sample size shall be minimum 60 x 100 mm (2-1/2 x 4 inches).

SD-06 Test Reports

Moisture Test

Copies of test reports showing that representative product samples of the flooring proposed for use have been tested by an independent testing laboratory within the past three years or when formulation change occurred and conforms to the requirements specified.

SD-08 Manufacturer's Instructions

Sheet Flooring

Tile Flooring

Copies of flooring manufacturer's recommended installation procedures.

1.4 DELIVERY AND STORAGE

Materials shall be delivered to the building site in original unopened containers bearing the manufacturer's name, brands, stock names, production run, project identification, and handling instructions. Materials shall be stored in a clean dry area with temperature maintained above 21 degrees C (70 degrees F) for 2 days prior to installation, and shall be stacked according to manufacturer's recommendations. Materials shall be protected from the direct flow of heat from hot-air registers, radiators and other heating fixtures and appliances. Do not open containers until materials are to be used, except for inspection to verify compliance with requirements.

1.5 ENVIRONMENTAL REQUIREMENTS

a. Areas to receive resilient flooring shall be maintained at a temperature above 21 degrees C (70 degrees F) and below 38 degrees C (100 degrees F) for 2 days before application, during application and 2 days after application and until Style C flooring is tensioned to a point of being completely smooth. A minimum temperature of 13 degrees C (55 degrees F) shall be maintained thereafter.

b. Provide adequate ventilation to remove moisture from area and to comply with regulations limiting concentrations of hazardous vapors.

1.6 SCHEDULING

Resilient flooring application shall be scheduled after the completion of other work which would damage the finished surface of the flooring.

1.7 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a one year period shall be provided.

1.8 EXTRA MATERIALS

Extra flooring material and butt-to base of each color and pattern shall be furnished at the rate of 5 tiles for each 1000 tiles and 0.5 square meters (5 square feet) for each 92 square meters (1000 square feet) of sheet flooring installed. Extra materials shall be from the same lot as those installed. Extra base material composed of 6 m 20 linear feet of each color shall be furnished. All extra materials shall be packaged in original containers, properly marked.

PART 2 PRODUCTS

2.1 UNDERLAYMENT

Underlayment shall be latex type, as recommended by flooring manufacturer. Wood and hardboard underlayments are specified in Section 06100N ROUGH CARPENTRY.

2.2 TILE FLOORING

2.2.1 Vinyl-Composition Tile

Vinyl-composition tile shall conform to ASTM F 1066, Class 1, (solid color tile) or Class 2,(through pattern tile), Composition 1, asbestos-free, and shall be 300 mm (12 inches) square and 3.2 mm (1/8) inch thick. Tile shall have the color and pattern uniformly distributed throughout the thickness of the tile. Flooring in any one continuous area shall be from the same lot and shall have the same shade and pattern.

2.2.2 Rubber Tile

Rubber tile shall conform to ASTM F 1344 Class 1 homogeneous construction, Type A (solid color) or Type B (through mottled) 300 mm (12 inches) square. Surface shall be raised round, square, or diamond studs with chamfered edges. Stud profile shall be low. Overall thickness shall be 3.2 mm (1/8 inch) thick.

2.2.3 Stair Treads, Risers, and Stringers

Treads, risers, and stringers shall conform to composition rubber compounded from a mixture of synthetic and reclaimed rubber. Overall thickness at treads shall be not less than 3 mm (1/8 inch). Durometer hardness shall be 90, plus or minus 5, when tested in accordance with ASTM D 2240. Treads to have 80 percent of back and nose sanded by manufacturer to assure good adhesion;

provide manufacturer's epoxy filler to completely fill gap between stair and tread nose for all treads. Design shall be either a one-piece nosing/tread/riser or a two-piece nosing/tread with a matching coved riser. Installation shall include stringer angles on both the wall and banister sides, and landing trim. Surface of treads shall be raised stud, rectangle, diamond or ribbed pattern.

2.2.4 Lining Felt

Asphalt felt shall be as recommended by flooring manufacturer.

2.2.5 Adhesive for Vinyl Composition Tile

Cutback adhesive for installation of tile over concrete above, on or above grade. Moisture and alkali resistant. Non-asbestos formulated or a latex adhesive recommended by flooring manufacturer.

2.2.6 Adhesive for Wall Base

Adhesive for wall base shall be emulsified acrylic latex; non-flammable.

2.3 SHEET FLOORING

2.3.1 Vinyl Style A, B or C

Sheet vinyl flooring shall be composed of a homogeneous, vinyl composition formulated without asbestos. Flooring shall be not less than 18OO mm (72 inches) wide. Sheet vinyl flooring with backing shall conform to ASTM F 1303, Type II, Grade 1 filled sheet with inorganic or filled fibrous composition backing with minimum wear layer thickness 1.27 mm (0.050 inches) and minimum overall thickness 2.03 mm (0.080 inches), or Type I, Grade 1, translucent- or transparent-surfaced with minimum wear layer thickness 0.51 mm (0.020 inches) and minimum overall thickness of 1.65 mm (0.065 inches). High quality vinyl welding rods for heat welding of joints shall be provided, as required.

2.3.1.1 Style A; Heat-Sealed, Rolls

Sheet vinyl flooring without backing shall meet the composition, flexibility, indentation, and the solvent resistance requirements of ASTM F 1913. The solid vinyl color and pattern shall extend through the total thickness of the material.

a. Size and Thickness: Roll width 1200 mm (48 inches) minimum; overall thickness 2.159 mm (0.085 inch); wear layer shall be a single layer with through pattern only, not embossed.

b. Wear Resistance: Maximum total volume loss of 0.05 cc when tested for 1,000 revolutions in accordance with ASTM F 510.

c. Dimensional Stability: No requirements, except appropriateness for intended purpose.

d. Chemical Composition: Polyvinyl chloride resin and plasticizer, and stabilizer, 65 percent minimum; colored pigments and fillers, 35 percent maximum. Stabilization against heat and light deterioration is required; protective coating is acceptable.

e. Pattern: Mottled or directionally veined or flecked.

2.3.1.2 Style B; Heat-Sealed, Squares

The following applies to Style B flooring:

a. Size and Thickness: 900 mm (36 inch) squares, overall thickness 3.175 mm (0.125 inch); single layer with through pattern only; not embossed. Pregroove for heat welding if practice is standard with manufacturer.

b. Wear Resistance: Maximum total volume loss of 0.10 cc when tested in accordance with ASTM F 510 for 1,000 revolutions.

c. Chemical Composition: Polyvinyl chloride resin and plasticizer, 40 percent; color pigments, stabilizers, and fillers, 60 percent.

d. Indentation Recovery: Average residual indentation of not greater than 6.3 percent of thickness.

e. Pattern: Directionally veined or mottled or flecked.

2.3.1.3 Style C; Edge Adhered, Tensioned Rolls

Flooring shall conform to ASTM F 1303, Type I, Grade 1, and as modified herein.

a. Size and Thickness: Roll width 3600 or 2700 mm (12 or 9 feet), nonfoamed; overall thickness 1.5 mm (0.060 inch); consisting of 0.5 mm (0.020 inch) wear layer, 0.89 mm (0.035 inch interlayer), and 0.125 mm (0.005 inch backing), all within manufacturer's normal tolerances.

b. Chemical Composition: Wear layer shall be opaque vinyl plastic containing printed design elements incorporated throughout, including extender and pigment. Interlayer shall be a binder with one or more vinyl resins and plasticizers stabilized against heat and light deterioration. Each resin shall be polyvinyl chloride or a copolymer of vinyl chloride. The vinyl resin shall be not less than 60 percent of the weight of the binder.

c. Flexibility: Pass with 2 mm (1/16 inch) mandrel.

d. Pattern: Geometric.

e. Foam Layer: Not allowed.

f. Dimensional Stability: Requirements not applicable. Flooring shall be manufactured to shrink after installation, exerting tension in all directions.

2.3.1.4 Seaming Bead

Provide seaming bead of same material as sheet vinyl flooring and as recommended by flooring manufacturer in conjunction with Styles A and B. Color will be selected from manufacturer's standard color.

2.3.2 Sheet Rubber

Sheer Rubber shall conform to ASTM F 1344 Class 1 homogeneous construction. Type A (solid color) or Type B (through mottled), 1 m (36 inches) wide. Surface shall be smooth or embossed as indicated. Overall thickness shall be 3 mm (1/8 inch) thick.

2.3.3 Integral Coved Base

A vinyl or rubber round cap strip and vinyl, rubber, or wood fillet strip with a minimum radius of 19 mm (3/4 inch) shall be provided for integral coved bases as shown. Integral cove shall be of the same material as flooring or heat-welded butt-to base as recommended by flooring manufacturer.

2.3.3.1 Integral Cove Trim

Provide inside and outside corner guards and capas of plastic or colored anodized aluminum and approved by flooring manufacturer.

2.3.3.2 Fillet for Integral Cove

Ensure minimum radius of 20 mm (3/4 inch), except 25 mm (1 inch) minimum when used with Style B; use wood, wax, or plastic as recommended by flooring manufacturer.

2.3.4 Adhesive for Sheet Vinyl

Adhesive for flooring and wall base shall be as recommended by the flooring manufacturer. When manufacturer allows option between epoxy-based adhesive and other types, use epoxy-based. Provide seam sealing adhesives for Style C flooring, as recommended by flooring manufacturer.

2.3.4.1 Seam Sealing

As recommended by sheet flooring manufacturer.

2.3.4.2 Flooring

As recommended by flooring manufacturer to suit material and substrate conditions. When manufacturer allows option between epoxy-based adhesive and other types, use epoxy-based.

2.3.4.3 Wall Base

As recommended by wall base manufacturer.

2.3.5 Accessories for Sheet Vinyl

2.3.5.1 Primer for Concrete Floor Surfaces

As recommended by flooring manufacturer for locations indicated.

2.3.5.2 Floor Crack Filler

Nonshrinking latex portland cement-based compound.

2.3.5.3 Mastic Underlay for Concrete Floor Surfaces

Latex or polyvinyl acetate resin base, as recommended by flooring manufacturer.

2.3.5.4 Cleaner and Polish

As recommended in flooring manufacturer's printed maintenance instructions.

2.4 STRIPS

2.4.1 Edge

Provide carpet reducer or tile reducer of vinyl or aluminum or other nonferrous metal and approved by flooring manufacturer. Limit vertical lips in edge strips to 6 mm (1/4 inch); limit total rise to 13 mm (1/2 inch).

2.4.2 Feature

Feature strips shall be vinyl or rubber, 25 mm (1 inch) wide, and of thickness to match the flooring. Color shall be as indicated.

2.4.3 Transition

A vinyl or rubber transition strip tapered to meet abutting material shall be provided.

2.5 WALL BASE

Base shall be manufacturers standard rubber or vinyl, straight style (installed with carpet), coved style (installed with resilient flooring) and butt toe cove (installed with 3 mm (1/8 inch) thick flooring). Base shall be 100 mm (4 inches) high and a minimum 3 mm (1/8 inch) thick, in black or brown or approved color, and in matte finish. Preformed outside corners shall be furnished. Use flexible base to conform to irregularities in walls, partitions, and floors. Provide premolded corners in matching size, shape, and color for all right-angle inside and outside corners.

2.6 POLISH/FINISH

Polish shall conform to ASTM D 4078. Use flooring manufacturer's standard high-solids finish for shine without buffing; non-flamable; compatible with factory-applied finish; may be buffed or burnished for maximum gloss.

2.7 CAULKING AND SEALANTS

Caulking and sealants shall be in accordance with Section 07900 JOINT SEALING.

2.8 MANUFACTURER'S COLOR AND TEXTURE

Color and distinct pattern shall be uniformly distributed throughout thickness of tile. Color and texture shall be as shown on the drawings. Flooring in continuous area or replacement of damaged flooring in continuous area shall be from same production run with same shade and pattern,

PART 3 EXECUTION

3.1 EXAMINATION/VERIFICATION OF CONDITIONS

The Contractor shall examine and verify that site conditions are in agreement with the design package and shall report all conditions that will prevent a proper installation. The Contractor shall not take any corrective action without written permission from the Government.

3.1.1 Removal of Existing Flooring

Remove existing flooring and adhesive in accordance with Section 02050 DEMOLITION and in accordance with new flooring manufacturer's printed instructions.

3.1.2 Subfloor Requirements

Provide subfloor and underlayment as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE and Section 06100 ROUGH CARPENTRY.

3.1.3 Surface Examination

Examine surfaces to receive sheet vinyl flooring. Correct conditions which will impair proper installation, including:

a. Variation in surface level greater than 1 mm in 1 m (1/8 inch in 10 feet).
b. Trowel marks, pits, dents, protrusions.
c. 2 mm (1/16 inch) wide or wider cracks.
d. Chalk and dust.
e. Oil, paint, wax, and other deleterious substances.
f. Moisture.

3.2 SURFACE PREPARATION

Flooring shall be in a smooth, true, level plane, except where indicated as sloped. Before any work under this section is begun, all defects such as rough or scaling concrete, low spots, high spots, and uneven surfaces shall have been corrected, and all damaged portions of concrete slabs shall have been repaired as recommended by the flooring manufacturer. Concrete curing compounds, other than the type that does not adversely affect adhesion, shall be entirely removed from the slabs. Paint, varnish, oils, release agents, sealers, waxers, and adhesives shall be removed, as recommended by the flooring manufacturer.

3.2.1 Concrete Floor

Grind ridges and other uneven surfaces smooth. Cut out and fill cracks 2 mm (1/16 inch) or wider with crack filler. Provide mastic underlayment to fill remaining holes, cracks, and depressions and for smoothing, leveling, or creating a feather edge in accordance with instructions of mastic manufacturer. After cleaning and removal of loose particles, prime chalky or dusty surfaces with primer recommended by flooring manufacturer.

3.2.2 Wood Floor

Fill knotholes, cracks wider than 3 mm (1/8 inch), and holes larger than 6 mm (1/4 inch) in diameter with crack filler. Plane, scrape, or sand smooth ridges or other uneven surfaces. Set nailheads, but not more than 2 mm (1/16 inch) below surface of subfloor. Provide lining felt over wood floor surface, if recommended by floor covering manufacturer. Roll felt into adhesive with three-section roller weighing no less than 45 kg (100 pounds) to remove air bubbles and ensure adhesion of flooring.

3.2.3 Plywood Underlayment

Set nail heads flush. Sand joints smooth. Avoid oversanding. Fill gouges, chipped areas, and open joints with crack filler. Leave joints slightly open to allow for expansion. Allow filler to dry; then sand smooth.

3.2.4 Final Cleaning of Substrate

Clean substrate with broom or vacuum immediately prior to the installation of flooring.

3.3 MOISTURE TEST

The suitability of the concrete subfloor for receiving the resilient flooring with regard to moisture content shall be determined by a moisture test as recommended by the flooring manufacturer, or spreading 150 mm (6 inch) square patch of adhesive in each 15 square meter (150 square foot) area to receive sheet vinyl flooring, and allowing it to dry overnight. If latex-based underlayment has been used, test patches shall include areas covered with underlayment. If the set adhesive can be scraped easily from floor surfaces, floor is not sufficiently dry. Repeat test until adhesive adheres properly. When adhesive adheres tightly to floor surface, proceed with installation.

3.4 GENERAL APPLICATION REQUIREMENTS

To avoid damage, install flooring after other work in same area has been completed. Apply flooring and accessories in accordance with manufacturer's directions, using experienced workers. Detailed requirements follow:

a. Adhesives: Do not allow smoking, open flames or other sources of ignition in area where solvent-containing adhesives are being used or spread, after posting conspicuous signs reading "NO SMOKING OR OPEN FLAME".

b. Flooring: Apply in patterns indicated. Start in center of room or area, and work toward edges. Keep tile lines and joints square, symmetrical, tight, and even. Keep each floor in true, level plane, except where slope is indicated. Vary width of edge tiles as necessary to maintain full-size tiles in field, but no edge tile shall be less than one-half full size, except where irregular-shape makes it impossible.

c. Cutting: Cut flooring edges and scribe to walls and partitions after field flooring has been applied.

d. Edge Strips: Provide edging strips where flooring terminates at points higher than contiguous finished flooring, except where thresholds are provided. Anchor metal strips to concrete floor surfaces by countersunk screws into metal or fiber expansion sleeves.

3.5 INSTALLATION OF VINYL-COMPOSITION TILE AND SOLID VINYL TILE

Tile flooring shall be installed with adhesive in accordance with the manufacturer's installation instructions. Tile lines and joints shall be kept square, symmetrical, tight, and even. Edge width shall vary as necessary to maintain full-size tiles in the field, but no edge tile shall be less than one-half the field tile size, except where irregular shaped rooms make it impossible. Flooring shall be cut to, and fitted around, all permanent fixtures, built-in furniture and cabinets, pipes, and outlets. Edge tile shall be cut, fitted, and scribed to walls and partitions after field flooring has been applied.

3.6 INSTALLATION OF SHEET VINYL FLOORING

Sheet vinyl flooring shall be installed with adhesive mixed and applied in accordance with the manufacturer's written installation instructions; adhesive shall be full coverage. Flooring shall be fitted to the room with minimum of seams by hand cutting, straight scribing, or pattern scribing as necessary to suit job conditions. Flooring shall be cut to, and fitted around, all permanent fixtures, built-in furniture and cabinets, pipes, and outlets. Reverse rolls, as indicated by manufacturer, for specific patterns, to butt sides to themselves, and match color and pattern. Seams shall be cut by overlapping or underscribing as recommended by the manufacturer. Seams and edges of sheet vinyl flooring in room areas shown on the drawings shall be bonded or welded as recommended by the manufacturer. Flooring shall be installed with an integral coved base. Roll with three-section, minimum 45 kg (100 pound) roller starting at middle of sheet to expel trapped air and to thoroughly embed flooring material, except that Style C flooring shall not be rolled.

3.6.1 Sealing at Seams

Cut and seal seams as recommended by flooring manufacturer. At locations indicated, embed seams and edges in waterproof adhesive, spread approximately 100 mm (4 inches) from seams and edges unless otherwise required by flooring manufacturer. Roll seams thoroughly, and weight with sandbags to ensure complete adhesion.

3.6.2 Heat Seaming

Provide heat-sealed seaming bead at each joint in flooring and between flooring and integral base, except at each joint of Style C flooring, provide sealed seam using adhesive. Construct seams using tools, materials, methods, and sequence of work in conformance with written instructions of flooring manufacturer. Finish joints flush, free from voids, recesses, and raised areas.

3.7 INSTALLATION OF RUBBER FLOORING

Rubber flooring shall be installed with adhesive in accordance with the manufacturer's written installation instructions. Lines and joints shall be kept square, symmetrical, tight, and even. Edge width shall vary as necessary to maintain full-size sheets or tiles in the field, but no edge pieces shall be less than one-half the field size, except where irregular shaped rooms make it impossible. Flooring shall be cut to, and fitted around, all permanent fixtures, built-in furniture and cabinets, pipes, and outlets. Edges shall be cut, fitted, and scribed to walls and partitions after field flooring has been applied.

3.8 INSTALLATION OF FEATURE STRIPS

Edge strips shall be secured with adhesive as recommended by the manufacturer. Edge strips shall be provided at locations where flooring termination is higher than the adjacent finished flooring, except at doorways where thresholds are provided. At doors, locate edge strip under door centerline. Anchor metal strips to concrete floor surfaces with countersunk screws in metal or fiber expansion sleeves.

3.9 INSTALLATION OF WALL BASE

Wall base shall be installed with adhesive in accordance with the manufacturer's written instructions. Base joints shall be tight and base shall be even with adjacent resilient flooring. Voids along the top edge of base at masonry walls shall be filled with caulk. Where wall base is used in conjunction with vinyl wall covering, cut vinyl wall covering off 6 mm (1/4 inch) below top of base. Roll entire vertical surface of base with hand roller, and press toe of base with a straight piece of wood to ensure proper alignment. Avoid excess adhesive in corners.

3.10 INSTALLATION OF TREADS AND RISERS

Stair treads and risers shall be installed with adhesive in accordance with the manufacturer's written installation instructions. Treads and risers shall cover the full width of the stairs. Stairs wider than manufacturer's standard lengths shall have equal length pieces butted together to cover the treads.

3.11 INSTALLATION OF INTEGRAL COVED BASE

Integral coved base shall be formed by extending the flooring material 100 mm (4 inches) onto the wall surface. Cove shall be supported by a plastic, rubber or wood coved filler having a minimum radius of 19 mm (3/4 inch). Coved base shall be installed with adhesive in accordance with the manufacturer's written instructions. A metal or vinyl cap strip shall be provided at the top of the base. Voids along the top edge of base at masonry walls shall be filled with caulk.

3.12 CLEANING

Immediately upon completion of installation of tile in a room or an area, flooring and adjacent surfaces shall be dry-cleaned to remove all surplus adhesive. No sooner than 5 days after installation, flooring shall be washed with a nonalkaline cleaning solution, rinsed thoroughly with clear cold water, and, except for raised pattern rubber flooring, rubber tile and sheet rubber flooring, rubber stair treads, and static control vinyl tile, given two coats of polish in accordance with manufacturers written instructions. Raised pattern rubber flooring, rubber tile and sheet rubber flooring, rubber stair treads, and static control vinyl tile shall be cleaned and maintained as recommended by the manufacturer.

a. Vinyl flooring, except prewaxed flooring and flooring designated as no-wax or never-wax by manufacturer, shall have two coats of polish applied and each coat buffed to an even luster with an electric polishing machine, using a lamb's wool pad when dry buffing.

b. Translucent or transparent-surfaced sheet vinyl flooring shall be cleaned by damp mopping. Do not buff finish. Follow flooring manufacturer's cleaning and maintenance instructions.

3.13 PROTECTION

From the time of laying until acceptance, flooring shall be protected from damage as recommended by the flooring manufacturer. Flooring which becomes damaged, loose, broken, or curled, Style C flooring which fails to achieve complete tension and cove base which is not tight to backing fillet shall be removed and replaced.

SECTION 09680

CARPET

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS (AATCC)

AATCC 16 (1998) Test Method: Colorfastness to Light

AATCC 134 (2001) Test Method: Electrostatic Propensity of Carpets

AATCC 165 (1999) Test Method: Colorfastness to Crocking: Carpets ? AATCC Crockmeter Method

AATCC 174 (1998) Antimicrobial Activity Assessment of Carpet

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 297 (1993; R 1998) Rubber Products ? Chemical Analysis

ASTM D 418 (1993; R 1997) Pile Yarn Floor Covering Construction

ASTM D 1423	(1999) Twist in Yarns by the Direct-Counting Method
ASTM D 1667	(1997) Flexible Cellular Materials ? Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam)
ASTM D 3278	(1996e1) Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus
ASTM D 3676	(2001) Rubber Cellular Cushion Used for Carpet or Rug Underlay
ASTM D 5252	(2001) Practice for the Operation of the Hexapod Tumble Drum Tester
ASTM D 5417	(1999) Practice for Operation of the Vettermann Drum Tester
ASTM D 5793	(1995) Standard Test Method for Binding Sites Per Unit Length or Width of Pile Yarn Floor Coverings
ASTM D 5848	(1999) Standard Test Method for Mass Per Unit Area of Pile Yarn Floor Coverings
ASTM E 648	(2000) Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source

CARPET AND RUG INSTITUTE (CRI)

CRI 104	(1996) Commercial Carpet Installation Standard

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

16 CFR 1630	Standard for the Surface Flammability of Carpet and Rugs (FF 1-70)
40 CFR 247	Comprehensive Procurement Guideline for Products Containing Recovered Materials

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 2551	(1981) Machine-made Textile Floor Coverings - Determination of Dimensional Changes Due to the Effect of Varied Water and Heat Conditins (AACHEN Test)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Carpet; G.

Manufacturer's catalog data and printed documentation stating physical characteristics, durability, resistance to fading, and flame resistance characteristics for each type of carpet material and installation accessory.

Surface Preparation; G.

Installation; G.

Two copies of the manufacturer's printed installation instructions for the carpet, including preparation of substrate, seaming techniques, and recommended adhesives and tapes.

SD-04 Samples

Carpet; G.

Molding; G.

a. Carpet: Two "Production Quality" samples 450 x 450 mm (18 x 18 inches) of each carpet proposed for use, showing quality, pattern, and color specified.

b. Vinyl or Aluminum Moldings: Two pieces of each type at least 300 mm (12 inches) long.

c. Special Treatment Materials: Two samples showing system and installation method.

SD-06 Test Reports

Moisture and Alkalinity Tests; G.

Two copies of test reports of moisture and alkalinity content of concrete slab stating date of test, person conducting the test, and the area tested.

SD-07 Certificates

Carpet

Certificates of compliance from a laboratory accredited by the National Laboratory Accreditation Program of the National Institute of Standards and Technology attesting that each type of carpet and carpet with cushion material conforms to the standards specified.

Regulatory Requirements

Report stating that the carpet contains recycled materials and indicating the actual percentage of recycled material.

SD-10 Operation and Maintenance Data

Carpet

Cleaning and Protection

Two copies of carpet manufacturer's maintenance instructions describing recommended type of cleaning equipment and material, spotting and cleaning methods, and cleaning cycles.

1.3 REGULATORY REQUIREMENTS

Carpet and adhesives shall bear the Carpet and Rug Institute (CRI) Indoor Air Quality (IAQ) label or demonstrate compliance with testing criteria and frequencies through independent laboratory test results. Carpet type bearing the label will indicate that the carpet has been tested and meets the criteria of the CRI IAQ Carpet Testing Program, and minimizes the impact on indoor air quality. Contractor shall procure carpet in accordance with 40 CFR 247. Where possible, product shall be purchased locally to reduce emissions of fossil fuels from transporting.

1.4 DELIVERY AND STORAGE

Materials shall be delivered to the site in the manufacturer's original wrappings and packages clearly labeled with the manufacturer's name, brand name, size, dye lot number, and related information. Materials shall be stored in a clean, dry, well ventilated area, protected from damage and soiling, and shall be maintained at a temperature above 16 degrees C (60 degrees F) for 2 days prior to installation.

1.5 ENVIRONMENTAL REQUIREMENTS

Areas in which carpeting is to be installed shall be maintained at a temperature above 16 degrees C (60 degrees F) for 2 days before installation, during installation, and for 2 days after installation. A minimum temperature of 13 degrees C (55 degrees F) shall be maintained thereafter for the duration of the contract. Traffic or movement of furniture or equipment in carpeted area shall not be permitted for 24 hours after installation. Other work which would damage the carpet shall be completed prior to installation of carpet.

1.6 WARRANTY

Manufacturer's standard performance guarantees or warranties including minimum ten (10) year wear warranty, two (2) year material and workmanship and ten (10) year tuft bind and delamination.

1.7 EXTRA MATERIAL

Extra material from same dye lot consisting of full width continuous broadloom and uncut carpet tiles shall be provided for future maintenance. A minimum of 1 percent of total square meters (square yards) of each carpet type, pattern, and color shall be provided.

PART 2 PRODUCTS

2.1 CARPET

Carpet shall be first quality; free of visual blemishes, streaks, poorly dyed areas, fuzzing of pile yarn, spots or stains, and other physical and manufacturing defects. Carpet materials and treatments shall be reasonably nonallergenic and free of other recognized health hazards. All grade carpets shall have a static control construction which gives adequate durability and performance.

2.1.1 Physical Characteristics

2.1.1.1 BROADLOOM CARPET, MODULAR TILE CARPET or ENTRANCE CARPET

Carpet shall comply with the following:

a. Carpet Construction: Tufted, Woven, Bonded or Needlebond as indicated.

b. Type: Broadloom 1.8 m (6 feet) minimum usable carpet width. Modular tile 450 x 450, 500 x 500 or 600 x 600 mm square (18 x 18, 20 x 20 or 24 x 24 inches) square as indicated with 0.15 percent growth/shrink rate in accordance with ISO 2551. Entrance 450 x 450 mm (18 x 18 inches) square 3.6 or 1.8 m (12 or 6 feet) width mat size.

c. Pile Type: Level-loop, Multilevel loop, Cut and loop, Cut pile or as indicated.

d. Pile Fiber: Commercial 100% branded (federally registered trademark) nylon continuous filament, nylon staple, wool with Wool Bureau certification, polyethylene terephthalate (PET) 100% recycled fiber, or polypropylene as indicated.

e. Pile or Wire Height: As shown on the drawings in accordance with ASTM D 418.

f. Yarn Ply: Minimum 2.

g. Gauge or Pitch: As shown on the drawings in accordance with ASTM D 5793.

h. Stitches or Rows/Wires: Minimum 27.6 per square meter (7 per square inch).

i. Finished Pile Yarn Weight: As shown on the drawings. This does not include weight of backings. Weight shall be determined in accordance with ASTM D 5848.

j. Pile Density: As shown on the drawings.

k. Dye Method: Solution dyed, Stock dyed, Yarn (or Skein) dyed, Piece dyed, Space dye, or Continuous dye as indicated.

l. Backing Materials: Primary backing materials shall be polypropylene, synthetic material, synthetic material, or rubber as indicated. Secondary backing to suit project requirements shall be those customarily used and accepted by the trade for each type of carpet, except when a special unitary back designed for gluedown is provided.

m. Attached Cushion: Attached cushion shall be as shown below as indicated on the drawings.

1) Chemically frothed polyurethane with minimum weight of 0.610 kg/sq. m (18 oz/sq. yard), minimum density of 176 kg/cubic m (11 lb/cubic foot)

2) Mechanically frothed polyurethane with minimum weight of 0.745 kg/sq. m (22 oz/sq. yard), minimum density of 224 kg/cubic m (14 lb/cubic foot), minimum thickness of 2.5 mm (0.100 inch), and maximum compression resistance of 34.5 kPa (5 psi), and compression set of 15 percent in accordance with ASTM D 3676

3) Ethylene vinyl acetate (EVA) or polyvinyl chloride (PVC) with minimum weight of 0.95 kg/sq. m (28 oz/sq. yard), minimum thickness of 3.8 mm (0.150 inch), and minimum density of 240.3 kg/cubic m (15 lb/cubic foot) and a maximum compression set of 15 percent in accordance with ASTM D 1667.

Maximum ash content shall not exceed 50 percent when tested in accordance with ASTM D 297. Cushion shall pass accelerated aging test in accordance with ASTM D 3676 or ASTM D 1667.

2.1.2 Performance Requirements

a. ARR (Appearance Retention Rating): Carpet shall be tested and have the minimum 3.0-3.5 (Heavy) ARR when tested in accordance with either the ASTM D 5252 (Hexapod) or ASTM D 5417 (Vettermann) test methods using the number of cycles for short and long term tests as specified.

b. Static Control: Static control shall be provided to permanently control static buildup to less than 3.5 kV for most commercial installations and 2.0 kV for computer rooms when tested at 20 percent relative humidity and 21 degrees C (70 degrees F) in accordance with AATCC 134.

c. Flammability and Critical Radiant Flux Requirements: Carpet shall comply with 16 CFR 1630. Carpet in corridors and exits shall have a minimum average critical radiant flux of 0.45 watts per square centimeter when tested in accordance with ASTM E 648.

d. Tuft Bind: Tuft bind force required to pull a tuft or loop free from carpet backing shall be a minimum 40 N (10 pound) average force for loop pile and 18 N (3 pound) average force for cut pile. Tuft bind for child care centers, youth centers, and dependents' schools, shall be a minimum 53 N (12 pound) average force for loop pile

e. Colorfastness to Crocking: Dry and wet crocking shall comply with AATCC 165 and shall have a Class 4 minimum rating on the AATCC Color Transference Chart for all colors.

f. Colorfastness to Light: Colorfastness to light shall comply with AATCC 16, Test Option E "Water-Cooled Xenon-Arc Lamp, Continuous Light" and shall have a minimum 4 grey scale rating after 40 hours.

g. Delamination Strength: Delamination strength for tufted carpet with a secondary back shall be minimum of 440 N/m (2.5 lbs./inch).

h. Antimicrobial: Nontoxic antimicrobial treatment in accordance with AATCC 174 Part I (qualitatiave), guaranteed by the carpet manufacturer to last the life of the carpet.

2.2 ADHESIVES AND CONCRETE PRIMER

Adhesives and concrete primers for installation of carpet shall be waterproof, nonflammable, meet local air-quality standards, and shall be as required by the carpet manufacturer. Seam adhesive shall be waterproof, nonflammable, and nonstaining as recommended by the carpet manufacturer. Release adhesive for modular tile carpet shall be as recommended by the carpet manufacturer. Adhesives flashpoint shall be minimum 60 degrees C (140 degrees F) in accordance with ASTM D 3278.

2.3 MOLDING

2.3.1 Aluminum Molding

Molding shall be a hammered surface, pinless clamp-down type, designed for the type of carpet being installed. Finish shall be natural color anodized. Floor flange shall be a minimum 38 mm (1-1/2 inches) wide and face shall be a minimum 16 mm (5/8 inch wide)

2.3.2 Vinyl Molding

Molding shall be heavy-duty and designed for the type of carpet being installed. Floor flange shall be a minimum 50 mm (2 inches) wide. Color shall be as indicated.

2.4 TAPE

Tape for seams shall be as recommended by the carpet manufacturer for the type of seam used in installation.

2.5 COLOR, TEXTURE, AND PATTERN

Color, texture, and pattern shall be as shown on the drawings.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Carpet shall not be installed on surfaces that are unsuitable and will prevent a proper installation. Holes, cracks, depressions, or rough areas shall be repaired using material recommended by the carpet or adhesive manufacturer. Floor shall be free of any foreign materials and swept broom clean. Before beginning work, subfloor shall be tested with glue and carpet to determine "open time" and bond.

3.2 MOISTURE AND ALKALINITY TESTS

Concrete slab shall be tested for moisture content and excessive alkalinity in accordance with CRI 104.

3.3 PREPARATION OF CONCRETE SUBFLOOR

Installation of the carpeting shall not commence until concrete substrate is at least 90 days old. The concrete surfaces shall be prepared in accordance with instructions of the carpet manufacturer. Type of concrete sealer, when required, shall be compatible with the carpet.

3.4 INSTALLATION

All work shall be performed by installers who are CFI certified (International Certified Floorcovering Installer Association), or manufacturer's approved installers. Installation shall be in accordance with the manufacturer's instructions and CRI 104. Edges of carpet meeting hard surface flooring shall be protected with molding; installation shall be in accordance with the molding manufacturer's instructions.

3.4.1 Broadloom Installation

Broadloom carpet shall be installed direct glue down or pre-applied adhesive glue down as recommended by manufacturer and shall be smooth, uniform, and secure, with a minimum of seams. Seams shall be regular, unnoticeable, and treated with a seam adhesive. Side seams shall be run toward the light where practical and where such layout does not increase the number of seams. Breadths shall be installed parallel, with carpet pile in the same direction. Patterns shall be accurately matched. Cutouts, as at door jambs, columns and ducts shall be neatly cut and fitted securely. Seams at doorways shall be located parallel to and centered directly under doors. Seams shall not be made perpendicular to doors or at pivot points. Seams at changes in directions of corridors shall follow the wall line parallel to the carpet direction. Corridors with widths less than 1.8 m (6 feet) shall have the carpet laid lengthwise down the corridors.

3.4.2 Modular Tile Installation

Modular tiles shall be installed with release adhesive and shall be snugly jointed together. Tiles shall be laid in the same direction or an alternating pattern with accessibility to the subfloor where required.

3.4.3 Entrance Carpet Installation

Tiles shall be installed with permanent vinyl-compatible or release adhesive and shall be snugly jointed together. Tiles shall be laid in the same direction or an alternating pattern. Roll goods shall be installed direct glue down and shall be smooth, uniform, and secure, with a minimum of seams. Seams shall be regular, unnoticeable, and treated with a seam adhesive. Breadths shall be installed parallel, with carpet pile in the same direction. Patterns shall be accurately matched. Cutouts, as at door jambs, columns and ducts shall be neatly cut and fitted securely. Seams at doorways shall be located parallel to and centered directly under doors. Seams shall not be made perpendicular to doors or at pivot points. Mats shall be cut to specified size and finished with a tapered vinyl edge that is glued and sewn on.

3.5 CLEANING AND PROTECTION

3.5.1 Cleaning

After installation of the carpet, debris, scraps, and other foreign matter shall be removed. Soiled spots and adhesive shall be removed from the face of the carpet with appropriate spot remover. Protruding face yarn shall be cut off and removed. Carpet shall be vacuumed clean.

3.5.2 Protection

The installed carpet shall be protected from soiling and damage with heavy, reinforced, nonstaining kraft paper, plywood, or hardboard sheets. Edges of kraft paper protection shall be lapped and secured to provide a continuous cover. Traffic shall be restricted for at least 45 hours. Protective covering shall be removed when directed by the Contracting Officer.

3.6 REMNANTS

Remnants remaining from the installation, consisting of scrap pieces more than 600 mm (2 feet) in dimension with more than 0.6 square meters (6 square feet) total, shall be provided. Non-retained scraps shall be removed from site and recycled appropriately.

SECTION 09720

WALLCOVERINGS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 423 (2001) Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method

ASTM E 84 (2001) Surface Burning Characteristics of Building Materials

ASTM F 793 (1993; R 1998) Standard Classification of Wallcovering by Durability Characteristics

CHEMICAL FABRICS & FILM ASSOCIATION (CFFA)

CFFA-W-101-D (1995) Vinyl Coated Fabric Wallcovering

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Wallcoverings; G.

Manufacturer's descriptive data, documentation stating physical characteristics, flame resistance, mildew and germicidal characteristics.

Installation

Preprinted installation instructions for wallcovering and accessories.

Maintenance

Clean-Up

Preprinted cleaning and maintenance instructions for wallcovering and accessories.

SD-04 Samples

Wallcoverings; G.

Two samples of each indicated type, pattern, and color of wallcovering. Samples of wall covering shall be minimum 125 x 175 mm (5 x 7 inches) and of sufficient size to show pattern repeat. Two samples of each indicated type corner guard and wainscot cap.

SD-07 Certificates

Wallcoverings; G.

Manufacturer's statement attesting that the product furnished meets or exceeds specification requirements. The statement must; be dated after the award of the contract, state Contractor's name and address, name the project and location, and list the requirements being certified.

SD-08 Manufacturer's Instructions

Wallcoverings

Submit complete procedures for an expert installation, including preparation of the substrate. Submit Material Safety Data Sheets (MSDS) for all primers, sealers, and adhesives to the Contracting Officer.

1.3 DELIVERY AND STORAGE

Deliver the material to the site in manufacturer's original wrappings and packages and clearly labeled with the manufacturer's name, brand name, size, and other related information. Store in a safe, dry, clean, and well-ventilated area at temperatures not less than 10 degrees C (50 degrees F) and within a relative humidity range of 30 to 60 percent. Store wall covering material in a flat position and protect from damage, soiling, and moisture. Do not open containers until needed for installation, unless verification inspection is required.

1.4 ENVIRONMENTAL REQUIREMENTS

Minimum temperature of area to receive wall covering, before, during, and after installation, and requirements for conditioning adhesive and wall covering shall comply with the wall covering manufacturer's printed instructions. However, in no case shall the area temperature be less than 10 degrees C (50 degrees F), 72 hours prior to, during installation, and until the adhesive is dry. Observe ventilation and safety procedures specified in the MSDS.

1.5 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a one-year period shall be provided.

1.6 EXTRA MATERIALS

Provide one linear meter (one linear foot) of full-width wall covering of each pattern and color for each 100 linear meters (100 linear feet) of wall covering installed. Extra stock shall be of the same manufacture, type, pattern, color, and lot number as the installed wall covering. Provide full rolls, packed for storage and marked with content, pattern, and color. Leave extra stock at the site at a location as directed.

PART 2 PRODUCTS

2.1 WALLCOVERINGS

Wallcoverings shall be material designed specifically for the specified use. The wallcovering shall contain a non-mercury based mildewcide. The wallcovering shall be type made without the use of cadmium based stabilizers. Wallcovering shall have a Class A flame spread rating of 0-25 and smoke development rating of 0-50 when tested in accordance with ASTM E 84.

2.1.1 Vinyl Wallcovering

Vinyl wallcovering shall be a vinyl coated woven or nonwoven fabric with germicidal additives and shall conform to ASTM F 793, Category V Type II, 0.445 to 0.815 kg (13.1 to 24 ounces) total weight per square meter (yard) and width of as shown on the drawings.

2.1.2 Fabric Wallcovering

Fabric wallcovering shall be a woven fabric with paper or acrylic backing and shall be colorfast, stain, and soil resistant. Fabric wallcovering shall meet or exceed the following:

a. Face fiber content: wool, linen, cotton, rayon, or jute as indicated.

b. Total weight: 0.679 kg/square meter (20 ounces per square yard).

c. Width: 914.4 and 1371.6 mm (36 and 54 inches).

2.1.3 Acoustical Wallcovering

Acoustical wallcovering shall be synthetic material or vinyl coated fabric with porous surface with fused back. Acoustical wall covering shall meet or exceed the following:

a. Total weight: 0.679 kg/square meter (20 ounces per square yard).

b. Width: 914.4 and 1219.2 mm (36 and 48 inches).

c. NRC rating in accordance with ASTM C 423; minimum NRC 55.

2.2 WALL LINER

Wall liner shall be a non-woven polyester cellulose blend having a minimum weight of 0.125 kg/square meter (3.7 ounces per square yard) and a total minimum thickness of 0.33 mm (0.013 inches). Wall liner shall have a Class A flame spread rating of 0-25 and smoke development rating of 0-50 when tested in accordance with ASTM E 84.

2.3 CORNER GUARDS

Corner guards shall be 2 mm (3/32 inch) thick and shall cover 19 mm (3/4 inch) each side of corner at right angles. Corner guards shall be clear, polycarbonate, vinyl, or rubber from the same lot and color. Corner guards shall be wainscot height or as indicated.

2.4 WAINSCOT CAP

Wainscot cap shall be satin-finished extruded aluminum about 19 mm (3/4 inch) high, feathered at bottom edge, with an approximate 5 mm (3/16 inch) exposed face on top edge, and grooved to receive the covering.

2.5 PRIMER AND ADHESIVE

Primer and adhesive shall be of a type recommended by the wallcovering manufacturer and shall contain a non-mercury based mildewcide. When substrate color variations show through vinyl wallcovering, a white pigmented primer as recommended by the wallcovering manufacturer shall be used to conceal the variations. Adhesive shall be strippable type. Adhesive to install cap shall be of a type recommended by the manufacturer of the wainscot cap.

2.6 COLOR, TEXTURE, AND PATTERN

Color, texture, and pattern shall be as shown on the drawings.

PART 3 EXECUTION

3.1 EXAMINATION

Contractor shall inspect all areas and conditions under which wallcoverings are to be installed. Contractor shall notify in writing of any conditions detrimental to the proper and timely completion of the installation. Work will proceed only when conditions have been corrected and accepted by the installer.

3.2 SURFACE PREPARATION

Wallcovering shall not be applied to surfaces that are rough, that contain stains that will bleed through the wallcovering, or that are otherwise unsuitable for proper installation. Cracks and holes shall be filled and rough spots shall be sanded smooth. Surfaces to receive wallcovering shall be thoroughly dry. Plaster surfaces shall age at least 30 days prior to installation of vinyl wallcoverings. Interior surfaces of new and existing gypsum wallboard shall be primed with a wallcovering primer in accordance with the manufacturer's instructions. As required, white primer shall be used when substrate color variations are visible through thin or light color wallcovering. Interior surfaces of exterior masonry walls shall be sealed to prevent moisture penetration, then primed with a wallcovering primer in accordance with the manufacturer's instructions. Moisture content of plaster, concrete, and masonry shall be tested with an electric moisture meter and reading shall be not more than 5 percent. Masonry walls shall have flush joints. Concrete and masonry walls shall be coated with a thin coat of joint compound or cement plaster as a substrate preparation. To promote adequate adhesion of wall lining over masonry walls, the walls shall be primed as recommended by the wall lining manufacturer. Surface of walls shall be primed as required by manufacturer's instructions to permit ultimate removal of wallcovering from the wall surface. Primer shall be allowed to completely dry before adhesive application.

3.3 INSTALLATION

3.3.1 Wall Liner

Wall liner shall be installed over masonry walls that are to receive wallcovering. Liner shall be installed in accordance with the manufacturer's installation instructions. Liner shall be installed perpendicular to wallcovering to prevent overlapping of seams between liner and wallcovering.

3.3.2 Vinyl and Fabric Wallcovering

Wallcovering shall be installed in accordance with the manufacturer's installation instructions. Glue and adhesive spillage shall be immediately removed from wallcovering face and seams with a remover recommended by the manufacturer. After the installation is complete, the fabric wallcovering shall be vacuumed with a ceiling to floor motion.

3.3.3 Corner Guards and Wainscot Cap

Corner guards and wainscot cap shall be installed where shown on the drawings and in accordance with the manufacturer's printed instructions. Corner guards shall run from top of base to wainscot cap or ceiling in a continuous length.

3.4 CLEAN-UP

Upon completion of the work, wallcovering shall be left clean and free of dirt, soiling, stain, or residual film. Surplus materials, rubbish, and debris resulting from the wallcovering installation shall be removed and area shall be left clean.

SECTION 09840

ACOUSTICAL WALL TREATMENT

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS (AATCC)

AATCC 16	(1998) Test Method: Colorfastness to Light

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 423	(1999a) Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
ASTM D 1117	(1999) Nonwoven Fabrics
ASTM D 5034	(1995) Breaking Strength and Elongation of Textile Fabrics Grab Test)
ASTM E 84	(2000a) Surface Burning Characteristics of Building Materials

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO)

ICBO UBC	(1997) Uniform Building Code (3 Vol.)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings; G.

Drawings showing plan locations, elevations and details.
Drawings shall include details of method of anchorage, location of doors and other openings, base detail and shape and thickness of materials.

SD-03 Product Data

Installation

Manufacturer's installation instructions and recommended cleaning instructions.

Acoustical Wall Panels; G.

Manufacturer's descriptive data and catalog cuts.

SD-04 Samples

Acoustical Wall Panels; G.

Manufacturer's standard fabric swatches, minimum 450 mm (18 inches) wide by 600 mm (24 inches) long 2 samples of each color range specified.

SD-07 Certificates

Acoustical Wall Panels; G.

Certificates of compliance from an independent laboratory accredited by the National Laboratory Accreditation Program of the National Institute of Standards. A label or listing from the testing laboratory will be acceptable evidence of compliance.

1.3 DELIVERY AND STORAGE

Materials delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt, dust, or other contaminants.

1.4 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a one year period shall be provided.

PART 2 PRODUCTS

2.1 FABRIC COVERED ACOUSTICAL WALL PANELS

Acoustical wall panels shall consist of prefinished factory assembled, seamless fabric covered, fiber glass or mineral fiber core system as described below. Wall panels shall be manufactured to the dimensions and configurations shown on the approved detail drawings. Perimeter edges shall be non-reinforced, or reinforced by either an aluminum frame or a formulated resin edge hardener as indicated. Acoustical wall panels installed in non-sprinklered areas must comply with the requirements of ICBO UBC, Standard 42-2.

a. Panel Width: Panel width shall be as detailed.

b. Panel Height: Panel height shall be as detailed.

c. Thickness: Panel thickness shall be as required to meet the indicated NRC range.

d. Fabric Covering shall be as shown below in accordance with the drawings.

1) Seamless non-woven, embossed texture, needle punched 100 percent polyester, minimum 0.034 kg per linear meter (11 ounces per linear yard). Tear strength shall be minimum 110 N (25 pounds) machine direction and minimum 178 N (40 pounds) cross-machine direction in accordance with ASTM D 1117. Tensile strength shall be minimum 220 N (50 pounds) machine direction and minimum 330 N (75 pounds) cross-machine direction in accordance with ASTM D 5034.

2) Seamless plain woven 2-ply 100 percent polyester, minimum 0.47 kg per linear meter (15 ounces per linear yard). Tear strength shall be minimum 129 N (29 pounds). Tensile strength shall be 667 N (150 pounds) minimum in accordance with ASTM D 5034.

3) Seamless perforated vinyl covering with fabric backing, minimum 0.62 kg per linear meter (20 ounces per linear yard) total weight.

Fabric covering shall be stretched free of wrinkles and then bonded to the edges and back or bonded directly to the panel face, edges, and back of panel a minimum distance standard with the manufacturer. Light fastness (fadeometer) shall be approximately 40 hours in accordance with AATCC 16.

e. Fire rating for the complete composite system: Class A, 200 or less smoke density and flame spread less than 25, when tested in accordance with ASTM E 84.

f. Substrate: Fiber glass or mineral fiber.

g. Noise Reduction Coefficient (NRC) Range (ASTM C 423): As shown on the drawings.

h. Edge Detail: Half bevel, Bevel, Radius, or Square, edge as indicated.

i. Core Type: High impact acoustical or Acoustical/tackable core as indicated.

J. Mounting: Acoustical panels shall be mounted by manufacturer's standard concealed spline, mechanical fasteners, magnetic fasteners, hook and loop, adhesive mounting as indicated.

k. Color: Color shall be as shown on the drawings.

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

Walls shall be clean, smooth, oil free and prepared in accordance with panel manufacturer's instructions. Installation shall not begin until all wet work, such as, plastering, painting, and concrete are completely dry.

3.2 INSTALLATION

Panel installation shall be by personnel familiar with and normally engaged in installation of acoustical wall panels. Panels shall be applied in accordance with the manufacturer's installation instructions.

3.3 CLEANING

Following installation, dirty or stained panel surfaces shall be cleaned in accordance with manufacturer's instructions and left free from defects. Panels that are damaged, discolored, or improperly installed shall be removed and new panels provided as directed.

SECTION 09900

PAINTS AND COATINGS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH Limit Values	(1991-1992) Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs)
ACGIH TLV-DOC	Documentation of Threshold Limit Values and Biological Exposure Indices

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A13.1	Scheme for Identification of Piping Systems

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 235	Standard Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)
ASTM D 523	(1999) Standard Test Method for Specular Gloss
ASTM C 669	(1995) Glazing Compounds for Back Bedding and Face Glazing of Metal Sash
ASTM C 920	(1998) Elastomeric Joint Sealants
ASTM D 2092	(1995) Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting
ASTM D 2824	(1994) Aluminum-Pigmented Asphalt Roof Coatings, Non-Fibered, Asbestos Fibered, and Fibered Without Asbestos
ASTM D 4214	(1998) Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D 4263	(1983; R 1999) Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D 4444	(1998) Standard Test Methods for Use and Calibration of Hand-Held Moisture Meters
ASTM F 1869	(1998) Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

CODE OF FEDERAL REGULATIONS (CFR)

29 CFR 1910.1000	Air Contaminants
29 CFR 1910.1001	Asbestos, Tremolite, Anthophyllite, and Actinolite
29 CFR 1910.1025	Lead
29 CFR 1926.62	Lead Exposure in Construction

FEDERAL AVIATION ADMINISTRATION (FAA)

FAA AC 70/7460-1	(Rev J) Obstruction Marking and Lighting

FEDERAL STANDARDS (FED-STD)

FED-STD-313	(Rev. C) Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities
FED-STD-595	(1989 Rev B) Color

MASTER PAINTERS INSTITUTE (MPI)

MPI 1	(2001) Aluminum Paint

MPI 2	(2001) Aluminum Heat Resistant Enamel (up to 427 C and 800 F)
MPI 4	(2001) Interior/Exterior Latex Block Filler
MPI 5	(2001) Exterior Alkyd Wood Primer
MPI 6	(2001) Exterior Latex Wood Primer
MPI 7	(2001) Exterior Oil Wood Primer
MPI 8	(2001) Exterior Alkyd, Flat
MPI 9	(2001) Exterior Alkyd Enamel
MPI 10	(2001) Exterior Latex, Flat
MPI 11	(2001) Exterior Latex, Semi-Gloss
MPI 13	(2001) Exterior Semi-Transparent Stain (Solvent Based)
MPI 16	(2001) Exterior Solid Color Latex Stain
MPI 19	(2001) Inorganic Zinc Primer
MPI 21	(2001) Heat Resistant Enamel, Gloss, (Up to 205 C or 400 F)
MPI 22	(2001) High Heat Resistant Coating
MPI 23	(2001) Surface Tolerant Metal Primer
MPI 26	(2001) Cementitious Galvanized Metal Primer
MPI 27	(2001) Exterior / Interior Alkyd Floor Enamel, Gloss
MPI 31	(2001) Polyurethane, Moisture Cured, Clear Gloss
MPI 39	(2001) Interior Latex-based Wood Primer
MPI 42	(2001) Latex Stucco and Masonry Textured Coating
MPI 44	Interior Latex, Gloss Level 2
MPI 45	(2001) Interior Primer Sealer
MPI 46	(2001) Interior Enamel Undercoat
MPI 47	(2001) Interior Alkyd, Semi-Gloss
MPI 48	(2001) Interior Alkyd, Gloss
MPI 49	(2001) Interior Alkyd, Flat
MPI 50	(2001) Interior Latex Primer Sealer

MPI 51	(2001) Interior Alkyd, Eggshell
MPI 52	(2001) Interior Latex, Gloss Level 3
MPI 54	(2001) Interior Latex, Semi-Gloss
MPI 56	(2001) Interior Alkyd Dry Fog/Fall
MPI 57	(2001) Interior Oil Modified Clear Urethane, Satin
MPI 59	(2001) Interior/Exterior Alkyd Porch & Floor Enamel, Low Gloss
MPI 60	(2001) Interior/Exterior Latex Porch & Floor Paint, Low Gloss
MPI 68	(2001) Interior/Exterior Latex Porch & Floor Paint, Gloss
MPI 71	(2001) Polyurethane, Moisture Cured, Clear, Flat
MPI 72	(2001) Polyurethane, Two Component, Pigmented, Gloss
MPI 77	(2001) Epoxy Cold Cured, Gloss
MPI 79	(2001) Marine Alkyd Metal Primer
MPI 90	(2001) Interior Wood Stain, Semi-Transparent
MPI 94	(2001) Exterior Alkyd, Semi-Gloss
MPI 95	(2001) Fast Drying Metal Primer
MPI 101	(2001) Cold Curing Epoxy Primer
MPI 107	(2001) Rust Inhibitive Primer (Water-Based)
MPI 108	(2001) High Build Epoxy Marine Coating
MPI 110	(2001) Interior/Exterior High Performance Acrylic
MPI 113	(2001) Elastomeric Coating
MPI 116	(2001) Epoxy Block Filler
MPI 119	(2001) Exterior Latex, High Gloss (acrylic)
MPI 134	(2001) Waterborne Galvanized Primer
MPI 138	(2001) High Performance Latex, White and Tints - MPI Gloss Level 2
MPI 139	(2001) High Performance Latex, White and Tints - MPI Gloss Level 3
MPI 140	(2001) High Performance Architectural Latex - Gloss Level 4

MPI 141	(2001) High Performance Semigloss Latex, White and Tints ? Gloss Level 5
MPI 144	(2001) Institutional Low Odor / VOC Interior Latex, Gloss Level 2
MPI 145	(2001) Institutional Low Odor / VOC Interior Latex, Gloss Level 3
MPI 146	Institutional Low Odor/VOC Interior Latex - Gloss Level 4 (a 'satin-like' finish)
MPI 147	(2001) Institutional Low Odor / VOC Interior Latex, Gloss Level 5

COMMERCIAL ITEM DESCRIPTION (CID)

CID A-A-2904	Thinner, Paint, Mineral Spirits, Regular and Odorless

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(Rev. B) Color Code for Pipelines and for Compressed Gas Cylinders

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS-EPP-SP01-01	(2001) Environmentally Preferable Product Specification for Architectural and Anti-Corrosive Paints

STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SSPC Guide 6	(1997) Containing Debris Generated During Paint Removal Operations
SSPC Guide 7	(1995) Disposal of Lead-Contaminated Surface Preparation Debris
SSPC QP 1	(1989) Evaluating Qualifications of Painting Contractors (Field Application to Complex Structures)
SSPC PA 1	(2000) Shop, Field, and Maintenance Painting
SSPC PA 3	(1995) Safety in Paint Application
SSPC VIS 1	(1989) Visual Standard for Abrasive Blast Cleaned Steel (Standard Reference Photographs)
SSPC VIS 3	(1993) Visual Standard for Power- and Hand-Tool Cleaned Steel (Standard Reference Photographs)
SSPC VIS 4	(2001) Guide and Reference Photographs for Steel Surfaces Prepared by Waterjetting
SSPC SP 1	(1982) Solvent Cleaning

SSPC SP 2	(1995) Hand Tool Cleaning
SSPC SP 3	(1995) Power Tool Cleaning
SSPC SP 6	(1994) Commercial Blast Cleaning
SSPC SP 7	(1994) Brush-Off Blast Cleaning
SSPC SP 10	(1994) Near-White Blast Cleaning
SSPC SP 12	(1995) Surface Preparation and Cleaning of Steel and Other Hard Materials by High-and Ultra high-Pressure Water Jetting Prior to Recoating
SSPC Paint 18	(1991) Chlorinated Rubber Intermediate Coat Paint

1.2 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

The current MPI, "Approved Product List" which lists paint by brand, label, product name and product code as of the date of contract award, will be used to determine compliance with the submittal requirements of this specification. The Contractor may choose to use a subsequent MPI "Approved Product List", however, only one list may be used for the entire contract and each coating system is to be from a single manufacturer. All coats on a particular substrate must be from a single manufacturer. No variation from the MPI Approved Products List is acceptable.

SD-02 Shop Drawings

Piping identification;

Submit color stencil codes

SD-03 Product Data

Coating; G

Manufacturer's Technical Data Sheets

Sealant;

SD-04 Samples

Color; G

Submit manufacturer's samples of paint colors. Cross reference color samples to color scheme as indicated.

Textured Wall Coating System; G

SD-07 Certificates

Applicator's qualifications;

Qualification Testing laboratory for coatings; G

SD-08 Manufacturer's Instructions

Application instructions; Mixing;

Detailed mixing instructions, minimum and maximum application temperature and humidity, potlife, and curing and drying times between coats.

Manufacturer's Material Safety Data Sheets;

Submit manufacturer's Material Safety Data Sheets for coatings, solvents, and other potentially hazardous materials, as defined in FED-STD-313.

SD-10 Operation and Maintenance Data

Coatings: G

Preprinted cleaning and maintenance instructions for all coating systems shall be provided.

1.3 REGULATORY REQUIREMENTS

1.3.1 Environmental Protection

In addition to requirements specified elsewhere for environmental protection, provide coating materials that conform to the restrictions of the local Air Pollution Control District and regional jurisdiction. Notify Contracting Officer of any paint specified herein which fails to conform.

1.3.2 Lead Content

Do not use coatings having a lead content over 0.06 percent by weight of nonvolatile content.

1.3.3 Chromate Content

Do not use coatings containing zinc-chromate or strontium-chromate.

1.3.4 Asbestos Content

Materials shall not contain asbestos.

1.3.5 Mercury Content

Materials shall not contain mercury or mercury compounds.

1.3.6 Silica

Abrasive blast media shall not contain free crystilline silica.

1.3.7 Human Carcinogens

Materials shall not contain ACGIH Limit Values and ACGIH TLV-DOC confirmed human carcinogens (A1) or suspected human carcinogens (A2).

1.4 PACKAGING, LABELING, AND STORAGE

Paints shall be in sealed containers that legibly show the contract specification number, designation name, formula or specification number, batch number, color, quantity, date of manufacture, manufacturer's formulation number, manufacturer's directions including any warnings and special precautions, and name and address of manufacturer. Pigmented paints shall be furnished in containers not larger than 20 liters (5 gallons). Paints and thinners shall be stored in accordance with the manufacturer's written directions, and as a minimum, stored off the ground, under cover, with sufficient ventilation to prevent the buildup of flammable vapors, and at temperatures between 4 to 35 degrees C (40 to 95 degrees F).

1.5 SAFETY AND HEALTH

Apply coating materials using safety methods and equipment in accordance with the following:

Work shall comply with applicable Federal, State, and local laws and regulations, and with the ACCIDENT PREVENTION PLAN, including the Activity Hazard Analysis as specified in Section 01525,"Safety Requirements" and in Appendix A of EM-385-1-1. The Activity Hazard Analysis shall include analyses of the potential impact of painting operations on painting personnel and on others involved in and adjacent to the work zone.

1.5.1 Safety Methods Used During Coating Application

Comply with the requirements of SSPC PA 3.

1.5.2 Toxic Materials

To protect personnel from overexposure to toxic materials, conform to the most stringent guidance of:

a. The applicable manufacturer's Material Safety Data Sheets (MSDS) or local regulation.

b. 29 CFR 1910.1000.

c. ACGIH Limit Values, threshold limit values.

1.6 ENVIRONMENTAL CONDITIONS

1.6.1 Coatings

Do not apply coating when air or substrate conditions are:

a. Less than 3 degrees C (5 degrees F) above dew point;

b. Below 10 degrees C (50 degrees F) or over 35 degrees C (95 degrees F), unless specifically pre-approved by the Contracting Officer and the product manufacturer. Under no circumstances shall application conditions exceed manufacturer recommendations.

1.7 COLOR SELECTION

Colors of finish coats shall be as indicated or specified. Where not indicated or specified, colors shall be selected by the Contracting Officer. Manufacturers' names and color identification are used for the purpose of color identification only. Named products are acceptable for use only if they conform to specified requirements. Products of other manufacturers are acceptable if the colors approximate colors indicated and the product conforms to specified requirements. Tint each coat progressively darker to enable confirmation of the number of coats. Color, texture, and pattern of wall coating systems shall be as indicated

1.8 LOCATION AND SURFACE TYPE TO BE PAINTED

1.8.1 Painting Included

Where a space or surface is indicated to be painted, include the following unless indicated otherwise.

a. Surfaces behind portable objects and surface mounted articles readily detachable by removal of fasteners, such as screws and bolts.

b. New factory finished surfaces that require identification or color coding and factory finished surfaces that are damaged during performance of the work.

c. Existing coated surfaces that are damaged during performance of the work.

1.8.1.1 Exterior Painting

Includes new surfaces, existing coated surfaces, and existing uncoated surfaces of the building and appurtenances as indicated. Also included are existing coated surfaces made bare by cleaning operations.

1.8.1.2 Interior Painting

Includes new surfaces, existing uncoated surfaces, and existing coated surfaces of the building and appurtenances as indicated and existing coated surfaces made bare by cleaning operations. Where a space or surface is indicated to be painted, include the following items, unless indicated otherwise.

a. Exposed columns, girders, beams, joists, and metal deck; and

b. Other contiguous surfaces.

1.8.2 Painting Excluded

Do not paint the following unless indicated otherwise.

a. Surfaces concealed and made inaccessible by panelboards, fixed ductwork, machinery, and equipment fixed in place.

b. Surfaces in concealed spaces. Concealed spaces are defined as enclosed spaces above suspended ceilings, furred spaces, attic spaces, crawl spaces, elevator shafts and chases.

c. Steel to be embedded in concrete.

d. Copper, stainless steel, aluminum, brass, and lead except existing coated surfaces.

e. Hardware, fittings, and other factory finished items.

1.8.3 Mechanical and Electrical Painting

Includes field coating of interior and exterior new and existing surfaces.

a. Where a space or surface is indicated to be painted, include the following items unless indicated otherwise:

(1) Exposed piping, conduit, and ductwork.
(2) Supports, hangers, air grilles, and registers.
(3) Miscellaneous metalwork and insulation coverings.

b. Do not paint the following, unless indicated otherwise:

(1) New zinc-coated, aluminum, and copper surfaces under insulation.
(2) New aluminum jacket on piping.
(3) New interior ferrous piping under insulation.

1.8.3.1 Fire Extinguishing Sprinkler Systems

Clean, pretreat, prime, and paint new fire extinguishing sprinkler systems including valves, piping, conduit, hangers, supports, miscellaneous metalwork, and accessories. Apply coatings to clean, dry surfaces, using clean brushes. Clean the surfaces to remove dust, dirt, rust, and loose mill scale. Immediately after cleaning, provide the metal surfaces with one coat primer per schedules. Shield sprinkler heads with protective covering while painting is in progress. Upon completion of painting, remove protective covering from sprinkler heads. Remove sprinkler heads which have been painted and replace with new sprinkler heads. Provide primed surfaces with the following:

a. Piping in Unfinished Areas: Provide primed surfaces with one coat of red alkyd gloss enamel applied to a minimum dry film thickness of 0.025 mm (1.0 mil) in attic spaces, spaces above suspended ceilings, crawl spaces, pipe chases, mechanical equipment room, and spaces where walls or ceiling are not painted or not constructed of a prefinished material. In lieu of red enamel finish coat, provide piping with 50 mm (2 inch) wide red enamel bands or self-adhering red plastic bands spaced at maximum of 6 meters (20 foot) intervals.

b. Piping in Finished Areas: Provide primed surfaces with two coats of paint to match adjacent surfaces, except provide valves and operating accessories with one coat of red alkyd gloss enamel applied to a minimum dry film thickness of 0.025 mm (1.0 mil). Provide piping with 50 mm (2 inch) wide red enamel bands or self-adhering red plastic bands spaced at maximum of 6 meters (20 foot) intervals throughout the piping systems.

1.8.4 MISCELLANEOUS PAINTING

Lettering shall be provided as scheduled on the drawings, shall be block or Gothic type, and shall be black enamel. Samples shall be approved before application. Obstructions to aviation shall be painted in the pattern and color prescribed by FAA AC 70/7460-1.

1.8.5 Definitions and Abbreviations

1.8.5.1 Qualification Testing

Qualification testing is the performance of all test requirements listed in the product specification. This testing is accomplished by MPI to qualify each product for the MPI Approved Product List, and may also be accomplished by Contractor's third party testing lab if an alternative to Batch Quality Conformance Testing by MPI is desired.

1.8.5.2 Batch Quality Conformance Testing

Batch quality conformance testing determines that the product provided is the same as the product qualified to the appropriate product specification. This testing shall only be accomplished by MPI testing lab.

1.8.5.3 Coating

A film or thin layer applied to a base material called a substrate. A coating may be a metal, alloy, paint, or solid/liquid suspensions on various substrates (metals, plastics, wood, paper, leather, cloth, etc.). They may be applied by electrolysis, vapor deposition, vacuum, or mechanical means such as brushing, spraying, calendering, and roller coating. A coating may be applied for aesthetic or protective purposes or both. The term "coating" as used herein includes emulsions, enamels, stains, varnishes, sealers, epoxies, and other coatings, whether used as primer, intermediate, or finish coat. The terms paint and coating are used interchangeably.

1.8.5.4 DFT or dft

Dry film thickness, the film thickness of the fully cured, dry paint or coating.

1.8.5.5 DSD

Degree of Surface Degradation, the MPI system of defining degree of surface degradation. Five (5) levels are generically defined under the Assessment sections in the MPI Maintenance Repainting Manual.

1.8.5.6 EPP

Environmentally Preferred Products, a standard for determining environmental preferability in support of Executive Order 13101.

1.8.5.7 EXT

MPI short term designation for an exterior coating system.

1.8.5.8 INT

MPI short term designation for an interior coating system.

1.8.5.9 micron / microns

The metric measurement for 0.001 mm or one/one-thousandth of a millimeter.

1.8.5.10 mil / mils

The English measurement for 0.001 in or one/one-thousandth of an inch, equal to 25.4 microns or 0.0254 mm.

1.8.5.11 mm

The metric measurement for millimeter, 0.001 meter or one/one-thousandth of a meter.

1.8.5.12 MPI Gloss Levels

MPI system of defining gloss. Seven (7) gloss levels (G1 to G7) are generically defined under the Evaluation sections of the MPI Manuals. Traditionally, Flat refers to G1/G2, Eggshell refers to G3, Semigloss refers to G5, and Gloss refers to G6.

Gloss levels are defined by MPI as follows:

Gloss Level	Description	Units @ 60 degrees	Units @ 85 degrees
G1	Matte or Flat	0 to 5	10 max
G2	Velvet	0 to 10	10 to 35
G3	Eggshell	10 to 25	10 to 35
G4	Satin	20 to 35	35 min
G5	Semi-Gloss	35 to 70	
G6	Gloss	70 to 85	
G7	High Gloss		

Gloss is tested in accordance with ASTM D 523. Historically, the Government has used Flat (G1 / G2), Eggshell (G3), Semi-Gloss (G5), and Gloss (G6).

1.8.6.13 MPI System Number

The MPI coating system number in each Division found in either the MPI Architectural Painting Specification Manual or the Maintenance Repainting Manual and defined as an exterior (EXT/REX) or interior system (INT/RIN). The Division number follows the CSI Master Format.

1.8.6.14 Paint

See Coating definition.

1.8.6.15 REX

MPI short term designation for an exterior coating system used in repainting projects or over existing coating systems.

1.8.6.16 RIN

MPI short term designation for an interior coating system used in repainting projects or over existing coating systems.

PART 2 PRODUCTS

2.1 MATERIALS

Conform to the coating specifications and standards referenced in PART 3. Submit manufacturer's technical data sheets for specified coatings and solvents.

PART 3 EXECUTION

3.1 PROTECTION OF AREAS AND SPACES NOT TO BE PAINTED

Prior to surface preparation and coating applications, remove, mask, or otherwise protect, hardware, hardware accessories, machined surfaces, radiator covers, plates, lighting fixtures, public and private property, and other such items not to be coated that are in contact with surfaces to be coated. Following completion of painting, workmen skilled in the trades involved shall reinstall removed items. Restore surfaces contaminated by coating materials, to original condition and repair damaged items.

3.2 REPUTTYING AND REGLAZING

Remove cracked, loose, and defective putty or glazing compound on glazed sash and provide new putty or glazing compound. Where defective putty or glazing compound constitutes 30 percent or more of the putty at any one light, remove the glass and putty or glazing compound and reset the glass. Remove putty or glazing compound without damaging sash or glass. Clean rabbets to bare wood or metal and prime prior to reglazing. Putty for wood sash shall be a linseed oil putty. Glazing compound for metal sash shall conform to ASTM C 669. Patch surfaces to provide smooth transition between existing and new surfaces. Finish putty or glazing compound to a neat and true bead. Allow glazing compound time to cure, in accordance with manufacturer's recommendation, prior to coating application. Allow putty to set one week prior to coating application.

3.3 RESEALING OF EXISTING EXTERIOR JOINTS

3.3.1 Surface Condition

Surfaces shall be clean, dry to the touch, and free from frost and moisture; remove grease, oil, wax, lacquer, paint, defective backstop, or other foreign matter that would prevent or impair adhesion. Where adequate grooves have not been provided, clean out to a depth of 13 mm (1/2 inch) and grind to a minimum width of 6 mm (1/4 inch) without damage to adjoining work. Grinding shall not be required on metal surfaces.

3.3.2 Backstops

In joints more than 13 mm (1/2 inch) deep, install glass fiber roving or neoprene, butyl, polyurethane, or polyethylene foams free of oil or other staining elements as recommended by sealant manufacturer. Backstop material shall be compatible with sealant. Do not use oakum and other types of absorptive materials as backstops.

3.3.3 Primer and Bond Breaker

Install the type recommended by the sealant manufacturer.

3.3.4 Ambient Temperature

Between 4 degrees C (38 degrees F) and 35 degrees C (95 degrees F) when applying sealant.

3.3.5 Exterior Sealant

For joints in vertical surfaces, provide ASTM C 920, Type S or M, Grade NS, Class 25, Use NT. For joints in horizontal surfaces, provide ASTM C 920, Type S or M, Grade P, Class 25, Use T. Color(s) shall be selected by the Contracting Officer. Apply the sealant in accordance with the manufacturer's printed instructions. Force sealant into joints with sufficient pressure to fill the joints solidly. Sealant shall be uniformly smooth and free of wrinkles.

3.3.6 Cleaning

Immediately remove fresh sealant from adjacent areas using a solvent recommended by the sealant manufacturer. Upon completion of sealant application, remove remaining smears and stains and leave the work in a clean condition. Allow sealant time to cure, in accordance with manufacturer's recommendations, prior to coating.

3.4 SURFACE PREPARATION

Remove dirt, splinters, loose particles, grease, oil, disintegrated coatings, and other foreign matter and substances deleterious to coating performance as specified for each substrate before application of paint or surface treatments. Oil and grease shall be removed prior to mechanical cleaning. Cleaning shall be programmed so that dust and other contaminants will not fall on wet, newly painted surfaces. Exposed ferrous metals such as nail heads on or in contact with surfaces to be painted with water-thinned paints, shall be spot-primmed with a suitable corrosion-inhibitive primer capable of preventing flash rusting and compatible with the coating specified for the adjacent areas.

3.4.1 Additional Requirements for Preparation of Surfaces With Existing Coatings

Before application of coatings, perform the following on surfaces covered by soundly-adhered coatings, defined as those which cannot be removed with a putty knife:

a. Wipe previously painted surfaces to receive solvent-based coatings, except stucco and similarly rough surfaces clean with a clean, dry cloth saturated with mineral spirits, ASTM D 235. Allow surface to dry. Wiping shall immediately precede the application of the first coat of any coating, unless specified otherwise.

b. Sand existing glossy surfaces to be painted to reduce gloss. Brush, and wipe clean with a damp cloth to remove dust.

c. The requirements specified are minimum. Comply also with the application instructions of the paint manufacturer.

d. Previously painted surfaces specified to be repainted or damaged during construction shall be thoroughly cleaned of all grease, dirt, dust or other foreign matter.

e. Blistering, cracking, flaking and peeling or other deteriorated coatings shall be removed.

f. Chalk shall be removed so that when tested in accordance with ASTM D 4214, the chalk resistance rating is no less than 8.

g. Slick surfaces shall be roughened. Damaged areas such as, but not limited to, nail holes, cracks, chips, and spalls shall be repaired with suitable material to match adjacent undamaged areas.

h. Edges of chipped paint shall be feather edged and sanded smooth.

i. Rusty metal surfaces shall be cleaned as per SSPC requirements. Solvent, mechanical, or chemical cleaning methods shall be used to provide surfaces suitable for painting.

j. New, proposed coatings shall be compatible with existing coatings.

3.4.2 Existing Coated Surfaces with Minor Defects

Sand, spackle, and treat minor defects to render them smooth. Minor defects are defined as scratches, nicks, cracks, gouges, spalls, alligatoring, chalking, and irregularities due to partial peeling of previous coatings.

3.4.3 Removal of Existing Coatings

Remove existing coatings from the following surfaces:

a. Surfaces containing large areas of minor defects;

b. Surfaces containing more than 20 percent peeling area; and

c. Surfaces designated by the Contracting Officer, such as surfaces where rust shows through existing coatings.

3.4.4 Substrate Repair

a. Repair substrate surface damaged during coating removal;

b. Sand edges of adjacent soundly-adhered existing coatings so they are tapered as smooth as practical to areas involved with coating removal; and

c. Clean and prime the substrate as specified.

3.5 PREPARATION OF METAL SURFACES

3.5.1 Existing and New Ferrous Surfaces

a. Ferrous Surfaces including Shop-coated Surfaces and Small Areas That Contain Rust, Mill Scale and Other Foreign Substances: Solvent clean or detergent wash in accordance with SSPC SP 1 to remove oil and grease. Where shop coat is missing or damaged, clean according to SSPC SP 2, SSPC SP 3, SSPC SP 6, or SSPC SP 10. Brush-off blast remaining surface in accordance with SSPC SP 7. Water jetting to SSPC SP 12 WJ-4 may be used to remove loose coating and other loose materials. Use inhibitor as recommended by coating manufacturer to prevent premature rusting. Shop-coated ferrous surfaces shall be protected from corrosion by treating and touching up corroded areas immediately upon detection.

b. Surfaces With More Than 20 Percent Rust, Mill Scale, and Other Foreign Substances: Clean entire surface in accordance with SSPC SP 6/SSPC SP 12 WJ-3 or SSPC SP 10/SSPC SP 12 WJ-2.

c. Metal Floor Surfaces to Receive Nonslip Coating: Clean in accordance with SSPC SP 10 or SSPC SP 12 WJ-2.

3.5.2 Final Ferrous Surface Condition:

For tool cleaned surfaces, the requirements are stated in SSPC SP 2 and SSPC SP 3. As a visual reference, cleaned surfaces shall be similar to photographs in SSPC VIS 3.

For abrasive blast cleaned surfaces, the requirements are stated in SSPC SP 7, SSPC SP 6, and SSPC SP 10. As a visual reference, cleaned surfaces shall be similar to photographs in SSPC VIS 1.

For waterjet cleaned surfaces, the requirements are stated in SSPC SP 12. As a visual reference, cleaned surfaces shall be similar to photographs in SSPC VIS 4.

3.5.3 Galvanized Surfaces

a. New or Existing Galvanized Surfaces With Only Dirt and Zinc Oxidation Products: Clean with solvent, steam, or non-alkaline detergent solution in accordance with SSPC SP 1. If the galvanized metal has been passivated or stabilized, the coating shall be completely removed by brush-off abrasive blast. New galvanized steel to be coated shall not be "passivated" or "stabilized" If the absence of hexavalent stain inhibitors is not documented, test as described in ASTM D 2092, Appendix X2, and remove by one of the methods described therein.

b. Galvanized with Slight Coating Deterioration or with Little or No Rusting: Water jetting to SSPC SP 12 WJ3 to remove loose coating from surfaces with less than 20 percent coating deterioration and no blistering, peeling, or cracking. Use inhibitor as recommended by the coating manufacturer to prevent rusting.

c. Galvanized With Severe Deteriorated Coating or Severe Rusting: Spot abrasive blast rusted areas as described for steel in SSPC SP 6, and waterjet to SSPC SP 12, WJ3 to remove existing coating.]

3.5.4 Non-Ferrous Metallic Surfaces

Aluminum and aluminum-alloy, lead, copper, and other nonferrous metal surfaces.

a. Surface Cleaning: Solvent clean in accordance with SSPC SP 1 and wash with mild non-alkaline detergent to remove dirt and water soluble contaminants.

3.5.5 Terne-Coated Metal Surfaces

Solvent clean surfaces with mineral spirits, ASTM D 235. Wipe dry with clean, dry cloths.

3.5.6 Existing Surfaces with a Bituminous or Mastic-Type Coating Remove chalk, mildew, and other loose material by washing with a solution of 0.20 liter 1/2 cup trisodium phosphate, 0.1 liter 1/4 cup household detergent, 1.6 liters one quart 5 percent sodium hypochlorite solution and 4.8 liters 3 quarts of warm water.

3.6 PREPARATION OF CONCRETE AND CEMENTITIOUS SURFACE

3.6.1 Concrete and Masonry

a. Curing: Concrete, stucco and masonry surfaces shall be allowed to cure at least 30 days before painting, except concrete slab on grade, which shall be allowed to cure 90 days before painting.

b. Surface Cleaning: Remove the following deleterious substances.

(1) Dirt, Chalking, Grease, and Oil: Wash new and existing uncoated surfaces with a solution composed of 0.2 liter 1/2 cup trisodium phosphate, 0.1 liter 1/4 cuphousehold detergent, and 6.4 liters 4 quarts of warm water. Then rinse thoroughly with fresh water. Wash existing coated surfaces with a suitable detergent and rinse thoroughly. For large areas, water blasting may be used.

(2) Fungus and Mold: Wash new or existing coated, and existing uncoated surfaces with a solution composed of 0.2 liter 1/2 cup trisodium phosphate, 0.1 liter 1/4 cup household detergent, 1.6 liters 1 quart 5 percent sodium hypochlorite solution and 4.8 liters 3 quarts of warm water. Rinse thoroughly with fresh water.

(3) Paint and Loose Particles: Remove by wire brushing.

(4) Efflorescence: Remove by scraping or wire brushing followed by washing with a 5 to 10 percent by weight aqueous solution of hydrochloric (muriatic) acid. Do not allow acid to remain on the surface for more than five minutes before rinsing with fresh water. Do not acid clean more than 0.4 square meter 4 square feet of surface, per workman, at one time.

(5) Removal of Existing Coatings: For surfaces to receive textured coating MPI 42, remove existing coatings including soundly adhered coatings if recommended by textured coating manufacturer.

c. Cosmetic Repair of Minor Defects: Repair or fill mortar joints and minor defects, including but not limited to spalls, in accordance with manufacturer's recommendations and prior to coating application.

d. Allowable Moisture Content: Latex coatings may be applied to damp surfaces, but not to surfaces with droplets of water. Do not apply epoxies to damp vertical surfaces as determined by ASTM D 4263 or horizontal surfaces that exceed 3 lbs of moisture per 1000 square feet in 24 hours as determined by ASTM F 1869. In all cases follow manufacturers recommendations. Allow surfaces to cure a minimum of 30 days before painting.

3.6.2 Gypsum Board, Plaster, and Stucco

a. Surface Cleaning: Plaster and stucco shall be clean and free from loose matter; gypsum board shall be dry. Remove loose dirt and dust by brushing with a soft brush, rubbing with a dry cloth, or vacuum-cleaning prior to application of the first coat material. A damp cloth or sponge may be used if paint will be water-based.

b. Repair of Minor Defects: Prior to painting, repair joints, cracks, holes, surface irregularities, and other minor defects with patching plaster or spackling compound and sand smooth.

c. Allowable Moisture Content: Latex coatings may be applied to damp surfaces, but not surfaces with droplets of water. Do not apply epoxies to damp surfaces as determined by ASTM D 4263. New plaster to be coated shall have a maximum moisture content of 8 percent, when measured in accordance with ASTM D 4444, Method A, unless otherwise authorized. In addition to moisture content requirements, allow new plaster to age a minimum of 30 days before preparation for painting.

3.6.3 Existing Asbestos Cement Surfaces

Remove oily stains by solvent cleaning with mineral spirts, CID A-A-2904 or ASTM D 235. Remove loose dirt, dust, and other deleterious substances by brushing with a soft brush or rubbing with a dry cloth prior to application of the first coat material. Do not wire brush or clean using other abrasive methods. Surfaces shall be dry and clean prior to application of the coating.

3.7 PREPARATION OF WOOD AND PLYWOOD SURFACES

3.7.1 New, Existing Uncoated, and Existing Coated Plywood and Wood Surfaces, Except Floors:

a. Wood surfaces shall be cleaned of foreign matter. Surface Cleaning: Surfaces shall be free from dust and other deleterious substances and in a condition approved by the Contracting Officer prior to receiving paint or other finish. Do not use water to clean uncoated wood. Scrape to remove loose coatings. Lightly sand to roughen the entire area of previously enamel-coated wood surfaces.

b. Removal of Fungus and Mold: Wash existing coated surfaces with a solution composed of 0.2 liter 3 ounces (2/3 cup) trisodium phosphate, 0.1 liter 1 ounce (1/3 cup) household detergent, 1.6 liters 1 quart 5 percent sodium hypochlorite solution and 4.8 liters 3 quarts of warm water. Rinse thoroughly with fresh water.

c. Moisture content of the wood shall not exceed 12 percent as measured by a moisture meter in accordance with ASTM D 4444, Method A, unless otherwise authorized.

d. Wood surfaces adjacent to surfaces to receive water-thinned paints shall be primed and/or touched up before applying water-thinned paints.

e. Cracks and Nailheads: Set and putty stop nailheads and putty cracks after the prime coat has dried.

f. Cosmetic Repair of Minor Defects:

(1) Knots and Resinous Wood and Fire, Smoke, Water, and Color Marker Stained Existing Coated Surface: Prior to application of coating, cover knots and stains with two or more coats of 1.3-kg-cut (3-pound-cut) shellac varnish, plasticized with 0.14 liters (5 ounces) of castor oil per liter gallon. Scrape away existing coatings from knotty areas, and sand before treating. Prime before applying any putty over shellacked area.

(2) Open Joints and Other Openings: Fill with whiting putty, linseed oil putty. Sand smooth after putty has dried.

(3) Checking: Where checking of the wood is present, sand the surface, wipe and apply a coat of pigmented orange shellac. Allow to dry before paint is applied.

g. Prime Coat For New Exterior Surfaces: Prime coat wood doors, windows, frames, and trim before wood becomes dirty, warped, or weathered.

3.7.2 Wood Floor Surfaces, Natural Finish

a. Initial Surface Cleaning: As specified in paragraph entitled "Surface Preparation."

b. Existing Loose Boards and Shoe Molding: Before sanding, renail loose boards. Countersink nails and fill with an approved wood filler. Remove shoe molding before sanding and reinstall after completing other work. At Contractor's option, new shoe molding may be provided in lieu of reinstalling old. New wood molding shall be same size, wood species, and finish as the existing.

c. Sanding and Scraping: Sanding of wood floors is specified in Section 09640 WOOD STRIP FLOORING. Floors of oak or similar open-grain wood shall be filled with wood filler recommended by the finish manufacturer and the excess filler removed.

d. Final Cleaning: After sanding, sweep and vacuum floors clean. Do not walk on floors thereafter until specified sealer has been applied and is dry.

3.7.3 Interior Wood Surfaces, Stain Finish

Interior wood surfaces to receive stain shall be sanded. Oak and other open-grain wood to receive stain shall be given a coat of wood filler not less than 8 hours before the application of stain; excess filler shall be removed and the surface sanded smooth.

3.8 APPLICATION

3.8.1 Coating Application

Painting practices shall comply with applicable federal, state and local laws enacted to insure compliance with Federal Clean Air Standards. Apply coating materials in accordance with SSPC PA 1. SSPC PA 1 methods are applicable to all substrates, except as modified herein. At the time of application, paint shall show no signs of deterioration. Uniform suspension of pigments shall be maintained during application. Unless otherwise specified or recommended by the paint manufacturer, paint may be applied by brush, roller, or spray. Rollers for applying paints and enamels shall be of a type designed for the coating to be applied and the surface to be coated. Paints, except water-thinned types, shall be applied only to surfaces that are completely free of moisture as determined by sight or touch. Thoroughly work coating materials into joints, crevices, and open spaces. Special attention shall be given to insure that all edges, corners, crevices, welds, and rivets receive a film thickness equal to that of adjacent painted surfaces. Each coat of paint shall be applied so dry film shall be of uniform thickness and free from runs, drops, ridges, waves, pinholes or other voids, laps, brush marks, and variations in color, texture, and finish. Hiding shall be complete. Touch up damaged coatings before applying subsequent coats. Interior areas shall be broom clean and dust free before and during the application of coating material. Apply paint to new fire extinguishing sprinkler systems including valves, piping, conduit, hangers, supports, miscellaneous metal work, and accessories. Shield sprinkler heads with protective coverings while painting is in progress. Remove sprinkler heads which have been painted and replace with new sprinkler heads. For piping in unfinished spaces, provide primed surfaces with one coat of red alkyd gloss enamel to a minimum dry film thickness of 0.025 mm (1.0 mil). Unfinished spaces include attic spaces, spaces above suspended ceilings, crawl spaces, pipe chases, mechanical equipment room, and space where walls or ceiling are not painted or not constructed of a prefinished material. For piping in finished areas, provide prime surfaces with two coats of paint to match adjacent surfaces, except provide valves and operating accessories with one coat of red alkyd gloss enamel. Upon completion of painting, remove protective covering from sprinkler heads.

a. Drying Time: Allow time between coats, as recommended by the coating manufacturer, to permit thorough drying, but not to present topcoat adhesion problems. Provide each coat in specified condition to receive next coat.

b. Primers, and Intermediate Coats: Do not allow primers or intermediate coats to dry more than 30 days, or longer than recommended by manufacturer, before applying subsequent coats. Follow manufacturer's recommendations for surface preparation if primers or intermediate coats are allowed to dry longer than recommended by manufacturers of subsequent coatings. Each coat shall cover surface of preceding coat or surface completely, and there shall be a visually perceptible difference in shades of successive coats.

c. Finished Surfaces: Provide finished surfaces free from runs, drops, ridges, waves, laps, brush marks, and variations in colors.

d. Thermosetting Paints: Topcoats over thermosetting paints (epoxies and urethanes) should be applied within the overcoating window recommended by the manufacturer.

e. Floors: For nonslip surfacing on level floors, as the intermediate coat is applied, cover wet surface completely with almandite garnet, Grit No. 36, with maximum passing U.S. Standard Sieve No. 40 less than 0.5 percent. When the coating is dry, use a soft bristle broom to sweep up excess grit, which may be reused, and vacuum up remaining residue before application of the topcoat. For nonslip surfacing on ramps, provide MPI 77 with non-skid additive, applied by roller in accordance with manufacturer's instructions.]

3.8.2 Mixing and Thinning of Paints

Reduce paints to proper consistency by adding fresh paint, except when thinning is mandatory to suit surface, temperature, weather conditions, application methods, or for the type of paint being used. Obtain written permission from the Contracting Officer to use thinners. The written permission shall include quantities and types of thinners to use. When thinning is allowed, paints shall be thinned immediately prior to application with not more than 0.125 L (1 pint) of suitable thinner per liter (gallon). The use of thinner shall not relieve the Contractor from obtaining complete hiding, full film thickness, or required gloss. Thinning shall not cause the paint to exceed limits on volatile organic compounds. Paints of different manufacturers shall not be mixed.

3.8.3 Two-Component Systems

Two-component systems shall be mixed in accordance with manufacturer's instructions. Any thinning of the first coat to ensure proper penetration and sealing shall be as recommended by the manufacturer for each type of substrate.

3.8.4 Coating Systems

a. Systems by Substrates: Apply coatings that conform to the respective specifications listed in the following Tables:

Table

Division 3. Exterior Concrete Paint Table
Division 4. Exterior Concrete Masonry Units Paint Table
Division 5. Exterior Metal, Ferrous and Non-Ferrous Paint Table
Division 6. Exterior Wood, Dressed Lumber, Paneling, Decking, Shingles Paint Table
Division 9: Exterior Stucco Paint Table
Division 10. Exterior Cloth Coverings and Bituminous Coated Surfaces Paint Table

Division 3. Interior Concrete Paint Table
Division 4. Interior Concrete Masonry Units Paint Table
Division 5. Interior Metal, Ferrous and Non-Ferrous Paint Table
Division 6. Interior Wood Paint Table
Division 9: Interior Plaster, Gypsum Board, Textured Surfaces Paint Table

b. Minimum Dry Film Thickness (DFT): Apply paints, primers, varnishes, enamels, undercoats, and other coatings to a minimum dry film thickness of 0.038 mm (1.5 mil) each coat unless specified otherwise in the Tables. Coating thickness where specified, refers to the minimum dry film thickness.

c. Coatings for Surfaces Not Specified Otherwise: Coat surfaces which have not been specified, the same as surfaces having similar conditions of exposure.

d. Existing Surfaces Damaged During Performance of the Work, Including New Patches In Existing Surfaces: Coat surfaces with the following:

(1) One coat of primer.

(2) One coat of undercoat or intermediate coat.

(3) One topcoat to match adjacent surfaces.

e. Existing Coated Surfaces To Be Painted: Apply coatings conforming to the respective specifications listed in the Tables herein, except that pretreatments, sealers and fillers need not be provided on surfaces where existing coatings are soundly adhered and in good condition. Do not omit undercoats or primers.

3.9 COATING SYSTEMS FOR METAL

Apply coatings of Tables in Division 5 for Exterior and Interior.

a. Apply specified ferrous metal primer on the same day that surface is cleaned, to surfaces that meet all specified surface preparation requirements at time of application.

b. Inaccessible Surfaces: Prior to erection, use one coat of specified primer on metal surfaces that will be inaccessible after erection.

c. Shop-primed Surfaces: Touch up exposed substrates and damaged coatings to protect from rusting prior to applying field primer.

d. Surface Previously Coated with Epoxy or Urethane: Apply MPI 101, 0.038 mm (1.5 mils) DFT immediately prior to application of epoxy or urethane coatings.

e. Pipes and Tubing: The semitransparent film applied to some pipes and tubing at the mill is not to be considered a shop coat, but shall be overcoated with the specified ferrous-metal primer prior to application of finish coats.

f. Exposed Nails, Screws, Fasteners, and Miscellaneous Ferrous Surfaces. On surfaces to be coated with water thinned coatings, spot prime exposed nails and other ferrous metal with latex primer MPI 107.

3.10 COATING SYSTEMS FOR CONCRETE AND CEMENTITIOUS SUBSTRATES

Apply coatings of Tables in Division 3, 4 and 9 for Exterior and Interior.

3.11 COATING SYSTEMS FOR WOOD AND PLYWOOD

a. Apply coatings of Tables in Division 6 for Exterior and Interior.

b. Prior to erection, apply two coats of specified primer to treat and prime wood and plywood surfaces which will be inaccessible after erection.

c. Apply stains in accordance with manufacturer's printed instructions.

d. Wood Floors to Receive Natural Finish: Thin first coat 2 to 1 using thinner recommended by coating manufacturer. Apply all coatings at rate of 30 square meters per 4 liters (300 to 350 square feet per gallon). Apply second coat not less than 2 hours and not over 24 hours after first coat has been applied. Apply with lambs wool applicators or roller as recommended by coating manufacturer. Buff or lightly sand between intermediate coats as recommended by coating manufacturer's printed instructions.

3.12 PIPING IDENTIFICATION

Piping Identification, Including Surfaces In Concealed Spaces: Provide in accordance with MIL-STD-101 or ANSI A13.1. Place stenciling in clearly visible locations. On piping not covered by MIL-STD-101 or ANSI A13.1, stencil approved names or code letters, in letters a minimum of 13 mm (1/2 Inch) high for piping and a minimum of 50 mm (2 inches) high elsewhere. Stencil arrow-shaped markings on piping to indicate direction of flow using black stencil paint.

3.13 INSPECTION AND ACCEPTANCE

In addition to meeting previously specified requirements, demonstrate mobility of moving components, including swinging and sliding doors cabinets, and windows with operable sash, for inspection by the Contracting Officer. Perform this demonstration after appropriate curing and drying times of coatings have elapsed and prior to invoicing for final payment.

3.14 PAINT TABLES

All DFT's are minimum values.

3.14.1 EXTERIOR PAINT TABLES

DIVISION 3: EXTERIOR CONCRETE PAINT TABLE

A. New and uncoated existing and Existing, previously painted concrete; vertical surfaces, including undersides of balconies and soffits but excluding tops of slabs:

1. Latex
   New; MPI EXT 3.1A-G2 (Flat) / Existing; MPI REX 3.1A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 10	MPI 10	MPI 10

   System DFT: 3.5 mils (88 microns)

   New; MPI EXT 3.1A-G5 (Semigloss) / Existing; MPI EXT 3.1A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 11	MPI 11	MPI 11

   System DFT: 3.5 mils (88 microns)

   New; MPI EXT 3.1A-G6 (Gloss) / Existing; MPI REX 3.1A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 119	MPI 119	MPI 119

System DFT: 3.5 mils (88 microns)

Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces.

B. New and uncoated existing and Existing, previously painted concrete, textured system; vertical surfaces, including undersides of balconies and soffits but excluding tops of slabs:

1. Latex Aggregate
New; MPI EXT 3.1B-G2 (Flat) / Existing; MPI REX 3.1B-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 10	MPI 10

System DFT: Per Manufacturer

New; MPI EXT 3.1B-G5 (Semigloss) / Existing; MPI REX 3.1B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 11	MPI 11

System DFT: Per Manufacturer

New; MPI EXT 3.1B-G6 (Gloss) / Existing; MPI REX 3.1B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 119	MPI 119

System DFT: Per Manufacturer

Texture ? Fine, Medium or Coarse. Surface preparation and number of coats in accordance with manufacturer's instructions. Topcoat: Coating to match adjacent surfaces.

C. New and uncoated existing and Existing, previously painted] concrete, elastomeric System; vertical surfaces, including undersides of balconies and soffits but excluding tops of slabs:

1. Elastomeric Coating
New; MPI EXT 3.1F / Existing; MPI REX 3.1F

Primer:	Intermediate:	Topcoat:
Per Manufacturer	MPI 113	MPI 113

System DFT: 16 mils (400 microns)

Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces. Surface preparation and number of coats in accordance with manufacturer's instructions.

NOTE: Apply sufficient coats of MPI 113 to achieve a minimum dry film thickness of 16 mils (400 microns).

D. New and uncoated existing and Existing, previously painted concrete: walls and bottom of swimming pools.

1. Chlorinated Rubber
New; / Existing;

Primer:	Intermediate:	Topcoat:
SSPC Paint 18	SSPC Paint 18	SSPC Paint 18

System DFT: Per Manufacturer

NOTE: Thin first coat (primer) with 1 part of approved thinner to 4 parts of paint by volume.

E. New and Existing Cementitious composition board (including Asbestos cement board):

1. Latex
New; MPI EXT 3.3A-G1 (Flat) /Existing; MPI REX 3.3A-G1 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 10	MPI 10	MPI 10

System DFT: 4.5 mils (112 microns)

New; MPI EXT 3.3A-G5 (Semigloss) / Existing; MPI REX 3.3A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 11	MPI 11	MPI 11

System DFT: 4.5 mils (112 microns)

New; MPI EXT 3.3A-G6 (Gloss) / Existing; MPI REX 3.3A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 119	MPI 119	MPI 119

System DFT: 4.5 mils (112 microns)

Topcoat: Coating to match adjacent surfaces.

DIVISION 4: EXTERIOR CONCRETE MASONRY UNITS PAINT TABLE

A. New and Existing concrete masonry on uncoated surface:

1. Latex
New; MPI EXT 4.2A-G1 (Flat) / Existing; MPI REX 4.2A-G1 (Flat)

Block Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 10	MPI 10

System DFT: 11 mils (275 microns)

New; MPI EXT 4.2A-G5 (Semigloss) / Existing; MPI REX 4.2A-G5 (Semigloss)

Block Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 11	MPI 11

System DFT: 11 mils (275 microns)

New; MPI EXT 4.2A-G6 (Gloss) / Existing; MPI REX 4.2A-G6 (Gloss)

Block Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 119	MPI 119

System DFT: 11 mils (275 microns)

Topcoat: Coating to match adjacent surfaces.

B. New and Existing concrete masonry, textured system; on uncoated surfaces:

1. Latex Aggregate
New; MPI EXT 4.2B-G1 (Flat) / Existing; MPI REX 4.2B-G1 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 42	MPI 10

System DFT: Per Manufacturer

New; MPI EXT 4.2B-G5 (Semigloss) / Existing; MPI REX 4.2B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 42	MPI 11

System DFT: Per Manufacturer

New; MPI EXT 4.2B-G6 (Gloss) / Existing; MPI REX 4.2B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 42	MPI 42	MPI 119

System DFT: Per Manufacturer

Texture ? Fine, Medium or Coarse. Surface preparation and number of coats in accordance with manufacturer's instructions. Topcoat: Coating to match adjacent surfaces.

C. New and Existing concrete masonry, elastomeric system; on uncoated surface:

1. Elastomeric Coating

New; MPI EXT 4.2D / Existing; MPI REX 4.2D

Primer:	Intermediate:	Topcoat:
Per Manufacturer	MPI 113	MPI 113

System DFT: 16 mils (400 microns)

Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces. Surface preparation and number of coats in accordance with manufacturer's instructions.

NOTE: Apply sufficient coats of MPI 113 to achieve a minimum dry film thickness of 16 mils (400 microns).

DIVISION 5: EXTERIOR METAL, FERROUS AND NON-FERROUS PAINT TABLE STEEL / FERROUS SURFACES

STEEL/FERROUS SURFACES

A. New Steel that has been hand or power tool cleaned to SSPC SP 2 or STEEL / FERROUS SURFACES SSPC SP 3

1. Alkyd

New; MPI EXT 5.1Q-G5 (Semigloss) Existing; MPI REX 5.1D-G5

Primer:	Intermediate:	Topcoat:
MPI 23	MPI 94	MPI 94

System DFT: 5.25 mils (131 microns)

New; MPI EXT 5.1Q-G6 (Gloss) / Existing; MPI REX 5.1D-G6

Primer:	Intermediate:	Topcoat:
MPI 23	MPI 9	MPI 9

System DFT: 5.25 mils (131 microns)

B. New Steel that has been blast-cleaned to SSPC SP 6:

2. Alkyd
New; MPI EXT 5.1D-G5 (Semigloss) / Existing; MPI REX 5.1D-G5

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 94	MPI 94

System DFT: 5.25 mils (131 microns)

New; MPI EXT 5.1D-G6 (Gloss) / Existing; MPI REX 5.1D-G6

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 9	MPI 9

System DFT: 5.25 mils (131 microns)

C. Existing steel that has been spot-blasted to SSPC SP 6:

1. Surface previously coated with alkyd or latex:

Waterborne Light Industrial Coating
MPI REX 5.1C-G5 (Semigloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 79	MPI 110-G5	MPI 110-G5

System DFT: 5 mils (125 microns)

MPI REX 5.1C-G6 (Gloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 79	MPI 110-G6	MPI 110-G6

System DFT: 5 mils (125 microns)

2. Surface previously coated with epoxy:

Waterborne Light Industrial
a. MPI REX 5.1L-G5 (Semigloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 101	MPI 110-G5	MPI 110-G5

System DFT: 5 mils (125 microns)

MPI REX 5.1L-G6 (Gloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 101	MPI 110-G6	MPI 110-G6

System DFT: 5 mils (125 microns)

Pigmented Polyurethane
b. MPI REX 5.1H-G6 (Gloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 101	MPI 108	MPI 72

System DFT: 8.5 mils (212 microns)

D. New and existing steel blast cleaned to SSPC SP 10:

1. Waterborne Light Industrial
MPI EXT 5.1R-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 108	MPI 110-G5

System DFT: 8.5 mils (212 microns)

MPI EXT 5.1R-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 101 MPI 108 MPI 110-G6
System DFT: 8.5 mils (212 microns)

2. Pigmented Polyurethane
MPI EXT 5.1J-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 101 MPI 108 MPI 72
System DFT: 8.5 mils (212 microns)

E. Metal floors (non-shop-primed surfaces or non-slip deck surfaces) with non-skid additive (NSA), load at manufacturer's recommendations.:

1. Alkyd Floor Enamel
MPI EXT 5.1S-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 79 MPI 27 MPI 27 (+NSA)
System DFT: 5.25 mils (131 microns)

EXTERIOR GALVANIZED SURFACES

F. New Galvanized surfaces:

1. Cementitious primer / Latex
MPI EXT 5.3A-G1 (Flat)
Primer: Intermediate: Topcoat:
MPI 26 MPI 10 MPI 10
System DFT: 4.5 mils (112 microns)

MPI EXT 5.3A-G5 (Semigloss)
Primer: Intermediate: Topcoat:
MPI 26 MPI 11 MPI 11
System DFT: 4.5 mils (112 microns)

MPI EXT 5.3A-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 26 MPI 119 MPI 119
System DFT: 4.5 mils (112 microns)

2. Waterborne Primer / Latex
MPI EXT 5.3H-G1 (Flat)
Primer: Intermediate: Topcoat:
MPI 134 MPI 10 MPI 10
System DFT: 4.5 mils (112 microns)

MPI EXT 5.3H-G5 (Semigloss)
Primer: Intermediate: Topcoat:
MPI 134 MPI 11 MPI 11
System DFT: 4.5 mils (112 microns)

MPI EXT 5.3H-G6 (Gloss)
Primer: Intermediate: Topcoat:
MPI 134 MPI 119 MPI 119
System DFT: 4.5 mils (112 microns)

3. Waterborne Primer / Waterborne Light Industrial Coating
   MPI EXT 5.3J-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 134	MPI 110-G5	MPI 110-G5

   System DFT: 4.5 mils (112 microns)

   MPI EXT 5.3J-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 134	MPI 110-G6	MPI 110-G6

   System DFT: 4.5 mils (112 microns)

4. Epoxy Primer / Waterborne Light Industrial Coating
   MPI EXT 5.3K-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 110-G5	MPI 110-G5

   System DFT: 5 mils (125 microns)

   MPI EXT 5.3K-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 110-G6	MPI 110-G6

   System DFT: 5 mils (125 microns)

5. Pigmented Polyurethane
   MPI EXT 5.3L-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 101	N/A	MPI 72

   System DFT: 5 mils (125 microns)

G. Galvanized surfaces with slight coating deterioration; little or no rusting:

1. Waterborne Light Industrial Coating
   MPI REX 5.3J-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 134	N/A	MPI 110-G5

   System DFT: 4.5 mils (112 microns)

2. Pigmented Polyurethane
   MPI REX 5.3D-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 101	N/A	MPI 72

   System DFT: 5 mils (125 microns)

H. Galvanized surfaces with severely deteriorated coating or rusting:

1. Waterborne Light Industrial Coating
   MPI REX 5.3L-G5(Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 108	MPI 110-G5

   System DFT: 8.5 mils (212 microns)

   MPI REX 5.3L-G6(Gloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 108	MPI 110-G6

   System DFT: 8.5 mils (212 microns)

2. Pigmented Polyurethane
   MPI REX 5.3K-G6(Gloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 108	MPI 72

   System DFT: 5 mils (125 microns)

EXTERIOR SURFACES, OTHER METALS (NON-FERROUS)

I. Aluminum, aluminum alloy and other miscellaneous non-ferrous metal items not otherwise specified except hot metal surfaces, roof surfaces, and new prefinished equipment. Match surrounding finish:

1. Alkyd
   MPI EXT 5.4F-G1 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 8	MPI 8

   System DFT: 5 mils (125 microns)

   MPI EXT 5.4F-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 94	MPI 94

   System DFT: 5 mils (125 microns)

   MPI EXT 5.4F-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 9	MPI 9

   System DFT: 5 mils (125 microns)

2. Waterborne Light Industrial Coating
   MPI EXT 5.4G-G3(Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 110-G3	MPI 110-G3

   System DFT: 5 mils (125 microns)

   MPI EXT 5.4G-G5(Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 110-G5	MPI 110-G5

   System DFT: 5 mils (125 microns)

   MPI EXT 5.4G-G6(Gloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 110-G6	MPI 110-G6

   System DFT: 5 mils (125 microns)

J. Existing roof surfaces previously coated:

1. Aluminum Pigmented Asphalt Roof Coating
   ASTM D 2824: Sufficient coats to provide not less than 200 microns (8 mils) of finished coating system (without asbestos fibers).

2. Aluminum Paint
   MPI REX 10.2D

Primer:	Intermediate:	Topcoat:
MPI 107	MPI 1	MPI 1

   System DFT: 3.5 mils (88 microns)

K. Surfaces adjacent to painted surfaces; Mechanical, Electrical, Fire extinguishing sprinkler systems including valves, conduit, hangers, supports, exposed copper piping and miscellaneous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment. Match surrounding finish:

1. Alkyd

   MPI EXT 5.1D-G1 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 8	MPI 8

   System DFT: 5.25 mils (131 microns)

   MPI EXT 5.1D-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 94	MPI 94

   System DFT: 5.25 mils (131 microns)

   MPI EXT 5.1D-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 9	MPI 9

   System DFT: 5.25 mils (131 microns)

2. Waterborne Light Industrial Coating

   MPI EXT 5.1C-G3(Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 110-G3	MPI 110-G3

   System DFT: 5 mils (125 microns)

   MPI EXT 5.1C-G5(Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 110-G5	MPI 110-G5

   System DFT: 5 mils (125 microns)

   MPI EXT 5.1C-G6(Gloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 110-G6	MPI 110-G6

   System DFT: 5 mils (125 microns)

L. Hot metal surfaces including smokestacks subject to temperatures up to 205 degrees C (400 degrees F):

1. Heat Resistant Enamel

   MPI EXT 5.2A

   Primer: Intermediate: Topcoat:

   MPI 21 Surface preparation and number of coats per manufacturer's instructions.

   System DFT: Per Manufacturer

M. Ferrous metal subject to high temperature, up to 400 degrees C (750 degrees F):

1. Inorganic Zinc Rich Coating

   MPI EXT 5.2C

   Primer: Intermediate: Topcoat:

   MPI 19 Surface preparation and number of coats per

manufacturer's instructions.
System DFT: Per Manufacturer

2. Heat Resistant Aluminum Enamel
MPI EXT 5.2B (Aluminum Finish)
Primer: Intermediate: Topcoat:
MPI 2 Surface preparation and number of coats per manufacturer's instructions.
System DFT: Per Manufacturer

N. New surfaces and Existing surfaces made bare cleaning to SSPC SP 10 subject to temperatures up to 593 degrees C (1100 degrees F):

1. Heat Resistant Coating
MPI EXT 5.2D
Primer: Intermediate: Topcoat:
MPI 22 Surface preparation and number of coats per manufacturer's instructions.
System DFT: Per Manufacturer

DIVISION 6: EXTERIOR WOOD; DRESSED LUMBER, PANELING, DECKING, SHINGLES PAINT TABLE

A. New and Existing, uncoated Dressed lumber, Wood and plywood, trim, including top, bottom and edges of doors not otherwise specified:

1. Alkyd

MPI EXT 6.3B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 7	MPI 94	MPI 94

System DFT: 5 mils (125 microns)

MPI EXT 6.3B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 7	MPI 9	MPI 9

System DFT: 5 mils (125 microns)

2. Latex

MPI EXT 6.3A-G1 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 7	MPI 10	MPI 10

System DFT: 5 mils (125 microns)

MPI EXT 6.3A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 7	MPI 11	MPI 11

System DFT: 5 mils (125 microns)

MPI EXT 6.3A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 7	MPI 119	MPI 119

System DFT: 5 mils (125 microns)

3. Waterborne Solid Color Stain
   MPI EXT 6.3K
   Primer: MPI 7 | Intermediate: MPI 16 | Topcoat: MPI 16
   System DFT: 4.25 mils (106 microns)

B. Existing, dressed lumber, Wood and plywood, trim, including top, bottom and edges of doors previously coated with an alkyd / oil based finish coat not otherwise specified:

1. Alkyd
   MPI REX 6.3B-G5 (Semigloss)
   Primer: MPI 5 | Intermediate: MPI 94 | Topcoat: MPI 94
   System DFT: 5 mils (125 microns)

   MPI REX 6.3B-G6 (Gloss)
   Primer: MPI 5 | Intermediate: MPI 9 | Topcoat: MPI 9
   System DFT: 5 mils (125 microns)

2. Latex
   MPI REX 6.3A-G1 (Flat)
   Primer: MPI 5 | Intermediate: MPI 10 | Topcoat: MPI 10
   System DFT: 5 mils (125 microns)

   MPI REX 6.3A-G5 (Semigloss)
   Primer: MPI 5 | Intermediate: MPI 11 | Topcoat: MPI 11
   System DFT: 5 mils (125 microns)

   MPI REX 6.3A-G6 (Gloss)
   Primer: MPI 5 | Intermediate: MPI 119 | Topcoat: MPI 119
   System DFT: 5 mils (125 microns)

C. Existing, dressed lumber, Wood and plywood, trim, including top, bottom and edges of doors previously coated with a latex / waterborne finish coat not otherwise specified:

1. Latex
   MPI REX 6.3L-G1 (Flat)
   Spot Primer: MPI 6 | Intermediate: MPI 10 | Topcoat: MPI 10
   System DFT: 4.5 mils (112 microns)

   MPI REX 6.3L-G5 (Semigloss)
   Spot Primer: MPI 6 | Intermediate: MPI 11 | Topcoat: MPI 11
   System DFT: 4.5 mils (112 microns)

   MPI REX 6.3L-G6 (Gloss)
   Spot Primer: MPI 6 | Intermediate: MPI 119 | Topcoat: MPI 119
   System DFT: 4.5 mils (112 microns)

2. Waterborne Solid Color Stain
   MPI REX 6.3K (Stain)

Spot Primer:	Intermediate:	Topcoat:
MPI 6	MPI 16	MPI 16

   System DFT: 4 mils (100 microns)

D. New, Uncoated wood siding:

1. Semi-Transparent Stain
   MPI EXT 6.3D

Spot Primer:	Intermediate:	Topcoat:
N/A	MPI 13	MPI 13

   System DFT: N/A

E. Existing, previously stained wood siding:

1. Latex
   MPI REX 6.2K-G1 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 5	MPI 10	MPI 10

   System DFT: 4.5 mils (112 microns)

   MPI REX 6.2K-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 5	MPI 11	MPI 11

   System DFT: 4.5 mils (112 microns)

F. Existing Uncoated or previously semitransparent stained wood siding:

1. Semi-Transparent Stain
   MPI REX 6.3D

Spot Primer:	Intermediate:	Topcoat:
N/A	MPI 13	MPI 13

   System DFT: Per Manufacturer

G. Wood: Steps, platforms, floors of open porches with non-skid additive (NSA), load at manufacturer's recommendations.:

1. Latex Floor Paint
   MPI EXT 6.5A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 5	MPI 60 (+NSA)	MPI 60 (+NSA)

   System DFT: 4.5 mils (112 microns)

   MPI EXT 6.5A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 5	MPI 68 (+NSA)	MPI 68 (+NSA)

   System DFT: 4.5 mils (112 microns)

2. Alkyd Floor Paint
   MPI EXT 6.5B-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 59	MPI 59 (+NSA)	MPI 59 (+NSA)

   System DFT: 5 mils (125 microns)

MPI EXT 6.5B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 27	MPI 27 (+NSA)	MPI 27 (+NSA)

System DFT: 5 mils (125 microns)

DIVISION 9: EXTERIOR STUCCO PAINT TABLE

A. New and Existing stucco:

1. Latex

New; MPI EXT 9.1A-G1 (Flat) / Existing; MPI REX 9.1A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 10	MPI 10	MPI 10

System DFT: 4.5 mils (112 microns)

New; MPI EXT 9.1A-G5 (Semigloss) / Existing; MPI REX 9.1A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 11	MPI 11	MPI 11

System DFT: 4.5 mils (112 microns)

New; MPI EXT 9.1A-G6 (Gloss) / Existing; MPI REX 9.1A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 119	MPI 119	MPI 119

System DFT: 4.5 mils (112 microns)

Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces. On existing stucco, apply primer based on surface condition.

B. New and Existing stucco, elastomeric system:

1. Elastomeric Coating

New; MPI EXT 9.1c / Existing; MPI REX 9.1C

Primer:	Intermediate:	Topcoat:
N/A	MPI 113	MPI 113

System DFT: 16 mils (400 microns)

Primer as recommended by manufacturer. Topcoat: Coating to match adjacent surfaces. Surface preparation and # of coats in accordance with manufacturer's instructions.

NOTE: Apply sufficient coats of MPI 113 to achieve a minimum dry film thickness of 16 mils 400 microns.

DIVISION 10: EXTERIOR CLOTH COVERINGS AND BITUMINOUS COATED SURFACES PAINT TABLE

A. Insulation and surfaces of insulation coverings (canvas, cloth, paper): (Interior and Exterior Applications)

1. Latex

MPI EXT 10.1A-G1 (Flat)

Primer:	Intermediate:	Topcoat:
N/A	MPI 10	MPI 10

System DFT: 3.2 mils (80 microns)

MPI EXT 10.1A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
N/A	MPI 11	MPI 11

System DFT: 3.2 mils (80 microns)

MPI EXT 10.1A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
N/A	MPI 119	MPI 119

System DFT: 3.2 mils (80 microns)

Topcoat: Coating to match adjacent surfaces.

3.14.2 INTERIOR PAINT TABLES

DIVISION 3: INTERIOR CONCRETE PAINT TABLE

A. New and uncoated existing and Existing, previously painted Concrete, vertical surfaces, not specified otherwise:

1. Latex

New; MPI INT 3.1A-G2 (Flat) / Existing; MPI RIN 3.1A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 44	MPI 44

System DFT: 4 mils (100 microns)

New; MPI INT 3.1A-G3 (Eggshell) / Existing; MPI RIN 3.1A-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 52	MPI 52

System DFT: 4 mils (100 microns)

New; MPI INT 3.1A-G5 (Semigloss) / Existing; MPI RIN 3.1A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 54	MPI 54

System DFT: 4 mils (100 microns)

2. High Performance Architectural Latex

New; MPI INT 3.1C-G2 (Flat) / Existing; MPI RIN 3.1J-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 138	MPI 138

System DFT: 4 mils (100 microns)

New; MPI INT 3.1C-G3 (Eggshell) / Existing; MPI RIN 3.1J-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 139	MPI 139

System DFT: 4 mils (100 microns)

New; MPI INT 3.1C-G4 (satin)/ Existing; MPI RIN 3.1J-G4

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 140	MPI 140

System DFT: 4 mils (100 microns)

New; MPI INT 3.1C-G5 (Semigloss) / Existing; MPI RIN 3.1J-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 141	MPI 141

System DFT: 4 mils (100 microns)

3. Institutional Low Odor / Low VOC Latex

New; MPI INT 3.1M-G2 (Flat) / Existing; MPI RIN 3.1L-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 144	MPI 144

System DFT: 4 mils (100 microns)

New; MPI INT 3.1M-G3 (Eggshell) / Existing; MPI RIN 3.1L-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 145	MPI 145

System DFT: 4 mils (100 microns)

New; MPI INT 3.1M-G4 (satin)/ Existing; MPI RIN 3.1L-G4

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 146	MPI 146

System DFT: 4 mils (100 microns)

New; MPI INT 3.1M-G5 (Semigloss) / Existing; MPI RIN 3.1L-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 147	MPI 147

System DFT: 4 mils (100 microns)

B. Concrete ceilings, uncoated:

1. Latex Aggregate

MPI INT 3.1N

Primer:	Intermediate:	Topcoat:
N/A	N/A	MPI 42

System DFT: Per Manufacturer

Texture ? Fine, Medium or Coarse. Surface preparation, number of coats, and primer in accordance with manufacturer's instructions.
Topcoat: Coating to match adjacent surfaces.]

C. New and uncoated existing and Existing, previously painted Concrete in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation and other high-humidity areas not otherwise specified except floors:

1. Waterborne Light Industrial Coating

New; MPI INT 3.1L-G3(Eggshell) / Existing; MPI RIN 3.1C-G3(Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 110-G3	MPI 110-G3	MPI 110-G3

System DFT: 4.8 mils (120 microns)

New; MPI INT 3.1L-G5(Semigloss) / Existing; MPI RIN 3.1C-G5(Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 110-G5	MPI 110-G5	MPI 110-G5

System DFT: 4.8 mils (120 microns)

New; MPI INT 3.1L-G6(Gloss) / Existing; MPI RIN 3.1C-G6(Gloss)

Primer:	Intermediate:	Topcoat:
MPI 110-G6	MPI 110-G6	MPI 110-G6

System DFT: 4.8 mils (120 microns)

2. Alkyd

New; MPI INT 3.1D-G3 (Eggshell) / Existing; RIN 3.1D-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 51	MPI 51

System DFT: 4.5 mils (112 microns)

MPI INT 3.1D-G5 (Semigloss) / Existing; RIN 3.1D-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 47	MPI 47

System DFT: 4.5 mils (112 microns)

MPI INT 3.1D-G6 (Gloss) / Existing; RIN 3.1D-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 48	MPI 48

System DFT: 4.5 mils (112 microns)

3. Epoxy

New; MPI INT 3.1F-G6 (Gloss) / Existing; MPI RIN 3.1E-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 77	MPI 77	MPI 77

System DFT: 4 mils (100 microns)

Note: Primer may be reduced for penetration per manufacturer's instructions.]

D. New and uncoated existing and Existing, previously painted concrete walls and bottom of swimming pools:

1. Chlorinated Rubber

Primer:	Intermediate:	Topcoat:
SSPC Paint 18	SSPC Paint 18	SSPC Paint 18

System DFT: Per Manufacturer

Note: Primer may be reduced for penetration per manufacturer's instructions.]

2. Epoxy

New; MPI INT 3.1F / Existing; MPI RIN 3.1E

Primer:	Intermediate:	Topcoat:
MPI 77	MPI 77	MPI 77

System DFT: 4 mils (100 microns)

Note: Primer may be reduced for penetration per manufacturer's instructions.

DIVISION 4: INTERIOR CONCRETE MASONRY UNITS PAINT TABLE

A. New and uncoated Existing Concrete masonry:

1. High Performance Architectural Latex

MPI INT 4.2D-G2 (Flat)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 138	MPI 138

System DFT: 11 mils (275 microns)

MPI INT 4.2D-G3 (Eggshell)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 139	MPI 139

System DFT: 11 mils (275 microns)

MPI INT 4.2D-G4 (Satin)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 140	MPI 140

System DFT: 11 mils (275 microns)

MPI INT 4.2D-G5 (Semigloss)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 141	MPI 141

System DFT: 11 mils (275 microns)

Fill all holes in masonry surface]

2. Institutional Low Odor / Low VOC Latex

New; MPI INT 4.2E-G2 (Flat)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 144	MPI 144

System DFT: 4 mils (100 microns)

New; MPI INT 4.2E-G3 (Eggshell)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 145	MPI 145

System DFT: 4 mils (100 microns)

New; MPI INT 4.2E-G4 (Satin)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 146	MPI 146

System DFT: 4 mils (100 microns)

New; MPI INT 4.2E-G5 (Semigloss)

Filler	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 147	MPI 147

System DFT: 4 mils (100 microns)

B. Existing, previously painted Concrete masonry:

1. High Performance Architectural Latex

MPI RIN 4.2K-G2 (Flat)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 138	MPI 138

System DFT: 4.5 mils 112 microns]

MPI RIN 4.2K-G3 (Eggshell)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 139	MPI 139

System DFT: 4.5 mils (112 microns)

MPI RIN 4.2K-G4

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 140	MPI 140

System DFT: 4.5 mils (112 microns)

MPI RIN 4.2K-G5 (Semigloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 141	MPI 141

System DFT: 4.5 mils (112 microns)

2. Institutional Low Odor / Low VOC Latex
   Existing; MPI RIN 4.2L-G2 (Flat)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 144	MPI 144

System DFT: 4 mils (100 microns)

Existing; MPI RIN 4.2L-G3 (Eggshell)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 145	MPI 145

System DFT: 4 mils (100 microns)

Existing; MPI RIN 4.2L-G4 (Satin)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 146	MPI 146

System DFT: 4 mils (100 microns)

Existing; MPI RIN 4.2L-G5 (Semigloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 147	MPI 147

System DFT: 4 mils (100 microns)

C. New and uncoated Existing Concrete masonry units in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation and other high humidity areas unless otherwise specified:

1. Waterborne Light Industrial Coating
   MPI INT 4.2K-G3(Eggshell)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 110-G3	MPI 110-G3

System DFT: 11 mils (275 microns)

MPI INT 4.2K-G5(Semigloss)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 110-G5	MPI 110-G5

System DFT: 11 mils (275 microns)

MPI INT 4.2K-G6(Gloss)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	N/A	MPI 110-G6	MPI 110-G6

System DFT: 11 mils (275 microns)

Fill all holes in masonry surface]

2. Alkyd
MPI INT 4.2N-G3 (Eggshell)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	MPI 50	MPI 51	MPI 51

System DFT: 12 mils (300 microns)

MPI INT 4.2N-G5 (Semigloss)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	MPI 50	MPI 47	MPI 47

System DFT: 12 mils (300 microns)

MPI INT 4.2N-G6 (Gloss)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 4	MPI 50	MPI 48	MPI 48

System DFT: 12 mils 300 microns]

Fill all holes in masonry surface]

3. Epoxy
MPI INT 4.2G-G6 (Gloss)

Filler:	Primer:	Intermediate:	Topcoat:
MPI 116	N/A	MPI 77	MPI 77

System DFT: 10 mils (250 microns)

Fill all holes in masonry surface

D. Existing, previously painted, concrete masonry units in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation and other high humidity areas unless otherwise specified:

1. Waterborne Light Industrial Coating
MPI RIN 4.2G-G3(Eggshell)

Spot Primer:	Intermediate:	Topcoat:
MPI 110-G3	MPI 110-G3	MPI 110-G3

System DFT: 4.5 mils (112 microns)

MPI RIN 4.2G-G5(Semigloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 110-G5	MPI 110-G5	MPI 110-G5

System DFT: 4.5 mils (112 microns)

MPI RIN 4.2G-G6(Gloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 110-G6	MPI 110-G6	MPI 110-G6

System DFT: 4.5 mils (112 microns)

2. Alkyd
MPI RIN 4.2C-G3 (Eggshell)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 51	MPI 51

System DFT: 4.5 mils (112 microns)

MPI RIN 4.2C-G5 (Semigloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 47	MPI 47

System DFT: 4.5 mils (112 microns)

MPI RIN 4.2C-G6 (Gloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 50	MPI 48	MPI 48

System DFT: 4.5 mils (112 microns)

3. Epoxy

MPI RIN 4.2D-G6 (Gloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 77	MPI 77	MPI 77

System DFT: 5 mils (125 microns)

DIVISION 5: INTERIOR METAL, FERROUS AND NON-FERROUS PAINT TABLE

INTERIOR STEEL / FERROUS SURFACES

A. Metal, Mechanical, Electrical, Fire extinguishing sprinkler systems including valves, conduit, hangers, supports, Surfaces adjacent to painted surfaces (Match surrounding finish), exposed copper piping, and miscellaneous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment:

1. High Performance Architectural Latex

MPI INT 5.1R-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 138	MPI 138

System DFT: 5 mils (125 microns)

MPI INT 5.1R-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 139	MPI 139

System DFT: 5 mils (125 microns)

MPI INT 5.1R-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 141	MPI 141

System DFT: 5 mils (125 microns)

2. Alkyd

MPI INT 5.1E-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 49	MPI 49

System DFT: 5.25 mils (131 microns)

MPI INT 5.1E-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 51	MPI 51

System DFT: 5.25 mils (131 microns)

MPI INT 5.1E-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 47	MPI 47

System DFT: 5.25 mils (131 microns)

MPI INT 5.1E-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 48	MPI 48

System DFT: 5.25 mils (131 microns)

B. Metal floors (non-shop-primed surfaces or non-slip deck surfaces) with non-skid additive (NSA), load at manufacturer's recommendations.:

1. Alkyd Floor Paint

MPI INT 5.1U-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 27	MPI 27 (+NSA)

System DFT: 5.25 mils (131 microns)

2. Epoxy

MPI INT 5.1L-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 77	MPI 77 (+NSA)

System DFT: 5.25 mils (131 microns)

C. Metal in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation and other high-humidity areas not otherwise specified except floors, hot metal surfaces, and new prefinished equipment:

1. Alkyd

MPI INT 5.1E-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 51	MPI 51

System DFT: 5.25 mils (131 microns)

MPI INT 5.1E-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 47	MPI 47

System DFT: 5.25 mils (131 microns)

MPI INT 5.1E-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 48	MPI 48

System DFT: 5.25 mils (131 microns)

2. Alkyd

MPI INT 5.1T-G3 (Eggshell) For hand tool cleaning

Primer:	Intermediate:	Topcoat:
MPI 23	MPI 51	MPI 51

System DFT: 5.25 mils (131 microns)

MPI INT 5.1T-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 23	MPI 47	MPI 47

System DFT: 5.25 mils (131 microns)

MPI INT 5.1T-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 23	MPI 48	MPI 48

System DFT: 5.25 mils (131 microns)

D. Ferrous metal in concealed damp spaces or in exposed areas having unpainted adjacent surfaces

1. Aluminum Paint

MPI INT 5.1M

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 1	MPI 1

System DFT: 4.25 mils (106 microns)

E. Miscellaneous non-ferrous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment. Match surrounding finish:

1. High Performance Architectural Latex

MPI INT 5.4F-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 138	MPI 138

System DFT: 5 mils (125 microns)

MPI INT 5.4F-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 139	MPI 139

System DFT: 5 mils (125 microns)

MPI INT 5.4F-G4 (Satin)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 140	MPI 140

System DFT: 5 mils (125 microns)

MPI INT 5.4F-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 141	MPI 141

System DFT: 5 mils (125 microns)

2. Alkyd

MPI INT 5.4J-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 49	MPI 49

System DFT: 5 mils (125 microns)

MPI INT 5.4J-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 51	MPI 51

System DFT: 5 mils (125 microns)

MPI INT 5.4J-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 47	MPI 47

System DFT: 5 mils (125 microns)

MPI INT 5.4J-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 48	MPI 48

System DFT: 5 mils (125 microns)

F. Hot metal surfaces including smokestacks subject to temperatures up to 205 degrees C (400 degrees F):

1. Heat Resistant Enamel
   MPI INT 5.2A
   Primer: Intermediate: Topcoat:
   MPI 21 Surface preparation and number of coats per manufacturer's instructions.
   System DFT: Per Manufacturer

G. Ferrous metal subject to high temperature, up to 400 degrees C (750 degrees F):

1. Inorganic Zinc Rich Coating
   MPI INT 5.2C
   Primer: Intermediate: Topcoat:
   MPI 19 Surface preparation and number of coats per manufacturer's instructions.
   System DFT: Per Manufacturer

2. Heat Resistant Aluminum Paint
   MPI INT 5.2B (Aluminum Finish)
   Primer: Intermediate: Topcoat:
   MPI 2 Surface preparation and number of coats per manufacturer's instructions.
   System DFT: Per Manufacturer

H. New surfaces and Existing surfaces made bare cleaning to SSPC SP 10 subject to temperatures up to 593 degrees C (1100 degrees F):

1. High Heat Resistant Coating
   MPI INT 5.2D
   Primer: Intermediate: Topcoat:
   MPI 22 Surface preparation and number of coats per manufacturer's instructions.
   System DFT: Per Manufacturer

DIVISION 6: INTERIOR WOOD PAINT TABLE

A. New and Existing, uncoated Wood and plywood not otherwise specified:

1. High Performance Architectural Latex
   MPI INT 6.4S-G3 (Eggshell)
   Primer: Intermediate: Topcoat:
   MPI 39 MPI 139 MPI 139
   System DFT: 4.5 mils (112 microns)

MPI INT 6.4S-G4 (Satin)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 140	MPI 140

System DFT: 4.5 mils (112 microns)

MPI INT 6.4S-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 141	MPI 141

System DFT: 4.5 mils (112 microns)

2. Alkyd

MPI INT 6.4B-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 51	MPI 51

System DFT: 4.5 mils (112 microns)

MPI INT 6.4B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 47	MPI 47

System DFT: 4.5 mils (112 microns)

MPI INT 6.4B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 48	MPI 48

System DFT: 4.5 mils (112 microns)

3. Institutional Low Odor / Low VOC Latex

New; MPI INT 6.3V-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 144	MPI 144

System DFT: 4 mils (100 microns)

New; MPI INT 6.3V-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 145	MPI 145

System DFT: 4 mils (100 microns)

New; MPI INT 6.3V-G4

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 146	MPI 146

System DFT: 4 mils (100 microns)

New; MPI INT 6.3V-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 147	MPI 147

System DFT: 4 mils (100 microns)

B. Existing, previously painted Wood and plywood not otherwise specified:

1. High Performance Architectural Latex

MPI RIN 6.4B-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 139	MPI 139

System DFT: 4.5 mils (1123 microns)

MPI RIN 6.4B-G4 (Satin)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 140	MPI 140

System DFT: 4.5 mils (112 microns)

MPI RIN 6.4B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 141	MPI 141

System DFT: 4.5 mils (112 microns)

2. Alkyd

MPI RIN 6.4C-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 51	MPI 51

System DFT: 4.5 mils (112 microns)

MPI RIN 6.4C-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 47	MPI 47

System DFT: 4.5 mils (112 microns)

MPI RIN 6.4C-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 48	MPI 48

System DFT: 4.5 mils (112 microns)

3. Institutional Low Odor / Low VOC Latex

Existing; MPI RIN 6.4D-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 144	MPI 144

System DFT: 4 mils (100 microns)

Existing; MPI RIN 6.4D-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 145	MPI 145

System DFT: 4 mils (100 microns)

Existing; MPI RIN 6.4D-G4

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 146	MPI 146

System DFT: 4 mils (100 microns)

Existing; MPI RIN 6.4D-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 39	MPI 147	MPI 147

System DFT: 4 mils (100 microns)

C. New and Existing, previously finished or stained Wood and Plywood, except floors; natural finish or stained:

1. Natural finish, oil-modified polyurethane

New; MPI INT 6.4J-G4 / Existing; MPI RIN 6.4L-G4

Primer:	Intermediate:	Topcoat:
MPI 57	MPI 57	MPI 57

System DFT: 4 mils (100 microns)

New; MPI INT 6.4J-G6 (Gloss) / Existing; MPI RIN 6.4L-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 56	MPI 56	MPI 56

System DFT: 4 mils (100 microns)

2. Stained, oil-modified polyurethane
New; MPI INT 6.4E-G4 / Existing; MPI RIN 6.4G-G4

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 57	MPI 57	MPI 57

System DFT: 4 mils (100 microns)

New; MPI INT 6.4E-G6 (Gloss) / Existing; MPI RIN 6.4G-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 56	MPI 56	MPI 56

System DFT: 4 mils (100 microns)

3. Stained, Moisture Cured Urethane
New; MPI INT 6.4V-G2 (Flat) / Existing; MPI RIN 6.4V-G2 (Flat)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 71	MPI 71	MPI 71

System DFT: 4 mils (100 microns)

New; MPI INT 6.4V-G6 (Gloss) / Existing; MPI RIN 6.4V-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 31	MPI 31	MPI 31

System DFT: 4 mils (100 microns)

D. New and Existing, previously finished or stained Wood Floors; Natural finish or stained:

1. Natural finish, oil-modified polyurethane
New; MPI INT 6.5C-G6 (Gloss) / Existing; MPI RIN 6.5C-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 56	MPI 56	MPI 56

System DFT: 4 mils (100 microns)

2. Natural finish, Moisture Cured Polyurethane
New; MPI INT 6.5K-G6 (Gloss) / Existing; MPI RIN 6.5D-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 31	MPI 31	MPI 31

System DFT: 4 mils (100 microns)

3. Stained, oil-modified polyurethane
New; MPI INT 6.5B-G6 (Gloss) / Existing; MPI RIN 6.5B-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 56	MPI 56	MPI 56

System DFT: 4 mils (100 microns)

4. Stained, Moisture Cured Polyurethane
New; MPI INT 6.5J-G6 (Gloss) / Existing; MPI RIN 6.5L-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 31	MPI 31	MPI 31

System DFT: 4 mils (100 microns)

E. New and Existing, previously coated Wood floors; pigmented finish:

1. Latex Floor Paint
New; MPI INT 6.5G-G2 (Flat) / Existing; MPI RIN 6.5J-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 60	MPI 60

System DFT: 4.5 mils (112 microns)

New; MPI INT 6.5G-G6 (Gloss) / Existing; MPI RIN 6.5J-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 68	MPI 68

System DFT: 4.5 mils (1123 microns)

2. Alkyd Floor Paint
New; MPI INT 6.5A-G2 (Flat) / Existing; MPI RIN 6.5A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 59	MPI 59	MPI 59

System DFT: 4.5 mils (112 microns)

New; MPI INT 6.5A-G6 (Gloss) / Existing; MPI RIN 6.5A-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 27	MPI 27	MPI 27

System DFT: 4.5 mils (112 microns)

F. New and Existing, uncoated wood surfaces in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation and other high humidity areas] not otherwise specified.:

1. As specified in Section 09963, "High-Build Glaze Coatings."

2. Waterborne Light Industrial
MPI INT 6.3P-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 110-G5	MPI 110-G5

System DFT: 4.5 mils (112 microns)

MPI INT 6.3P-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 110-G6	MPI 110-G6

System DFT: 4.5 mils (112 microns)

3. Alkyd
MPI INT 6.3B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 47	MPI 47

System DFT: 4.5 mils (112 microns)

MPI INT 6.3B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 48	MPI 48

System DFT: 4.5 mils (112 microns)

G. Existing, previously painted wood surfaces in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation and other high humidity areas not otherwise specified:

1. As specified in Section 09963, "High-Build Glaze Coatings."

2. Waterborne Light Industrial Coating
   MPI RIN 6.3P-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 110-G5	MPI 110-G5

   System DFT: 4.5 mils (112 microns)

   MPI RIN 6.3P-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 110-G6	MPI 110-G6

   System DFT: 4.5 mils 112 microns]]

3. Alkyd
   MPI RIN 6.3B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 47	MPI 47

   System DFT: 4.5 mils (112 microns)

   MPI RIN 6.3B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 48	MPI 48

   System DFT: 4.5 mils (112 microns)

H. New and Existing, previously finished or stained Wood Doors; Natural Finish or Stained:

1. Natural finish, oil-modified polyurethane
   New; MPI INT 6.3K-G4 / Existing; MPI RIN 6.3K-G4

Primer:	Intermediate:	Topcoat:
MPI 57	MPI 57	MPI 57

   System DFT: 4 mils (100 microns)

   New; MPI INT 6.3K-G6 (Gloss) / Existing; MPI RIN 6.3K-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 56	MPI 56	MPI 56

   System DFT: 4 mils (100 microns)

   Note: Sand between all coats per manufacturers recommendations.

2. Stained, oil-modified polyurethane
   New; MPI INT 6.3E-G4 / Existing; MPI RIN 6.3E-G4

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 57	MPI 57	MPI 57

   System DFT: 4 mils (100 microns)

   New; MPI INT 6.3E-G6 (Gloss) / Existing; MPI RIN 6.3E-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 56	MPI 56	MPI 56

   System DFT: 4 mils (100 microns)

   Note: Sand between all coats per manufacturers recommendations.

3. Stained, Moisture Cured Urethane
   New; MPI INT 6.4V-G2 (Flat) / Existing; MPI RIN 6.4V-G2 (Flat)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 71	MPI 71	MPI 71

   System DFT: 4 mils (100 microns)

New; MPI INT 6.4V-G6 (Gloss) / Existing; MPI RIN 6.4V-G6 (Gloss)

Stain:	Primer:	Intermediate:	Topcoat:
MPI 90	MPI 31	MPI 31	MPI 31

System DFT: 4 mils (100 microns)

Note: Sand between all coats per manufacturers recommendations.]

I. New and Existing, uncoated Wood Doors; Pigmented finish:

1. Alkyd

New; MPI INT 6.3B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 45	MPI 47	MPI 47

System DFT: 4.5 mils (112 microns)

New; MPI INT 6.3B-G6 (Gloss)

Primer: Intermediate: Topcoat:

MPI 45	MPI 48	MPI 48

System DFT: 4.5 mils (112 microns)

Note: Sand between all coats per manufacturers recommendations.]

2. Pigmented Polyurethane

New; MPI INT 6.1E-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 72	MPI 72	MPI 72

System DFT: 4.5 mils (112 microns)

Note: Sand between all coats per manufacturers recommendations.]

J. Existing, previously painted] Wood Doors; Pigmented finish:

1. Alkyd

New; MPI RIN 6.3B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 47	MPI 47

System DFT: 4.5 mils (112 microns)

New; MPI RIN 6.3B-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 46	MPI 48	MPI 48

System DFT: 4.5 mils (112 microns)

Note: Sand between all coats per manufacturers recommendations.

DIVISION 9: INTERIOR PLASTER, GYPSUM BOARD, TEXTURED SURFACES PAINT TABLE

A. New and Existing, previously painted] [Plaster] [and] [Wallboard] not otherwise specified:

1. Latex

New; MPI INT 9.2A-G2 (Flat) / Existing; RIN 9.2A-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 44	MPI 44

System DFT: 4 mils (100 microns)

New; MPI INT 9.2A-G3 (Eggshell) / Existing; RIN 9.2A-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 52	MPI 52

System DFT: 4 mils (100 microns)

New; MPI INT 9.2A-G5 (Semigloss) / Existing; RIN 9.2A-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 54	MPI 54

System DFT: 4 mils (100 microns)

2. High Performance Architectural Latex - High Traffic Areas

New; MPI INT 9.2B-G2 (Flat) / Existing; MPI RIN 9.2B-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 138	MPI 138

System DFT: 4 mils (100 microns)

New; MPI INT 9.2B-G3 (Eggshell) / Existing; MPI RIN 9.2B-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 139	MPI 139

System DFT: 4 mils (100 microns)

New; MPI INT 9.2B-G5 (Semigloss) / Existing; MPI RIN 9.2B-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 141	MPI 141

System DFT: 4 mils (100 microns)

3. Institutional Low Odor / Low VOC Latex

New; MPI INT 9.2M-G2 (Flat) / Existing; MPI RIN 9.2M-G2 (Flat)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 144	MPI 144

System DFT: 4 mils (100 microns)

New; MPI INT 9.2M-G3 (Eggshell) / Existing; MPI RIN 9.2M-G3 (Eggshell)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 145	MPI 145

System DFT: 4 mils (100 microns)

New; MPI INT 9.2M-G4 (Satin) / Existing; MPI RIN 9.2M-G4 (Satin)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 146	MPI 146

System DFT: 4 mils (100 microns)

New; MPI INT 9.2M-G5 (Semigloss) / Existing; MPI RIN 9.2M-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 147	MPI 147

System DFT: 4 mils (100 microns)

B. New and Existing, previously painted Plaster and Wallboard in toilets, food-preparation, food-serving, restrooms, laundry areas, shower areas, areas requiring a high degree of sanitation, and other high humidity areas not otherwise specified.:

1. Waterborne Light Industrial Coating
   New; MPI INT 9.2L-G5(Semigloss) / Existing; MPI RIN 9.2L-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 110-G5	MPI 110-G5

   System DFT: 4 mils (100 microns)

2. Alkyd
   New; MPI INT 9.2C-G5 (Semigloss) / Existing; MPI RIN 9.2C-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 47	MPI 47

   System DFT: 4 mils (100 microns)

3. Epoxy
   New; MPI INT 9.2E-G6 (Gloss) / Existing; MPI RIN 9.2D-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 50	MPI 77	MPI 77

   System DFT: 4 mils (100 microns)

SECTION 09961

RADIATION CONTROL COATING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 1371	(1998) Determination of Emittance of Materials Near Room Temperature Using Portable emissionmeters
ASTM D 16	(2000) Paint, Related Coatings, Materials and Applications
ASTM D 522	(Rev A 1993) for Mandrel Bend Test of Attached Organic Coatings
ASTM D 968	(1993) Abrasion Resistance of Organic Coatings by Falling Abrasive

ASTM D 1211	(1997) Temperature-Change Resistance of Clear Nitrocellulose Lacquer Films Applied to Wood
ASTM D 1360	(1998) Fire Retardancy of Paints (Cabinet Method)
ASTM D 1653	(1993) Water Vapor Transmission of Organic Coating Films
ASTM D 1654	(1992) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 2794	(1993) Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D 3273	(2000) Resistance to Growth of Mold on the Surface of Interior Coating in an Environmental Chamber
ASTM D 3359	(2002) Measuring Adhesion by Tape Test
ASTM D 4060	(2001) for Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM D 4541	(2002) Pull-Off Strength of Coatings Using Portable Adhesion Testers EI-1995
ASTM D 4708	(1999) Preparation of Uniform Free Films of Organic Coatings
ASTM D 5894	(1996) Cyclic Salt Fog/UV Exposure of Painted Metal (Alternating Exposure in a Fog/Dry Cabinet and UV/Condensation Cabinet)
ASTM E 84	(2001) Surface Burning Characteristics of Building Materials
ASTM E 903	(1996) Solar Absorption, Reflectance, and Transmittance of Materials Using Integrated Spheres
ASTM G 23	(1996) Operating Light-Exposure Apparatus (Xenon-Arc Type) with or without Water for Exposure of Nonmetallic Materials
ASTM G 53	(1996) Operating Light and Water Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials

FEDERAL SPECIFICATIONS (FS)

FS TTC-555	(Rev B Am 1) Coating, Textured (for Interior and Exterior Masonry Surfaces)

KOREAN INDUSTRIAL STANDARDS (KS)

KS F 4715	(2001) Wall Coatings for Thin Textured Finishes
KS M 5307	(1996) Tar Epoxy Resin Paints

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PA-2	(1996) Measurement of Dry Coating Thickness with Magnetic Gages
SSPC SP-1	(1982) Solvent Cleaning
SSPC SP-2	(1995) Hand Tool Cleaning
SSPC SP-12	(1995) Surface Preparation and Cleaning of Steel and Other Hard Materials by High- and Ultrahigh-Pressure Water Jetting Prior to Recoating

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Coating;

The result of a theoretical heat transfer calculation for the structures. Show at lest the following.

1. Assumed outside air temperature, inside temperature, solar radiation.
2. Calculated roof temperature with and without coating.
3. Calculated heat flux reduction due to coating.
4. Calculated energy savings (reduction in cooling load)

SD-04 Samples

Coating; G.

A complete sample of applied coating illustrating color and finish appearance, on galvanized steel panels size 6 x 4 inch.

SD-06 Test Reports

Coating; G.

The reports of tests performed by recognized independent testing laboratories showing the coating complies with the specified physical property requirements.

1.3 QUALITY ASSUARANCE

a. Manufacturer's Qualifications: Minimum of five years record of successful in-service experience of manufacturing radiation control coatings.

b. Applicator Qualifications: Minimum of five years successful experience in projects similar scope using specified or similar treatment materials and manufacturer's approval for application.

1.4 REGULATORY REQUIREMENTS

All coatings must conform to all state and local regulations including VOC rules at the time of application. The contractor that performs this work shall be fully responsible for having his equipment comply with current regulations and to have available all Material Safety Data Sheets that pertain to the products used.

1.5 DELIVERY, STORAGE AND PROTECTION

a. All coatings must be delivered to the job site in manufacturer's original unopened containers.

b. Materials shall be stored in a secure dry area where the temperature is maintained between 40 degree F and 110 degree F.

1.6 ENVIRONMENTAL REQUIREMENTS

a. Exterior coating shall not be undertaken if surface temperature is not between 40 degree F and 180 degree F or not above dew point.

b. Exterior coating shall not be undertaken if during rain, mist, inclement weather, immediately following rain and until frost, dew and all condensation has evaporated.

c. Exterior coating shall not be undertaken if the meteorological forecast indicates a probability of precipitation within two hours of application or if forecast indicates a probability that surface temperature will drop below freezing within 24 hours of application.

d. When the environmental conditions are highly caustic (i.e. acid raid or high concentration of aggressive chemicals in the air), two coats of metal primer with a total dry film thickness of 4 mils will be required on metal surfaces.

1.7 WARRANTY

At the completion of the project and prior to final acceptance by the Government, provide the manufacturer's signed standard written warranty for 5 years in accordance with contract special clauses. A separate warranty will be provided for each building covered by this contract. The authorized applicator must offer the manufacturer's product warranty and match it with an equivalent labor guarantee.

PART 2 PRODUCTS

2.1 RADIATION CONTROL COATING

a. The coating shall be a fluid applied ceramic pigmented terpolymer or acrylic which cures to form a fully adhered dry film. The cured coating film prepared in accordance with paragraph 2.1.b shall have the recommended properties equal or equivalent as detailed in Table 1.

Table 1 Properties Recommended - Radiation Control Coating

Physical Property	Test Method	Requirement
Thermal Emissivity	ASTM E 903 or C 1371	0.90 or less
Solar Reflectivity	ASTM E 903 or D 5894	0.90 or greater
Solids by Volume	Independent accredited Laboratory	55% or greater
Wind Driven Rain	FS TTC-555B	Pass
Cold Checking	ASTM D 1211 or KS F 4715	No cracking or other deleterious effects after 10 cycles
Cold/Hot Cycling	Independent accredited laboratory +82/-40 degree C	No cracking or other deleterious effects after 10 cycles
Abrasion Resistance	ASTM D 968 or D 4060	No wear through at 450 liters
Adhesion	ASTM D 3359 or D 4541 Tape cross hatch method	No disbonding or minimum tensile strength 200 psi
Fire Retardency	ASTM D 1360 or E 84	Does not support combustion Flame spread not more than 5
Impact Resistance	ASTM D 2794 or KS M 5307	Withstand 160 pounds or Greater
Moisture Vapor Permeability	ASTM D 1653	0.08 perms or less
Fungi Resistance	ASTM D 3273	Zero @28 days
Flexibility	ASTM D 522 Conical mandrel or KS M 5307	pass
Corrosion Resistance	ASTM D 1654	No corrosion at 200 hr
Accelerated Weathering	ASTM G 23 or G 53	No deleterious effects at 2000 hr
Fire Resistance	ASTM D 1360 or E 84	Does not support combustion flame spread 5 or less
Permeability and Chemical Resistance	ASTM D 4708	0.6 grams or greater

b. The coating shall not contain solvents or hazardous chemical elements such as fluorides, chlorines or iodines.

2.2 PRIMER

Primer shall be as recommended by coating manufacturer.

2.3 SEALANT

Sealant shall be as recommended by coating manufacturer.

2.4 PATCHING COMPOUND

Patching compound shall be as recommended by coating manufacturer.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

a. General

1. Surfaces shall be prepared according to Society for Protective Coatings (SPC) surface preparation standards when applicable, and surfaces shall be clean and dry at the time the coatings are applied.

2. Unsound existing coatings shall be removed. Sound, adherent existing coatings shall be tested for compatibility by application and testing of a trial patch.

b. Concrete, Masonry, Block, Stucco, Fiber Cement

1. Remove all loose, defective, peeling or perished coating to a sound substrate by hand scraping, use of mechanical grinders, or use of pressure power wash. (SPC-SP 12/NACE N 5: LP WC standard applied to concrete surfaces). Feather the edges of existing coating by abrading to smooth out and level the stepped edges. Low-pressure water cleaning is to be performed at pressures less than 5,000 psi.

2. If mildew or biological growth is present, it shall be removed by scrubbing with a commercial mildew wash formulated for this purpose.

3. V-notch the surface of the crack approximately 1/4-inch wide x 1/4-inch deep. Remove dust and debris from the crack and blow clean using oil-free compressed air. The crack may be dry or damp, but must be free of standing water. All holes, cracks and crevices shall be filled with appropriate sealing or patching compounds. Allow the sealant or the patching compound to cure. Follow manufacturer's directions.

c. Previously Painted Galvanized Steel

1. All surfaces shall be cleaned free of grease, oil and other contaminants in accordance with SPC-SP1, "Solvent Cleaning".

2. Loose, peeling, chalky and defective existing coating shall be removed by scraping, sanding, wire brushing or pressure water cleaning (SPC-SP 12) usually at pressures less than 5,000 psi.

3. White rust (zinc salts) on galvanized surfaces shall be abraded or power washed to remove all deposits.

4. Patches of red rust areas shall be abraded clean to SPC-SP 2 standard and spot primed with two coats of primer for a total of dry film thickness 4 mils.

5. Fasteners shall be spot primed with two coats of primer.

d. Unpainted Galvanized Steel

1. Solvent and detergent cleaning shall be used initially to remove oil, grease and dirt in accordance with SPC-SP 1.

2. Corrosion products (white rust) shall be removed by lightly rubbing with an abrasive plastic pad (SPC-SP 2 standard).

3. New bright-galvanized surfaces are to be roughen to a dull gray appearance by light abrasion.

4. Fasteners shall be spot primed with two coats of primer.

e. Aluminum

1. Surface shall be cleaned free of grease, oil and other contaminants in accordance with SPC-SP 1, "Solvent Cleaning".

2. Loose, peeling, chalky and defective existing coating shall be removed by scraping, sanding or high pressure water blasting.

3. Surface shall be clean and dry at the time coating is applied.

3.2 APPLICATION

a. All materials shall be applied in accordance with the manufacturer's product data sheets and written instructions.

b. Ceramic pigmented coatings shall be applied by airless spray with a suitable tungsten tip.

c. All materials shall be applied uniformly and shall be free from visible defects such as unevenness, patchiness, runs, wrinkles, streaks and brush marks.

3.3 FIELD QUALITY CONTROL

a. Measure coating film thickness in accordance with SPC PA 2. Retain records of testing for 12 months. For non metallic surfaces measure thickness with a Tooke gage in accordance with gage manufacturers instructions.

b. Record batch numbers and retain samples of each batch for 12 months.

c. Record material quantities used. Retain records for 12 months.

d. A field quality control shall be completed and submitted to owner for approval signature at regular agreed intervals.

3.4 PROTECTION

Exercise due care to prevent the contamination of nearby surfaces. Identify surfaces not to be painted and protect these surfaces by covering, masking or other means.

3.5 CLEANUP

a. Upon completion of an area, it shall be left in a clean and orderly condition and all coating spatters, contaminated rags and debris removed.

b. Upon completion of the job, all surplus materials, scaffolds, etc. that relate to the job shall be removed from the site. Clean all window glass free of excess coating and spatters and remove coating that has been misplaced on other surfaces.

3.6 WASTE MATERIAL

Remove from site and dispose of waste material in accordance with local regulations.

3.7 COATING SCHEDULE FOR METAL SURFACES

a. Surface Preparation: Prepare surface in accordance with section 3.1.

b. Tighten fasteners to ensure sheets are firmly held.

c. Report defective and missing fasteners to the contracting officer's representative.

d. Primer: As required by coating manufacturer.

e. Reflective coating: Apply coat/coats of radiation control coating as required to meet final dry film thickness of 20 mils.

3.8 COATING SCHEDULE FOR FLAT CONCRETE/MASONRY SURFACES

a. Surface Preparation: Prepare surface in accordance with section 3.1.

b. Primer: As recommended by coating manufacturer.

c. Reflective coating: Apply coat/coats of radiation control coating as required to meet final dry film thickness of 20 mils.

3.9 COATING SCHEDULE FOR PITCHED OR VERTICAL CONCRETE/MASONRY SURFACES

a. Surface Preparation: Prepare surface in accordance with section 3.1.

b. Primer: As recommended by coating manufacturer.

c. Reflective coating: Apply coat/coats of radiation control coating as required to meet final dry film thickness of 20 mils.

3.10 COATING SCHEDULE FOR ASBESTOS/FIBER CEMENT SURFACES

a. Surface Preparation: Prepare surface in accordance with section 3.1.

b. Reflective coating: Apply coat/coats of radiation control coating as required to meet final dry film thickness of 20 mils.

DIVISION 10 SPECIALTIES

SECTION 10153

TOILET PARTITIONS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by basic designation only.

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

36 CFR 1191 (1998) ADA Accessibility Guidelines for - Buildings and Facilities

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-60003 (Basic) Partitions, Toilet, Complete

1.2 SYSTEM DESCRIPTION

Toilet partition system, including toilet enclosures, room entrance screens, and urinal screens, shall be a complete and usable system of panels, hardware, and support components. The partition system shall be provided by a single manufacturer, and shall be a standard product as shown in the most recent catalog data. The partition system shall be as shown.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Toilet Partition System; G.

Drawings showing plans, elevations, details of construction, hardware, reinforcing, fittings, mountings, and anchorings.

SD-03 Product Data

Toilet Partition System; G.

Manufacturer's technical data and catalog cuts including installation and cleaning instructions.

1.4 DELIVERY, STORAGE, AND HANDLING

Components shall be delivered to the jobsite in the manufacturer's original packaging with the brand, item identification, and project reference clearly marked. Components shall be stored in a dry location that is adequately ventilated; free from dust, water, or other contaminants; and shall have easy access for inspection and handling.

1.5 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period shall be provided.

PART 2 PRODUCTS

2.1 TOILET ENCLOSURES

Toilet enclosures shall conform to CID A-A-60003, Type I, Style A, floor supported or B, ceiling hung. Width, length, and height of toilet enclosures shall be as shown. Finish surface of panels shall be painted metal, Finish 1 or laminated plastic, Finish 3 as shown. Panels indicated to receive toilet paper holders or grab bars as specified in Section 10800 TOILET ACCESSORIES, shall be reinforced for mounting of the items required. Grab bars shall withstand a bending stress, shear stress, shear force, and a tensile force induced by 1112 N (250 lbf). Grab bars shall not rotate within their fittings.

2.2 ROOM ENTRANCE SCREENS

Room entrance screens shall conform to CID A-A-60003, Type II, Style A, floor supported or E, wall hung as shown. Finish surface of screens shall be painted metal, Finish 1 or laminated plastic, Finish 3 as shown. Length and height of screens shall be as shown.

2.3 URINAL SCREENS

Urinal screens shall conform to CID A-A-60003, Type III, Style A, floor supported or B, ceiling hung. Finish surface of screens shall be painted metal, Finish 1 or laminated plastic, Finish 3 as shown. Width and height of urinal screens shall be as shown. Secure wall hung urinal screens with a minimum of three wall stirrup brackets or 1050 mm (42 inch) long, continuous flanges as shown.

2.4 HARDWARE

Hardware for the toilet partition system shall conform to CID A-A-60003 for the specified type and style of partitions. Hardware finish shall be highly resistant to alkalies, urine, and other common toilet room acids. Latching devices and hinges for handicap compartments shall comply with 36 CFR 1191 and shall be chrome-plated steel or stainless steel door latches that operate without either tight grasping or twisting of the wrist of the operator.

2.5 COLORS AND FINISHES

2.5.1 Colors

Color of finishes for toilet partition system components shall be manufacturer's standard as shown on the drawings.

2.5.2 Finishes No. 1 and No. 3

Partitions, panels, screen, and door finishes shall conform to CID A-A-60003 and shall be Finish No. 1, baked enamel or Finish No. 3, laminated plastic.

PART 3 EXECUTION

3.1 INSTALLATION

Toilet partitions shall be installed straight and plumb with uniform clearance of 13 mm (1/2 inch) between pilasters and panels; 25 mm (1 inch) between pilasters and walls; and not more than 5 mm (3/16 inch) between pilasters and doors, in accordance with approved manufacturer's instructions with horizontal lines level and rigidly anchored to the supporting construction. Where indicated, anchorage to walls shall be by through-bolting or toggle-bolting. Drilling and cutting for installation of anchors shall be at locations that will be concealed in the finished work. In the finished work, conceal evidence of drilling in floors and walls. Screws and bolts shall be stainless steel.

3.2 ADJUSTING AND CLEANING

Doors shall have a uniform vertical edge clearance of approximately 5 mm (3/16 inch) and shall rest open at approximately 30 degrees when unlatched. Baked enamel finish shall be touched up with the same color of paint that was used for the finish. Toilet partitions shall be cleaned in accordance with approved manufacturer's instructions and shall be protected from damage until accepted.

SECTION 10260

WALL AND CORNER GUARDS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by thebasic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF-45	(1997) Designation System for Aluminum Finishes

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 167	(1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM B 221	(2000) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM D 256	(2000e1) Determining the IZOD Pendulum Impact Resistance of Plastics
ASTM D 543	(1995; R 2001) Evaluating the Resistence of Plastics to Chemical Reagents
ASTM D 635	(1998) Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position

ASTM E 84 (2001) Surface Burning Characteristics of Building Materials

ASTM G 21 (1996) Determining Resistence of Synthetic Polymeric Materials to Fungi

ASTM G 22 (1976; R 1996) Determining Resistance of Plastics to Bacteria

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM MFM (1988) Metal Finishes Manual

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80 (1999) Fire Doors and Fire Windows

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J1545 (1986) Instrumental Color Difference Measurement for Exterior Finishes, Textiles and Colored Trim

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Corner Guards; G.

Wall Guards (Bumper Guards); G.

Door Protectors; G.

Wall Covering/Panels; G.

Manufacturer's descriptive data, catalog cuts, installation instructions, and recommended cleaning instructions.

SD-06 Test Reports

Corner Guards; G.

Wall Guards (Bumper Guards); G.

Door Protectors; G.

Wall Covering/Panels; G.

Fire rating and extinguishing test results for resilient material.

1.3 DELIVERY AND STORAGE

Materials shall be delivered to the project site in manufacturer's original unopened containers with seals unbroken and labels and trademarks intact. Materials shall be kept dry, protected from weather and damage, and stored under cover. Materials shall be stored at approximately 21 degrees C (70 degrees F) for at least 48 hours prior to installation.

1.4 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period shall be provided.

PART 2 PRODUCTS

2.1 GENERAL

To the maximum extent possible, corner guards, door and door frame protectors, wall guards (bumper guards), wall panels and wall covering shall be the standard products of a single manufacturer and shall be furnished as detailed. Drawings show general configuration of products required, and items differing in minor details from those shown will be acceptable.

2.1.1 Resilient Material

Resilient material shall consist of high impact resistant extruded acrylic vinyl, polyvinyl chloride, or injection molded thermal plastic and shall conform to the following:

2.1.1.1 Minimum Impact Resistance

Minimum impact resistance shall be 960.8 N.m/m (18 ft. lb/sq. inch) when tested in accordance with ASTM D 256, (Izod impact, ft. lbs per sq inch notched).

2.1.1.2 Fire Rating

Fire rating shall be Class 1 when tested in accordance with ASTM E 84, having a maximum flame spread of 25 and a smoke developed rating of 450 or less. Material shall be rated self extinguishing when tested in accordance with ASTM D 635. Material shall be labeled and tested by an approved nationally known testing laboratory. Resilient material used for protection on fire rated doors and frames shall be listed by the testing laboratory performing the tests. Resilient material installed on fire rated wood/steel door and frame assemblies shall have been tested on similar type assemblies. Test results of material tested on any other combination of door/frame assembly will not be acceptable.

2.1.1.3 Integral Color

Colored components shall have integral color and shall be matched in accordance with SAE J1545 to within plus or minus 1.0 on the CIE-LCH scales.

2.1.1.4 Chemical and Stain Resistance

Materials shall be resistant to chemicals and stains reagents in accordance with ASTM D 543.

2.1.1.5 Fungal and Bacterial Resistance

Materials shall be resistant to fungi and bacteria in accordance with ASTM G 21 or ASTM G 22, as applicable.

2.2 CORNER GUARDS

2.2.1 Resilient Corner Guards

Corner guard units shall be flush mounted or surface mounted type, radius formed to profile shown. Corner guards shall extend from floor to ceiling for medical facilities, or as indicated height. Mounting hardware, cushions, and base plates shall be furnished. Assembly shall consist of a snap-on corner guard formed from high impact resistant resilient material, minimum 1.98 mm (0.078 inch) thick, mounted on a continuous aluminum retainer. Extruded aluminum retainer shall conform to ASTM B 221, alloy 6063, temper T5 or T6. Flush mounted type guards shall act as a stop for adjacent wall finish material. Factory fabricated end closure caps shall be furnished for top and bottom of surface mounted corner guards. Flush mounted corner guards installed in fire rated wall shall maintain the rating of the wall. Insulating materials that are an integral part of the corner guard system shall be provided by the manufacturer of the corner guard system. Exposed metal portions of fire rated assemblies shall have a paintable surface.

2.2.2 Stainless Steel Corner Guards

Stainless steel corner guards shall be fabricated of 1.58 mm (0.0625 inch) thick material conforming to ASTM A 167, type 302 or 304. Corner guards shall extend from floor to ceiling for medical facilities, or as indicated height. Corner guard shall be formed to dimensions shown.

2.3 WALL GUARDS (BUMPER GUARDS)

2.3.1 Wall Guards, Combination Handrail/Wall Guards and Handrails

Wall guards, combination handrail/wall guards, and handrails shall be provided with prefabricated end closure caps, inside and outside corners, concealed splices, cushions, mounting hardware and other accessories standard with the manufacturer. Extruded aluminum retainers shall conform to ASTM B 221, alloy 6063, temper T5 or T6. End caps and corners shall be field adjustable to assure close alignment with handrails and wall guards. Wall guards or combination handrail/wall guards shall have profile as shown.

2.3.1.1 Wall Guards/Bed Locators

Wall guards shall consist of snap-on covers of high impact resistant resilient material, minimum 1.98 mm (0.078 inch) thick, mounted over 50 mm (2 inch) wide aluminum, minimum 1.57 mm (0.062 inch) thick retainer, anchored to wall at maximum 600 mm (24 inches) on center.

2.3.1.2 Combination Handrail/Wall Guards

Combination handrail/wall guards shall consist of snap-on covers of high impact resistant resilient material, minimum 1.98 mm (0.078 inch) thick, on a continuous, extruded aluminum retainer, minimum 1.83 mm (0.072 inch) thick anchored to wall at maximum 800 mm (32 inches) on center.

2.3.1.3 Handrails

Handrails shall consist of snap-on covers of high impact resistant resilient material, minimum 1.98 mm (0.078 inch) thick on a continuous extruded aluminum retainer, minimum 1.83 mm (0.072 inch) thick anchored to wall at maximum 800 mm (32 inches) on center. Handrails shall be provided with prefabricated end closure caps, inside and outside corners, concealed splices, cushions, mounting hardware and other accessories standard with the manufacturer. End caps and corners shall be field adjustable to assure close alignment with handrails.

2.4 DOOR PROTECTORS

Door and door frame protection items shall consist of high impact resistant acrylic vinyl or polyvinyl chloride resilient material, minimum 1.52 mm (0.060 inch) thick for doors and 0.89 mm (0.035 inch) thick for door frames. Coordinate door and door frame protection material requirements with door and frame suppliers to insure fit for all components and color matching with other resilient materials. Provide adhesive as recommended by resilient material manufacturer.

2.5 WALL COVERING/PANELS

Wall covering/panels shall consist of high impact rigid acrylic vinyl or polyvinyl chloride resilient material. Panel sizes shall be 0.61 x 2.94 m (2 x 4 ft) or as shown.

2.5.1 Rigid Vinyl Acrylic Wall Covering

Wall covering thickness shall be as shown on the drawings.

2.5.2 High Impact Wall Panels

Wall panel face and edge thickness shall be as shown on the drawings. Panel face shall be factory banded to a 9.53 mm (0.375 inch) thick fiberboard core. The backside of the panel shall be laminated with a moisture resistant vapor barrier.

2.6 TRIM, FASTENERS AND ANCHORS

Vinyl trim, fasteners and anchors shall be provided for each specific installation as shown.

2.7 FINISH

2.7.1 Aluminum Finish

Finish for aluminum shall be in accordance with AA DAF-45. Exposed aluminum shall be designation AA-C22A32 chemically etched medium matte with integrally colored anodic coating class II architectural coating 0.010 mm (0.4 mil) thick. Concealed aluminum shall be mill finish as fabricated, uniform in natural color and free from surface blemishes.

2.7.2 Stainless Steel Finish

Finish for stainless steel shall be in accordance with ASTM A 167, Type 302 or 304, finish number 4.

2.7.3 Resilient Material Finish

Finish for resilient material shall be embossed velour or stipple, or high gloss vinyl texture with colors in accordance with SAE J1545.

2.8 ADHESIVES

Adhesive for resilient material shall be in accordance with manufacturers recommendations.

2.9 COLOR

Color shall be as shown on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Corner Guards and Wall Guards (Bumper Guards)

Material shall be mounted at location indicated in accordance with manufacturer's recommendations.

3.1.2 Door, Door Frame Protectors, and Wall Panels

Surfaces to receive protection shall be clean, smooth, and free of obstructions. Protectors shall be installed after frames are in place, but prior to hanging of doors, in accordance with manufacturer's specific instructions. Adhesives shall be applied in controlled environment in accordance with manufacturer's recommendations. Protection for fire doors and frames shall be installed in accordance with NFPA 80.

3.1.3 Stainless Steel Guards

a. Mount guards on external corners of interior walls, partitions and columns as per manufacturer's recommendations.

b. Where corner guards are installed on walls, partitions or columns finished with plaster or ceramic tile, anchor corner guards as indicated, or provide continuous 1.5 mm (16 gage) thick, perforated, galvanized z-shape steel anchors welded to back edges of corner guards and expansion bolted to concrete or masonry with four 10 mm (3/8 inch) diameter bolts, spaced 400 mm (16 inches) on centers. Coat back surfaces of corner guards, where shown, with a non-flammable, sound deadening material. Corner guards shall overlap finish plaster surfaces.

(1) Where corner guards are installed on exposed structural glazed facing tile units or masonry wall, partitions or columns, anchor corner guards as shown on the drawings or anchor corner guards to existing walls with 6 mm (1/4 inch) oval head stainless steel countersunk expansion or toggle bolts. Grout spaces solid between guards and backing with portland cement and sand mortar.

(2) Where corner guards are installed on gypsum board, clean surfaces and anchor guards with a neoprene solvent-type adhesive specifically manufactured for use on gypsum board construction. Remove excess adhesive from the guard edges and allow to cure undisturbed for 24 hours.

c. For wall guards, space brackets at no more than 900 mm (3 feet) on centers and anchor to the wall in accordance with the manufacturer's installation instructions.

SECTION 10270

RAISED FLOOR SYSTEM

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 84 (1998e1) Surface Burning Characteristics of Building Materials

ASTM E 648 (1998) Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source

CEILINGS & INTERIOR SYSTEMS CONTRACTORS ASSOCIATION (CISCA)

CISCA Access Floors (1987) Recommended Test Procedures for Access Floors

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS SS-T-312 (Rev B; Int Am 1; Notice 2; Canc. Notice 1) Tile, Floor:

Asphalt, Rubber, Vinyl, and Vinyl Composition

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO)

ICBO Bldg Code (1997) Uniform Building Code (3 Vol.)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA LD 3 (1995) High-Pressure Decorative Laminates

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 75 (1999) Protection of Electronic Computer/Data Processing Equipment

NFPA 99 (1999) Health Care Facilities

1.2 SYSTEM DESCRIPTION

Raised flooring shall be installed at the location and elevation and in the arrangement shown on the drawings. The floor system shall be of the stringer or stringerless type, complete with all supplemental items, and shall be the standard product of a manufacturer specializing in the manufacture of raised floor systems.

1.2.1 Floor Panels

Floor panel testing shall be conducted in accordance with CISCA Access Floors. When tested as specified, all deflection and deformation measurements shall be made at the point of load application on the top surface of the panel. Floor panels shall be capable of supporting 4450, 5563, 6675 N or as indicated (1000, 1250 or 1500 pounds) concentrated load without deflecting more than 2.03 mm (0.080 inch) and without permanent deformation in excess of 0.25 mm (0.010 inch) in any of the specified tests. Floor panels shall be capable of supporting 11.97, 14.36, 16.76 KPa per square meter or as indicated (250, 300 or 350 pounds per square foot) uniform live load without deflection more than 1.02 mm (0.040 inch). Floor panels shall be capable of supporting 2670, 4450 N or as indicated (600, 1000 pounds) rolling load without deflecting more than 1.02 mm (0.040 inch) and without permanent deformation in excess of 0.51 mm (0.020 inch). In accordance with CISCA Access Floors, the permanent deformation limit under rolling load shall be satisfied in all of the specified tests. In the specified tests, the permanent deformation shall be measured after 10 passes with Wheel 1 and after 10,000 passes with Wheel 2.

1.2.2 Stringers

Stringers shall be capable of supporting a 1110 N (250 pound) concentrated load at midspan without permanent deformation in excess of 0.25 mm (0.010 inch).

1.2.3 Pedestals

Pedestals consist of a base plate, post and an adjustable head, and are available in heights from 150 mm (6 inches) to 600 mm (24 inches). Pedestals shall be capable of supporting a 22.24 KN (5000 pound) axial load without permanent deformation.

1.2.4 Pedestal Adhesive

Adhesive shall be capable of securing a pedestal in place with sufficient bonding strength to resist an overturning force of 113 Nm (1000 inch pounds).

1.2.5 Bond Strength of Factory Installed Floor Covering

Bond strength of floor covering shall be sufficient to permit handling of the panels by use of the panel lifting device, and to withstand moving caster loads up to 4.45 KN (1000 pounds), without separation of the covering from the panel.

1.2.6 Leakage

When the space below the finished floor is to be an air plenum, air leakage through the joints between panels and around the perimeter of the floor system shall not exceed 0.15 L/s of air per linear meter (0.1 cubic foot of air per minute per linear foot) of joint subjected to 2.5 mm (0.1 inch), water gauge, positive pressure in the plenum.

1.2.7 Grounding

The raised floor system shall be grounded for safety hazard and static suppression.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Raised Floor System; G.

Drawings showing layout of the work, sizes and details of components, details at floor perimeter, bracing to resist seismic or other lateral loads, typical cutout details including size and shape limitation, method of grounding, description of shop coating, and installation height above structural floor.

SD-03 Product Data

Raised Floor System; G.

Manufacturer's descriptive data, catalog cuts, and installation instructions. The data shall include information about any design and production techniques, procedures and policies used to conserve energy, reduce material, improve waste management or incorporate green building/recycled products into the manufacturer of their components or products. Cleaning and maintenance instructions shall be included. Design calculations which demonstrate that the proposed floor system meets requirements for seismic loading, prepared in accordance with subparagraph Underfloor Bracing under paragraph PANEL SUPPORT SYSTEM and ICBO Bldg Code. Certified copies of test reports may be submitted in lieu of calculations.

SD-04 Samples

Raised Floor System; G.

One sample of each panel type and suspension system proposed for use.

SD-06 Test Reports

Tests; G. Testing of Electrical Resistance; G.

Certified copies of test reports from an approved testing laboratory, attesting that the proposed floor system components meet the performance requirements specified.

SD-07 Certificates

Raised Floor System;

Certificate of compliance attesting that the raised floor system meets specification requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

Materials shall be stored in original protective packaging in a safe, dry, and clean location and shall be handled in a manner to prevent damage. Panels shall be stored at temperatures between 4 and 32 degrees C (40 and 90 degrees F), and between 20 percent and 70 percent humidity.

1.5 EXTRA MATERIALS

Spare floor panels, spare complete pedestal assemblies, and spare stringers shall be furnished at the rate of one space for each 100 or fraction thereof required.

1.6 OPERATION AND MAINTENANCE MANUALS

Provide maintenance instructions for proper care of the floor panel surface. When conductive flooring is specified, require submittal of maintenance instructions to identify special cleaning and maintenance requirements to maintain "conductivity" properties of the panel finish.

PART 2 PRODUCTS

2.1 FLOOR PANELS

2.1.1 Panel Construction

Except for edge panels, panel size shall be 600 by 600 mm (24 by 24 inches). Finished panels shall be within a 0.25 mm (0.010 inch) tolerance of the nominal size, and shall be square within a tolerance of 0.38 mm (0.015 inch) measured corner-to-corner. The top surface of panels shall be flat within a 0.51 mm (0.020 inch) tolerance measured corner-to-corner. Panels shall be permanently marked to indicate load rating and model number.

2.1.1.1 Aluminum Panels

Aluminum panels shall be of die-cast or extruded construction.

2.1.1.2 Hollow Formed Steel Panels

Steel panels shall be of die-formed construction, consisting of a flat steel top sheet welded to one or more formed steel stiffener sheets. Panels shall be chemically cleaned, bonderized, and painted with the manufacturer's standard finish.

2.1.1.3 Metal-Clad Cementitious Fill Panel (Composite Panels)

Composite panels shall be of die-formed steel construction totally enclosing the panel, including the top surface. The void spaces between the top sheet and the formed steel bottom sheet shall be completely filled with an incombustible cementitious or concrete material.

2.1.2 Floor Covering

Floor panels shall be surfaced with materials firmly bonded in place with waterproof adhesive. The electrical resistance shall remain stable over the life expectancy of the floor covering. Any antistatic agent used in the manufacturing process shall be an integral part of the material, and shall not be surface applied. Bolt heads or similar attachments shall not rise above the traffic surface.

2.1.2.1 High Pressure Laminate

High pressure laminate surfacing shall conform to NEMA LD 3, Grade HW 62. Total system electrical resistivity from the wearing surface of the floor to the ground connection shall be between 150,000 ohms and 20,000,000,000 ohms.

2.1.2.2 Conductive Surfacing for Clean Rooms and Hospital Operating Rooms

Conductive surfacing shall conform to NEMA LD 3, Grade HW 62. The total system electrical resistivity from the wearing surface of the floor to the ground connection shall be between 25,000 ohms and 1,000,000 ohms.

2.1.2.3 Vinyl Composition Tile

Vinyl composition tile surfacing shall be 3 mm (1/8 inch) thick conforming to FS SS-T-312, Type IV, and Composition 1. Tiles may be approximately 300 mm (12 inches) square or may be the full size of the panel.

2.1.2.4 Carpet

Carpet surfacing shall be factory installed using one full carpet square per panel. Carpet shall be nylon filament, loop pile, minimum 0.8 kg/square m (24 ounce per square yard), minimum density 4000, and without cushion. Carpet shall conform to ASTM E 648 with a minimum average critical radiant flux of 0.25 watts per square centimeter. Static control shall be less than 2.0 kV at 20 percent relative humidity at 21 degrees C (70 degrees F).

2.1.3 Edge Strip

Panels shall be edged with extruded vinyl edge strips secured in place with mechanical interlock or adhesive bond, or shall be of a replaceable type. Top of strip shall be approximately 3 mm (1/8 inch) wide, and shall be flush with the floor surfacing.

2.1.4 Accessories

Registers, grilles, perforated panels, and plenum dividers shall be provided where indicated, and shall be the manufacturer's standard type. Registers, grilles, and perforated panels shall be designed to support the same static loads as floor panels without structural failure, and shall be capable of delivering the air volumes indicated. Registers and perforated panels shall be 25 percent open area and shall be equipped with adjustable dampers.

2.1.5 Resilient Base

Base shall be manufacturers standard rubber or vinyl straight style (installed with carpet) or coved style (installed with resilient flooring). Base shall be 100 mm (4 inches) high and a minimum 3 mm (1/8 inch) thick. Performed outside corners shall be furnished.

2.1.6 Lifting Device

Each individual room shall be provided with one floor panel lifting device standard with the floor manufacturer. A minimum of two devices shall be furnished.

2.2 PANEL SUPPORT SYSTEM

2.2.1 Pedestals

Pedestals shall be of steel or aluminum or a combination thereof. Ferrous materials shall have a factory-applied corrosion-resistant finish. Pedestal base plates shall provide a minimum of 10,300 square millimeter (16 square inches) of bearing surface and shall be a minimum of 3 mm (1/8 inch) thick. Pedestal shafts shall be threaded to permit height adjustment within a range of approximately 50 mm (2 inches), to permit overall floor adjustment within plus or minus 2.5 mm (0.10 inch) of the required elevation, and to permit leveling of the finished floor surface within 1.56 mm (0.062 inch) in 3000 mm (10 feet) in all directions. Locking devices shall be provided to positively lock the final pedestal vertical adjustments in place. Pedestal caps shall interlock with panels or stringers to preclude tilting or rocking of the panels.

2.2.2 Stringers

Stringers shall be of rolled steel or extruded aluminum, and shall interlock with the pedestal heads to prevent lateral movement.

2.2.3 Underfloor Bracing

Special bracing to resist the effects of seismic or other forces shall be as shown on the approved detail drawings.

2.3 FASCIA

Aluminum or steel fascia plates shall be provided at open ends of floor, at sides of ramps and steps, and elsewhere as required to enclose the free area under the raised floor. Steel plates shall have a factory applied baked enamel finish. Finish on aluminum plates shall be as standard with the floor system manufacturer. Fascia plates shall be reinforced on the back, and shall be supported using the manufacturer's standard lateral bracing at maximum 1200 mm (4 feet) on center. Trim, angles, and fasteners shall be provided as required.

2.4 STEPS AND RAMPS

Steps and ramps shall be securely fastened to the raised floor system and to the structural floor. Construction shall include standard floor system components and custom components as required, and shall include all supports, fasteners, and trim necessary for a finished installation. Step nosings, threshold strips, and floor bevel strips shall be cast or extruded aluminum with nonslip traffic surfaces.

2.4.1 Steps

Height of risers shall not exceed 180 mm (7 inches). Steps shall be designed to support a uniform load of 7.18k Pa (150 pounds per square foot). Treads shall be surfaced with the manufacturer's standard nonslip floor finish.

2.4.2 Ramps

Slope of ramps shall not exceed 25 mm (1 inch) rise to 300 mm (12 inches) of run. Ramps shall be designed to support the same loads as specified for floor panels. Ramps shall be surfaced with the manufacturer's standard nonslip floor finish.

2.5 RAILINGS

Railings shall be the double rail and post type, fabricated of at least 25 mm (1 inch) round or square seamless aluminum tubing with a satin natural anodized finish. At steps and ramps, the top rail shall be approximately 900 mm (36 inches) high and parallel to the incline. The top rail shall be 1050 mm (42 inches) high at open ends of the floor. Guardrails shall have intermediate rails or an ornamental pattern such that a sphere 100 m (4 inches) in diameter cannot pass thru.

2.6 TESTS

Raised flooring shall be factory tested by an independent laboratory at the same position and maximum design elevation and in the same arrangement as shown on the drawings for installation so as to duplicate service conditions as much as possible.

2.6.1 Load Tests

Floor panel, stringer, and pedestal testing shall be conducted in accordance with CISCA Access Floors.

2.7 Test for Bond Strength of Factory Installed Floor Covering

The test panel shall be supported on pedestals and stringers as specified for the installed floor. The supports shall be braced as necessary to prevent sideways movement during the test. A test load of 4.45 kN1000 pounds shall be imposed on the test assembly through a hard plastic caster 75 mm (3 inches) in diameter and 25 mm (1 inch) wide. The caster shall be rolled completely across the center of the panel. The panel shall withstand 20 passes of the caster with no delamination or separation of the covering.

2.8 COLOR

Color shall be as shown on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

The floor system shall be installed in accordance with the manufacturer's instructions and with the approved detail drawings. Open ends of the floor, where the floor system does not abut wall or other construction, shall have positive anchorage and rigid support. Areas to receive raised flooring shall be maintained between 16 and 32 degrees C (60 and 90 degrees F), and between 20 percent and 70 percent humidity for 24 hours prior to and during installation.

3.1.1 Preparation for Installation

The area in which the floor system is to be installed shall be cleared of all debris. Structural floor surfaces shall be thoroughly cleaned and all dust shall be removed. Floor coatings required for dust or vapor control shall be installed prior to installation of pedestals only if the pedestal adhesive will not damage the coating. If the coating and adhesive are not compatible, the coating shall be applied after the pedestals have been installed and the adhesive has cured.

3.1.2 Pedestals

Pedestals shall be accurately spaced, and shall be set plumb and in true alignment. Base plates shall be in full and firm contact with the structural floor, and shall be secured to the structural floor with adhesive.

3.1.3 Stringers

Stringers shall be interlocked with the pedestal caps to preclude lateral movement, and shall be spaced uniformly in parallel lines at the indicated elevation.

3.1.4 Auxiliary Framing

Auxiliary framing or pedestals shall be provided around columns and other permanent construction, at sides of ramps, at open ends of the floor, and beneath panels that are substantially cut to accommodate utility systems. Special framing for additional lateral support shall be as shown on the approved detail drawings.

3.1.5 Panels

The panels shall be interlocked with supports in a manner that will preclude lateral movement. Perimeter panels, cutout panels, and panels adjoining columns, stairs, and ramps must be fastened to the supporting components to form a rigid boundary for the interior panels. Floors shall be level within 2 mm measured with a 250 mm (1/16 inch measured with a 10 foot) straightedge in all directions. Cut edges of steel and wood-core panels shall be painted as recommended by the panel manufacturer. Cut edges of composite panels shall be coated with a silicone rubber sealant or with an adhesive recommended by the panel manufacturer. Extruded vinyl edging shall be secured in place at all cut edges of all panel cut-outs to prevent abrasion of cables. Where the space below the floor is a plenum, cutouts for conduit and similar penetrations shall be closed using self-extinguishing sponge rubber.

3.1.6 Resilient Base

Base shall be provided at vertical wall intersections. Cracks and voids in walls and other vertical surfaces to receive base shall be filled with an approved filler. The base shall be applied after the floor system has been completely installed. Base shall be applied with adhesive in accordance with the manufacturer's recommendations.

3.1.7 Fascia Plates

Exposed floor ends and exposed openings of ramps and stairs shall be covered with aluminum or steel closures.

3.1.8 Repair of Zinc Coating

Zinc coating that has been damaged, and cut edges of zinc-coated components and accessories, shall be repaired by the application of a galvanizing repair paint. Areas to be repaired shall be thoroughly cleaned prior to application of the paint.

3.2 TESTING OF ELECTRICAL RESISTANCE

Testing of electrical resistance in the completed installation shall be conducted in the presence of the Contracting Officer. Testing shall be in accordance with NFPA 99 modified by placing one electrode on the center of the panel surface and connecting the other electrode to the metal flooring support. Measurements shall be made at five or more locations. Each measurement shall be the average of five readings of 15 seconds duration at each location. During the tests, relative humidity shall be 45 to 55 percent and temperature shall be 21 to 24 degrees C (69 to 75 degrees F). The panels used in the testing will be selected at random and will include two panels most distant from the ground connection. Electrical resistance shall be measured with instruments that are accurate within 2 percent and that have been calibrated within 60 days prior to the performance of the resistance tests. The metal-to-metal resistance from panel to supporting pedestal shall not exceed 10 ohms. The resistance between the wearing surface of the floor covering and the ground connection, as measured on the completed installation, shall be in accordance with paragraph FLOOR COVERING.

3.3 CLEANING AND PROTECTION

3.3.1 Cleaning

The space below the completed floor shall be free of all debris. Before any traffic or other work on the completed raised floor is started, the completed floor shall be cleaned in accordance with the floor covering manufacturer's instructions.

3.3.2 Protection

Traffic areas of raised floor systems shall be protected with a covering of building paper, fiberboard, or other suitable material to prevent damage to the surface. Cutouts shall be covered with material of sufficient strength to support the loads to be encountered. Plywood or similar material shall be placed on the floor to serve as runways for installation of heavy equipment. Protection shall be maintained until the raised floor system is accepted.

3.4 FIRE SAFETY

An automatic detection system shall be installed below the raised floor meeting the requirements of NFPA 75 paragraph 5-2.1 and shall sound an audible and visual alarm. Air space below the raised floor shall be subdivided into areas not exceeding 929 squared meters (10,000 square feet) by tight, noncombustible bulkheads. All penetrations for piping and cables shall be sealed to maintain bulkhead properties.

SECTION 10430

EXTERIOR SIGNAGE

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF-45 (1997) Designation System for Aluminum Finishes

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z97.1 (1984; R 1994) Safety Performance Specifications and Methods

	of Test for Safety Glazing Materials Used in Buildings

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36 (M)	(2000) Carbon Structural Steel
ASTM A 123 (M)	(2000) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 570 (M)	(1998) Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality
ASTM A 653 (M)	(2000) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 924 (M)	(1999) General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B 26 (M)	(1999) Aluminum-Alloy Sand Castings
ASTM B 62	(1993) Composition Bronze or Ounce Metal Castings
ASTM B 108	(1999) Aluminum-Alloy Permanent Mold Castings
ASTM B 209	(1996) Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B 209M	(2000) Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B 221 (M)	(2000) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM C 1036	(1991; R 1997) Flat Glass
ASTM D 3841	(1997) Glass-Fiber-Reinforced Polyester Plastic Panels
ASTM E 84	(2000a) Surface Burning Characteristics of Building Materials

AMERICAN WELDING SOCIETY (AWS)

AWS C1.1M/C1.1	(2000) Recommended Practices for Resistance Welding
AWS D1.1	(2000) Structural Welding Code - Steel
AWS D1.2	(1997) Structural Welding Code - Aluminum

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM AMP 505	(1988) Metal Finishes Manual for Architectural and Metal Products

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE AMS 3611 (1994; Rev D) Plastic Sheet, Polycarbonate General Purpose

KOREAN INDUSTRIAL STANDARDS (KS) PUBLICATIONS

KS D 3503 (1998) Rolled Steel for General Structure

KS D 3506 (2001) Hot-Dip Zinc Coated Steel Sheet and Coil

KS D 6701 (2002) Aluminum and Aluminum Alloy Sheets and Plates, Strips and Coiled Sheets

KS D 6759 (2002) Aluminum and Aluminum Alloy Extruded Shapes

1.2 GENERAL

All exterior signage shall be provided by a single manufacturer. Exterior signage shall be of the design, detail, sizes, types, and message content shown on the drawings, shall conform to the requirements specified, and shall be provided at the locations indicated. Signs shall be complete with lettering, framing as detailed, and related components for a complete installation.

1.3 WIND LOAD REQUIREMENTS

Exterior signage shall be designed to withstand 96 km/h (60 mph) windload.

1.4 CHARACTER PROPORTIONS AND HEIGHTS

Letters and numbers on indicated signs for handicapped-accessible buildings shall have a width-to-height ratio between 3:5 and 1:1 and a stroke-width-to-height ratio between 1:5 and 1:10. Characters and numbers on indicated signs shall be sized according to the viewing distance from which they are to be read. The minimum height is measured using an upper case letter "X". Lower case characters are permitted.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings; G.

Drawings showing elevations of each type of sign; dimensions, details, and methods of mounting or anchoring; shape and thickness of materials; and details of construction. A schedule showing the location, each sign type, and message shall be included.

SD-03 Product Data

Modular Exterior Signage System; G.

Manufacturer's descriptive data and catalog cuts.

Installation;

Manufacturer's installation instructions and cleaning instructions.

Exterior Signs;

Exterior signage schedule in electronic media with spread sheet format. Spread sheet shall include sign location, sign type, and message.

Wind Load Requirements; G.

Design analysis and supporting calculations performed in support of specified signage.

SD-04 Samples

Exterior Signs; G.

One 300 mm (12 inch) length of framing for illuminated signs. One sample of each type of sign. Each sample shall consist of a complete sign panel with letters and symbols. Samples may be installed in the work, provided each sample is identified and location recorded. Two samples of manufacturer's standard color chips for each material requiring color selection and 305 mm (12 inch) square sample of sign face color sample.

1.6 QUALIFICATIONS

Signs, plaques, and dimensional letters shall be the standard product of a manufacturer regularly engaged in the manufacture of the products. Items of equipment shall essentially duplicate equipment that has been in satisfactory use at least 2 years prior to bid opening.

1.7 DELIVERY AND STORAGE

Materials shall be wrapped for shipment and storage, delivered to the jobsite in manufacturer's original packaging, and stored in a clean, dry area in accordance with manufacturer's instructions.

1.8 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a one year period shall be provided.

PART 2 PRODUCTS

2.1 MODULAR EXTERIOR SIGNAGE SYSTEM

Exterior signage shall consist of a system of coordinated directional, identification, and regulatory type signs located where shown. Dimensions, details, materials, message content, and design of signage shall be as shown.

2.1.1 Free-Standing Base Mount Pylon/Monolith Type Signs

2.1.1.1 Framing

Interior framing shall consist of aluminum or galvanized steel tube columns welded to companion plates. Perimeter framing shall consist of aluminum or steel angle framing welded to the post and plate system as designed. Framing members shall be designed to permit access to electrical equipment and panel removal. Mounting shall be provided as shown. Framing members of steel shall be finished with semi-gloss baked enamel or two-component acrylic polyurethane. Openings shall be sealed from moisture and made tamper-proof.

2.1.1.2 Exterior Sheeting Panels

Modular panels shall be provided in sizes shown on drawings. Panels shall be fabricated a minimum of 2.3 mm (0.090 inch) thick aluminum or steel. Panels shall be heliarc welded to framing system. Top and end panels shall be removable and shall be secured by 5 mm (3/16 inch) socket head jack nuts. Finish for metal panels shall be semi-gloss baked enamel two-component acrylic polyurethane or anodized conforming to AA DAF-45.

2.1.1.3 Mounting

Mounting shall be provided by securing to concrete foundation as shown.

2.1.1.4 Finishes

Base finish shall be semi-gloss baked enamel or two-component acrylic polyurethane. Metal panel system finish shall be baked enamel or two-component acrylic polyurethane or anodized conforming to AA DAF-45 as shown.

2.1.2 Panel And Post/Panel Type Signs

2.1.2.1 Posts

One-piece aluminum or galvanized steel posts shall be provided with minimum 3.2 mm (0.125 inch) wall thickness. Posts shall be designed to accept panel framing system described. The post shall be designed to permit attachment of panel framing system without exposed fasteners. Caps shall be provided for each post.

2.1.2.2 Panel Framing System

Panel framing consisting of aluminum sections and interlocking track components shall be designed to interlock with posts with concealed fasteners.

2.1.2.3 Panels

Modular message panels shall be provided in sizes shown on drawings. Panels shall be fabricated a minimum of 3.2 mm (0.125) inch aluminum, 3.2 mm (0.125 inch) acrylic or 3.2 mm (0.125 inch fiberglass reinforced plastic (FRP). Panels shall be designed to be interchangeable. Panels with metal return sheeting shall have welded corners, ground smooth. Panels shall be heliarc welded to framing system. Face panels shall be removable to provide access to electrical components.

2.1.2.4 Finishes

Post finish shall be semi-gloss baked enamel or two-component acrylic polyurethane or anodized conforming to AA DAF-45 as shown. Metal panel system finish shall be baked enamel or two-component acrylic polyurethane or anodized conforming to AA DAF-45 as shown.

2.1.2.5 Mounting

Permanent mounting shall be provided by embedding posts in concrete foundation as shown. Removable mounting shall be provided by a steel or an aluminum sleeve or flange embedded in concrete as shown.

2.2 GRAPHICS FOR EXTERIOR SIGNAGE SYSTEMS

See drawings and schedule for message content. Typeface and Type size as indicated.

2.3 DIMENSIONAL BUILDING LETTERS

2.3.1 Fabrication

Letters shall be fabricated from cast aluminum or cast bronze 2.29 mm (0.090 inch) aluminum sheet or 3.17 mm (0.125 inch) aluminum sheet. Letters shall be cleaned by chemical etching or cleaned ultrasonically in a special degreasing bath. Letters shall be packaged for protection until installation.

2.3.2 Typeface

Typeface shall be helvetica medium or as indicated.

2.3.3 Size

Letter size shall be as indicated.

2.3.4 Finish

Anodized aluminum, Baked enamel or two-component acrylic polyurethane or Polished bronze with clear coat finish shall be provided.

2.3.5 Mounting

Threaded studs or Steel U-bracket, cap screws, and expansion bolts of number and size as recommended by manufacturer, shall be used for concealed anchorage. Letters which project from the building line shall have stud spacer sleeves. Letters, studs, and sleeves shall be of the same material. Templates for mounting shall be supplied.

2.4 ALUMINUM ALLOY PRODUCTS

Aluminum alloy products shall conform to ASTM B 209(M) or KS D 6701 for sheet or plate, ASTM B 221(M) or KS D 6759 for extrusions and ASTM B 26(M) or ASTM B 108 for castings. Aluminum extrusions shall be provided at least 3 mm (1/8 inch) thick and aluminum plate or sheet at least 16 gauge thick. Welding for aluminum products shall conform to AWS C1.1M/C1.1.

2.5 ANODIC COATING

Anodized finish shall conform to AA DAF-45 as follows: Clear (natural) designation AA-M10-C22-A31, Architectural Class II 0.010 mm (0.4 mil) or thicker. Integrated color anodized designation AA-M10-C22-A32, Architectural Class 0.010 to 0.018 mm (0.4 to 0.7 mil). Electrolytically deposited color - anodized designation AA-M10-C22-A34, Architectural Class II 0.010 to 0.018 mm (0.4 to 0.7 mil).

2.6 ORGANIC COATING

Surfaces shall be cleaned, primed, and given a semi-gloss baked enamel or two-component acrylic polyurethane finish in accordance with NAAMM AMP 505 with total dry film thickness not less than 0.030 mm (1.2 mils).

2.7 STEEL PRODUCTS

Structural steel products shall conform to ASTM A 36(M) KS D 3503. Sheet and strip steel products shall conform to ASTM A 570(M) or KS D 3506. Welding for steel products shall conform to AWS D1.2.

2.8 CAST BRONZE

Components shall be fabricated with sharp corners, flat faces, and accurate profiles. Burrs and rough spots shall be removed and polished. Faces shall be finished to a uniform high luster. Cast bronze shall be in accordance with ASTM B 62.

2.9 VINYL SHEETING FOR GRAPHICS

Vinyl sheeting shall be 5 to 7 year premium type and shall be in accordance with the flammability requirements of ASTM E 84 and shall be a minimum 0.08 mm (0.003 inch) film thickness. Film shall include a precoated pressure sensitive adhesive backing, Class 1, or positionable pressure sensitive adhesive backing, Class 3.

2.10 GLASS

Glass shall be in accordance with ASTM C 1036, Type I, Class 1, Quality q3 and ANSI Z97.1.

2.11 FIBER-REINFORCED POLYESTER (FRP) PANELS

Fiber-reinforced polyester (FRP) shall be in accordance with ASTM D 3841, Type II, Grade 1, Class 124 or as indicated.

2.12 ACRYLIC SHEET

Acrylic sheet shall be in accordance with the flammability requirements of ASTM E 84 and shall conform to ANSI Z97.1.

2.13 POLYCARBONATE SHEET

Polycarbonate sheet shall conform to SAE AMS 3611.

2.14 ANCHORS AND FASTENERS

Exposed anchor and fastener materials shall be compatible with metal to which applied and shall match in color and finish and shall be non-rusting, non-corroding, and non-staining. Exposed fasteners shall be tamper-proof.

2.15 SHOP FABRICATION AND MANUFACTURE

2.15.1 Factory Workmanship

Work shall be assembled in the shop, as far as practical, ready for installation at the site. Work that cannot be shop assembled shall be given a trial fit in the shop to ensure proper field assembly. Holes for bolts and screws shall be drilled or punched. Drilling and punching shall produce clean, true lines and surfaces. Welding to or on structural steel shall be in accordance with AWS D1.1. Welding shall be continuous along the entire area of contact. Exposed welds shall be ground smooth. Exposed surfaces of work shall have a smooth finish and exposed riveting shall be flush. Fastenings shall be concealed where practical. Items specified to be galvanized shall be by hot-dip process after fabrication if practical. Galvanization shall be in accordance with ASTM A 123(M) and ASTM A 653(M), as applicable. Other metallic coatings of steel sheet shall be in accordance with ASTM A 924(M). Joints exposed to the weather shall be formed to exclude water. Drainage and weep holes shall be included as required to prevent condensation buildup.

2.15.2 Dissimilar Materials

Where dissimilar metals are in contact, or where aluminum is in contact with concrete, mortar, masonry, wet or pressure-treated wood, or absorptive materials subject to wetting, the surfaces shall be protected with a coat of asphalt varnish or a coat of zinc-molybdate primer to prevent galvanic or corrosive action.

2.15.3 Shop Painting

Surfaces of miscellaneous metal work, except nonferrous metal, corrosion resisting steel, and zinc-coated work, shall be given one coat of zinc-molybdate primer or an approved rust-resisting treatment and metallic primer in accordance with manufacturer's standard practice. Surfaces of items to be embedded in concrete shall not be painted. pon completion of work, damaged surfaces shall be recoated.

2.16 COLOR, FINISH, AND CONTRAST

Color of products shall be as indicated. For buildings required to be handicapped-accessible, the characters and background of signs shall be eggshell, matte, or other non-glare finish. Characters and symbols shall contrast with their background - either light characters on a dark background or dark characters on a light background.

PART 3 EXECUTION

3.1 INSTALLATION

Signs, plaques, or dimensional letters shall be installed in accordance with approved manufacturer's instructions at locations shown on the approved detail drawings. Circuits installed underground shall conform to the requirements of Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Steel conduits installed underground and illuminated signage mounted directly on buildings shall be in conformance with the requirements of Section 16415 ELECTRICAL WORK, INTERIOR. Signs shall be installed plumb and true at mounting heights indicated, and by method shown or specified. Signs mounted on other surfaces shall not be installed until finishes on such surfaces have been completed.

3.1.1 Anchorage

Anchorage and fastener materials shall be in accordance with approved manufacturer's instructions for the indicated substrate. Anchorage not otherwise specified or indicated shall include slotted inserts, expansion shields, and powder-driven fasteners when approved for concrete; toggle bolts and through bolts for masonry; machine carriage bolts for steel; lag bolts and screws for wood.

3.1.2 Protection and Cleaning

The work shall be protected against damage during construction. Hardware and electrical equipment shall be adjusted for proper operation. Glass, frames, and other sign surfaces shall be cleaned in accordance with manufacturer's instructions. After signs are completed and inspected, the Contractor shall cover all project identification, directional, and other signs which may mislead the public. Covering shall be maintained until instructed to be removed by the Contracting Officer. Signs shall be cleaned, as required, at time of cover removal.

3.2 FIELD PAINTED FINISH

Miscellaneous metals and frames shall be field painted in accordance with Section 09900 PAINTING, GENERAL. Anodized metals, masonry, and glass shall be protected from paint. Finish shall be free of scratches or other blemishes.

SECTION 10440

INTERIOR SIGNAGE

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF-45 (1997) Designation System for Aluminum Finishes

AA PK-1 (1999) Registration Record of Aluminum Association Alloy Designations and Chemical Composition Limits for Aluminum Alloys in the Form of Castings and Ingot

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 605 (1998) Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z97.1 (1984; R 1994) Safety Performance Specifications and Methods of Test for Safety Glazing Materials Used in Buildings

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 209	(1996) Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B 209M	(2000) Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B 221 (M)	(2000) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM C 1036	(1991; R 1997) Flat Glass

AMERICAN WELDING SOCIETY (AWS)

AWS D1.2	(1997) Structural Welding Code - Aluminum

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

KOREAN INDUSTRIAL STANDARDS (KS) PUBLICATIONS

KS D 6701	(2002) Aluminum and Aluminum Alloy Sheets and Plates, Strips and Coiled Sheets
KS D 6759	(2002) Aluminum and Aluminum alloy Extruded Shapes

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G.

Drawings showing elevations of each type of sign, dimensions, details and methods of mounting or anchoring, shape and thickness of materials, and details of construction. A schedule showing the location, each sign type, and message shall be included.

SD-03 Product Data

Installation; G.

Manufacturer's descriptive data, catalogs cuts, installation and cleaning instructions.

1.3 GENERAL

Interior signage shall be of the design, detail, sizes, types, and message content shown on the drawings, shall conform to the requirements specified, and shall be provided at the locations indicated. Signs shall be complete with lettering, framing as detailed, and related components for a complete installation.

1.3.1 Character Proportions and Heights

Letters and numbers on indicated signs in handicapped-accessible buildings, which do not designate permanent rooms or spaces, shall have a width-to-height ratio between 3:5 and 1:1 and a stroke-width-to-height ratio between 1:5 and 1:10. Characters and numbers on indicated signs shall be sized according to the viewing distance from which they are to be read. The minimum height is measured using an upper case letter "X". Lower case characters are permitted. Suspended or projected overhead signs shall have a minimum character height of 75 mm (3 inches).

1.3.2 Raised and Brailled Characters and Pictorial Symbol Signs (Pictograms)

Letters and numbers on indicated signs which designate permanent rooms and spaces in handicapped-accessible buildings shall be raised 0.8 mm (1/32 inch) upper case, sans serif or simple serif type and shall be accompanied with Grade 2 Braille. Raised characters shall be at least 16 mm (5/8 inch) in height, but no higher than 50 mm (2 inches). Pictograms shall be accompanied by the equivalent verbal description placed directly below the pictogram. The border dimension of the pictogram shall be 152 mm (6 inches) minimum in height. Indicated accessible facilities shall use the international symbol of accessibility.

1.4 QUALIFICATIONS

Signs, plaques, and dimensional letters shall be the standard product of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate signs that have been in satisfactory use at least 2 years prior to bid opening.

1.5 DELIVERY AND STORAGE

Materials shall be delivered to the jobsite in manufacturer's original packaging and stored in a clean, dry area in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 ROOM IDENTIFICATION/DIRECTIONAL SIGNAGE SYSTEM

Signs shall be fabricated of Type ES/MP laminated thermosetting plastic suitable for engraving or acrylic plastic conforming to ANSI Z97.1.

2.1.1 Standard Room Signs

Signs shall consist of matte finish acrylic plastic. Frames shall be aluminum or molded acrylic. Corners of signs shall be as shown.

2.1.2 Changeable Message Strip Signs

Changeable message strip signs shall consist of polycarbonate, cast acrylic, laminated thermosetting Type MP plastic or Type MP plastic captive message magnetic back face with message slots and associated end caps, as detailed, for insertion of changeable message strips. Size of signs shall be as shown on the drawings. Individual message strips to permit removal, change, and reinsertion shall be provided as detailed. Corners of signs shall be squared.

2.1.3 Type of Mounting For Signs

Extruded aluminum brackets, mounted as shown, shall be furnished for hanging, projecting, and double-sided signs. Mounting for framed, hanging, and projecting signs shall be by mechanical fasteners. Surface mounted signs shall be provided with 1.6 mm (1/16 inch) thick vinyl foam tape or countersunk mounting holes in plaques and mounting screws. Sign inserts shall be provided with 1.6 mm (1/16 inch) thick foam tape.

2.2 BUILDING DIRECTORIES

Building directories shall be lobby directories or floor directories, and shall be provided with a changeable directory listing consisting of the areas, offices and personnel located within the facility. Dimensions, details, and materials of sign shall be as shown on the drawings. Where required, message content shall be as shown on drawings and schedule.

2.2.1 Header Panel

Header panel shall be acrylic with raised acrylic letters or as shown on the drawings.

2.2.2 Doors

2.2.2.1 Door Glazing

Door glazing shall be clear acrylic sheet 4.8 mm (3/16 inch) thick or clear polycarbonate sheet 4.8 mm (3/16 inch) thick.

2.2.2.2 Door Construction

Extruded aluminum door frame shall be of same finish as surrounding frame. Corners shall be mitered, welded, and assembled with concealed fasteners. Hinges shall be standard with the manufacturer, in finish to match frames and trim. Glazing shall be set in frame with resilient glazing channels.

2.2.2.3 Door Locks

Door locks shall be manufacturer's standard, and shall be keyed alike.

2.2.3 Fabrication

Extruded aluminum frames and trim shall be assembled with corners reinforced or welded and mitered to a hairline fit, with no exposed fasteners.

2.2.4 Illuminated Units

Illuminated directory units shall have concealed internal top lighting with rapid start fluorescent tube lamp, internal wiring, and lead at wire for connection. Electrical work shall comply with NFPA 70 and shall be UL or FM listed.

2.2.5 Negative Graphics Directory System

Directory shall consist of internally illuminated unit with backlit photo negative directory strips and a black background. Unit shall have a tinted tempered safety solar glass door. Design of unit shall be as shown.

2.2.5.1 Construction

The directory shall be constructed of an aluminum 100 or 150 mm (4 or 6 inch) deep frame with satin black, dark bronze anodized finish. Unit shall be semi or fully recessed pedestal mounted. Unit shall have a 75 mm (3 inch) high header lettering or as shown on the drawings. Unit shall have a 9.3 mm (3/8 inch) face door frame with concealed hinges and locking system. Door frame shall be aluminum with dark bronze or solid chrome plated brass or as indicated.

2.2.5.2 Message Strips

Message strips shall be photo negative type updatable by user with book reordering and with 7 to 10 day delivery. Message strips shall be as shown on the drawings.

2.2.6 Changeable Letter/Message Strip Directory System

Directory shall consist of a non-illuminated unit with laminated plastic magnetic back message strips or as shown on the drawings. Design of unit shall be as shown in the drawings.

2.3 ALUMINUM ALLOY PRODUCTS

Aluminum extrusions shall be at least 3 mm (1/8 inch) thick, and aluminum plate or sheet shall be at least 1.3 mm (0.0508 inch) thick. Extrusions shall conform to ASTM B 221(M) or KS D 6759, plate and sheet shall conform to ASTM B 209(M) or KS D 6701. Where anodic coatings are specified, alloy shall conform to AA PK-1 alloy designation 514.0. Exposed anodized aluminum finishes shall be as shown. Welding for aluminum products shall conform to AWS D1.2.

2.4 ANODIC COATING

Anodized finish shall conform to AA DAF-45 as follows:

Clear (natural) designation AA-M10-C22-A31, Architectural Class II 0.010 mm (0.4 mil) or thicker. Integral color anodized designation AA-M10-C22-A32, Architectural Class 0.010 to 0.018 mm (0.4 to 0.7 mil). Electrolytically deposited color-anodized designation AA-M10-C22-A34, Architectural Class II 0.010 to 0.018 mm (0.4 to 0.7 mil).

2.5 ORGANIC COATING

Organic coating shall conform to AAMA 605, with total dry film thickness not less than 0.030 mm (1.2 mils).

2.6 FABRICATION AND MANUFACTURE

2.6.1 Factory Workmanship

Holes for bolts and screws shall be drilled or punched. Drilling and punching shall produce clean, true lines and surfaces. Exposed surfaces of work shall have a smooth finish and exposed riveting shall be flush. Fastenings shall be concealed where practicable.

2.6.2 Dissimilar Materials

Where dissimilar metals are in contact, the surfaces will be protected to prevent galvanic or corrosive action.

2.7 COLOR, FINISH, AND CONTRAST

Color shall be as shown on the drawings. In buildings required to be handicapped-accessible, the characters and background of signs shall be eggshell, matte, or other non-glare finish. Characters and symbols shall contrast with their background - either light characters on a dark background or dark characters on a light background.

PART 3 EXECUTION

3.1 INSTALLATION

Signs shall be installed in accordance with approved manufacturer's instructions at locations shown on the detail drawings. Illuminated signage shall be in conformance with the requirements of Section 16415 ELECTRICAL WORK, INTERIOR. Signs shall be installed plumb and true at mounting heights indicated, and by method shown or specified. Required blocking shall be installed as detailed. Signs which designate permanent rooms and spaces in handicapped-accessible buildings shall be installed on the wall adjacent to the latch side of the door. Where there is no wall space to the latch side of the door, including at double leaf doors, signs shall be placed on the nearest adjacent wall. Mounting location for such signage shall be so that a person may approach within 75 mm (3 inches) of signage without encountering protruding objects or standing within the swing of a door. Signs on doors or other surfaces shall not be installed until finishes on such surfaces have been installed. Signs installed on glass surfaces shall be installed with matching blank back-up plates in accordance with manufacturer's instructions.

3.1.1 Anchorage

Anchorage shall be in accordance with approved manufacturer's instructions. Anchorage not otherwise specified or shown shall include slotted inserts, expansion shields, and powder-driven fasteners when approved for concrete; toggle bolts and through bolts for masonry; machine carriage bolts for steel; lag bolts and screws for wood. Exposed anchor and fastener materials shall be compatible with metal to which applied and shall have matching color and finish. Where recommended by signage manufacturer, foam tape pads may be used for anchorage. Foam tape pads shall be minimum 2 mm (1/16 inch) thick closed cell vinyl foam with adhesive backing. Adhesive shall be transparent, long aging, high tech formulation on two sides of the vinyl foam. Adhesive surfaces shall be protected with a 0.13 mm (5 mil) green flatstock treated with silicone. Foam pads shall be sized for the signage as per signage manufacturer's recommendations. Signs mounted to painted gypsum board surfaces shall be removable for painting maintenance. Signs mounted to lay-in ceiling grids shall be mounted with clip connections to ceiling tees.

3.1.2 Protection and Cleaning

The work shall be protected against damage during construction. Hardware and electrical equipment shall be adjusted for proper operation. Glass, frames, and other sign surfaces shall be cleaned in accordance with the manufacturer's approved instructions.

SECTION 10800

TOILET ACCESSORIES

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 1036 (1991; R 1997) Flat Glass

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-2380 (Rev A)(Canc. Notice 1) Dispenser, Paper Towel

CID A-A-2398 (Rev BC); (Canc. Notice 1 Curtain, Shower and Window (Metric - SI)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Finishes; G. Accessory Items; G.

Manufacturer's descriptive data and catalog cuts indicating materials of construction, fasteners proposed for use for each type of wall construction, mounting instructions, operation instructions, and cleaning instructions.

SD-04 Samples

Finishes; G. Accessory Items; G.

One sample of each accessory proposed for use. Approved samples may be incorporated into the finished work, provided they are identified and their locations noted.

SD-10 Operation and Maintenance Data

Electric Hand Dryer;

Two complete copies of maintenance instructions listing routine maintenance procedures and possible breakdowns and repairs. Instructions shall include simplified wiring and control diagrams and other information necessary for unit maintenance.

1.3 DELIVERY, STORAGE, AND HANDLING

Toilet accessories shall be wrapped for shipment and storage, delivered to the jobsite in manufacturer's original packaging, and stored in a clean, dry area protected from construction damage and vandalism.

1.4 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period shall be provided.

PART 2 PRODUCTS

2.1 MANUFACTURED UNITS

Toilet accessories shall be provided where indicated in accordance with paragraph SCHEDULE. Porcelain type, tile-wall accessories are specified in Section 09310 CERAMIC TILE. Each accessory item shall be complete with the necessary mounting plates and shall be of sturdy construction with corrosion resistant surface.

2.1.1 Anchors and Fasteners

Anchors and fasteners shall be capable of developing a restraining force commensurate with the strength of the accessory to be mounted and shall be suited for use with the supporting construction. Exposed fasteners shall be of tamperproof design and shall be finished to match the accessory.

2.1.2 Finishes

Except where noted otherwise, finishes on metal shall be provided as follows:

Metal	Finish
Stainless steel	No. 4 satin finish
Carbon steel, copper alloy, and brass	Chromium plated, bright

2.2 ACCESSORY ITEMS

Accessory items shall conform to the requirements specified below.

2.2.1 Facial Tissue Dispenser (FTD)

Facial tissue dispenser shall be surface or recessed mounted, Type 304 stainless steel face, satin or bright polished finish. Face of recessed dispenser shall be secured by friction with suitable spring steel clips. Dispenser shall have a minimum capacity of 150 two-ply tissues.

2.2.2 Grab Bar (GB)

Grab bar shall be 18 gauge, 32 mm (1-1/4 inches) OD Type 304 stainless steel. Grab bar shall be form and length as indicated. Exposed mounting flange shall have mounting holes concealed. Grab bar shall have satin finish or peened non-slip surface. Installed bars shall be capable of withstanding a 2.225 kN (500 pound) vertical load without coming loose from the fastenings and without obvious permanent deformation. Space between wall and grab bar shall be 38 mm (1-1/2 inch).

2.2.3 Medicine Cabinet (MC)

Medicine cabinet shall be constructed with cold-rolled carbon steel sheet of not less than 0.76 mm (0.03 inch) thick, formed from a single sheet of steel or shall have mechanically formed spot welded or any other suitable joints. Width, height and depth of cabinet shall be in accordance with paragraph SCHEDULE.

2.2.3.1 Sliding Door Cabinet, Class 1

Sliding door cabinet assembly shall be surface mounted vanity or recessed cabinet with design and lighting arrangement as indicated. Cabinet shall have a minimum of 2 shelves. The mirror shall have a wide frame, narrow frame or no frame as indicated.

2.2.3.2 Swinging Door Cabinet, Class 2

Swinging door cabinet assembly including the lighting arrangement shall be as indicated. Assembly shall be surface or recess mounted. Cabinet shall be located centrally behind the door and shall contain a minimum of two shelves. Door hinges shall be stainless steel or carbon steel. Magnets used in door catches shall be permanent type. Doors shall be with a mirror.

2.2.4 Mirrors, Glass (MG)

Glass for mirrors shall be Type I transparent flat type, Class 1-clear. Glazing Quality q1 6 mm (1/4 inch) thick conforming to ASTM C 1036. Glass shall be coated on one surface with silver coating, copper protective coating, and mirror backing paint. Silver coating shall be highly adhesive pure silver coating of a thickness which shall provide reflectivity of 83 percent or more of incident light when viewed through 6 mm (1/4 inch) thick glass, and shall be free of pinholes or other defects. Copper protective coating shall be pure bright reflective copper, homogeneous without sludge, pinholes or other defects, and shall be of proper thickness to prevent "adhesion pull" by mirror backing paint. Mirror backing paint shall consist of two coats of special scratch and abrasion-resistant paint and shall be baked in uniform thickness to provide a protection for silver and copper coatings which will permit normal cutting and edge fabrication.

2.2.5 Mirror, Metal (MM)

Metal mirror shall be bright polished stainless steel, mirror quality, 0.94 mm (0.037 inch) minimum thickness, edges turned back 6 mm (1/4 inch) and recess fitted with tempered hardboard backing, and theft-proof fasteners. Size shall be in accordance with paragraph SCHEDULE.

2.2.6 Mirror, Tilt (MT)

Tilt mirror shall be surface mounted and shall provide full visibility for persons in a wheelchair. Mirror shall have adjustable or fixed tilt, extending at least 100 mm (4 inches) from the wall at the top and tapering to 25 mm (1 inch) at the bottom. Size shall be in accordance with the drawings. Glass for mirrors shall conform to ASTM C 1036 and paragraph Glass Mirrors.

2.2.7 Paper Towel Dispenser (PTD)

Paper towel dispenser shall conform to CID A-A-2380, Type I, II or III, shall be constructed of not less than 0.683 mm (0.269 inch) Type 304 stainless steel, and shall be surface or recessed mounted. Dispenser shall have a towel compartment. Locking mechanism shall be tumbler key lock or concealed tumbler key lock.

2.2.8 Combination Paper Towel Dispenser/Waste Receptacle Units (PTDWR)

Dispenser/receptacle shall be recessed or semi-recessed and shall have a minimum capacity of 400 sheets of C-fold, single-fold, or quarter-fold towel. Waste receptacle shall be designed to be locked in unit and removable for service. Locking mechanism shall be tumbler key lock. Waste receptacle shall have a capacity of minimum 45 L (12 gallons). Unit shall be fabricated of not less than 0.8 mm (0.30 inch) stainless steel welded construction with all exposed surfaces having a satin finish. Waste receptacle that accepts reusable liner standard for unit manufacturer shall be provided.

2.2.9 Shower Curtain (SC)

Shower curtain shall conform to CID A-A-2398, Style I, size to suit conditions. Curtain shall be anti-bacterial nylon/vinyl fabric. Color shall be as shown on the drawings.

2.2.10 Shower Curtain Rods (SCR)

Shower curtain rods shall be Type 304 stainless steel 32 mm (1-1/4 inch) OD by 1.24 mm (0.049 inch) minimum straight or bent as required to meet installation conditions.

2.2.11 Soap Dispenser (SD)

Soap dispenser shall be lavatory mounted, liquid type consisting of a polyethylene tank with a minimum 0.94 L (32 fluid ounces) holding capacity and a 100 mm (4 inch) or 150 mm (6 inch) spout length.

2.2.12 Soap Holder (SH)

Soap holder shall be surface mounted or recessed Type 304 stainless steel. Separate supports shall be stainless steel.

2.2.13 Shelf, Metal, Heavy Duty (SMHD)

Heavy duty metal shelf shall be minimum of 18 gauge stainless steel with hemmed edges. Shelves over 750 mm (30 inches) shall be provided with intermediate supports. Supports shall be minimum of 16 gauge, shall be welded to the shelf, and shall be spaced no more than 750 mm (30 inches) apart.

2.2.14 Shelf, Metal, Light Duty (SMLD)

Light duty metal shelf shall be supported between brackets or on brackets. Brackets shall prevent lateral movement of the shelf. Shelf shall be 450 mm (18 inches) long. Shelf and brackets shall be stainless steel.

2.2.15 Towel Bar (TB)

Towel bar shall be stainless steel with a minimum thickness of 0.38 mm (0.015 inch). Bar shall be minimum 19 mm (3/4 inch) diameter, or 16 mm (5/8 inch) square. Finish shall be satin.

2.2.16 Towel Pin (TP)

Towel pin shall have concealed wall fastenings, and a pin integral with or permanently fastened to wall flange. Maximum projection shall be 100 mm (4 inches). Design shall be consistent with design of other accessory items. Finish shall be satin.

2.2.17 Toilet Tissue Dispenser (TTD)

Toilet tissue holder shall be Type II - surface mounted or Type III - recess mounted with two rolls of standard tissue mounted horizontally or stacked vertically. Cabinet shall be stainless steel, satin finish.

2.2.18 Toilet Seat Cover Dispenser (TSCD)

Toilet seat cover dispensers shall be Type 304 stainless steel and shall be recessed mounted or surface mounted. Dispenser shall have a minimum capacity of 500 seat covers.

2.2.19 Electric Hand Dryer (EHD)

Electric hand dryer shall be wall mounted and shall be designed to operate on 110/125 volts, 60 cycle, single phase alternating current with a heating element core rating of not more than 2100 watts. Dryer housing shall be of single piece construction and shall be chrome plated steel or baked electrostatically applied epoxy.

PART 3 EXECUTION

3.1 INSTALLATION

Toilet accessories shall be securely fastened to the supporting construction in accordance with the manufacturer's approved instructions. Accessories shall be protected from damage from the time of installation until acceptance.

3.2 CLEANING

Material shall be cleaned in accordance with manufacturer's recommendations. Alkaline or abrasive agents shall not be used. Precautions shall be taken to avoid scratching or marring of surfaces.

DIVISION 12 FURNISHINGS

SECTION 12320

CABINETS AND COUNTERTOPS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z124.3 (1995) American National Standard for Plastic Lavatories.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 570 (1995) Water Absorption of Plastics

ASTM D 638 (1997) Tensile Properties of Plastics

ASTM D 2583 (1995) Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor

ASTM E 84 (1997a) Surface Burning Characteristics of Building Materials

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

BHMA A156.9 (1994) Cabinet Hardware

KITCHEN CABINET MANUFACTURERS ASSOCIATION (KCMA)

KCMA A161.1	(1995) Performance & Construction Standards for Kitchen and Vanity Cabinets

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA LD 3	(1995) High-Pressure Decorative Laminates

1.2 DESIGN

Cabinets shall be wood, factory-fabricated and finished in the manufacturer's standard sizes and finishes of the type, design, and configuration indicated. Cabinets shall be constructed as specified and shall meet the requirements of KCMA A161.1. Wall and base cabinet assemblies shall consist of individual units joined into continuous sections. Fastenings shall be accomplished to permit removal and replacement of individual units without affecting the remainder of the installation. Counters shall be provided with watertight sink rim when indicated. Drawers shall be removable and shall be equipped with position stops to avoid accidental complete withdrawals. Shelves shall be fixed or adjustable as indicated.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation; G.

Drawings showing each type of cabinet and related item, and clearly indicating the complete plan, location, and elevations of the cabinets and accessories and pertinent details of construction, fabrication, and attachments.

SD-03 Product Data

Cabinets; G. Countertops and Backsplash; G.

Manufacturer's printed data, catalog cuts, installation and cleaning instructions.

SD-04 Samples

Cabinets; G. Countertops and Backsplash; G.

In lieu of individual samples, complete minimum size cabinets may be furnished as samples. Mock-up units are not acceptable. Samples shall be of sufficient size to show color, pattern, and method of assembly.

a. Countertop and backsplash - One section, containing both.

b. Door and drawer front - One of each, with hardware mounted.

c. Countertop color samples approximately 50 x 75 mm (2 x 3 inches) size.

d. Stain/color samples approximately 50 x 75 mm (2 x 3 inches) size.

SD-06 Test Reports

Cabinets and Countertops;

Test reports certifying that all cabinets comply with the requirements of KCMA A161.1. Tests shall be conducted by independent laboratories approved by KCMA. KCMA certification seals affixed to the cabinets will be accepted in lieu of certified test reports.

1.4 DELIVERY AND STORAGE

Cabinets shall be delivered to the jobsite wrapped in a protective covering. Cabinets shall be stored in accordance with manufacturer's recommendations in an adequately ventilated, dry location that is free of dust, water, or other contaminants and in a manner to permit access for inspection and handling. Cabinets shall be handled carefully to prevent damage to the surfaces. Damaged items that cannot be restored to like-new condition shall be replaced.

PART 2 PRODUCTS

2.1 CABINETS

Wall and base cabinets shall be of the same construction and same outside appearance. Door design shall be solid flush face, framed inset hardwood panels or glass face from vendors standard styles. Corner cabinets shall be equipped with notched shelving or full circle shelves as indicated. Shelves shall be fixed or fully adjustable as indicated. Adjustable shelves shall be capable of adjusting on approximately 75 mm (3 inch) increments. Shelves shall be supported by self-locking clips or wood dowels. Dowels shall be approximately 8 mm (5/16 inch) in diameter by 40 mm (1-9/16 inches) long. Dowels shall be inserted into borings for the shelf adjustments. Shelves shall be minimum 13 mm (1/2 inch) thick plywood or minimum 13 mm (1/2 inch) thick 20 kg (45 pound) density particle board. Drawer fronts shall be 20 kg (45 pound) density particle board or hardwood plywood to match cabinet door construction or 19 mm (3/4 inch) thick solid hardwood frame with hardwood plywood panel as indicated.

2.1.1 Frame Type Cabinets

The cabinets shall be constructed with frame fronts and solid ends, or frame construction throughout. Frame members shall be 19 mm (3/4 inch) thick by 38 mm (1-1/2 inch) wide; kiln-dried hardwood, glued together, and shall be either mortised and tenoned, dovetailed or doweled, nailed, stapled or screwed. Top and bottom corners shall be braced with either hardwood blocks that are glued together with water resistant glue and nailed in place, or metal or plastic corner braces. Backs of wall cabinets shall be 3 mm (1/8 inch) thick plywood, tempered hardboard or 9 mm (3/8 inch) thick, 20 kg (45 pound) density particle board. Backs of base and tall cabinets shall be 9 mm (3/8 inch) thick hardwood or 9 mm (3/8 inch) thick, 20 kg (45 pound) density particle board. Bottoms of cabinets shall be minimum 9 mm (3/8 inch) thick plywood 20 kg (45 pound) density particle board or sound grade plywood and shall be braced with wood members glued in place. Cabinet ends shall be 16 mm (5/8 inch) thick hardwood plywood or 16 mm (5/8 inch) thick, 20 kg (45 pound) density particle board core.

2.1.2 Frameless Type Cabinets

The cabinets shall be of frameless design and construction. Cabinets shall be constructed of minimum 16 mm (5/8 inch) thick, 20 kg (45 pound) density particle board end and floor panels. Cabinet back shall be constructed of minimum 5 mm (3/16 inch) thick, 20 kg (45 pound) density particle board. Hanging rails shall be doweled and glued to end panels, then fastened and hot melt glued to cabinet back. Toe kick plates shall be recessed, doweled and glued to the end panels. Top and bottom corners shall be braced with either hardwood blocks glued together with water resistant glue and nailed in place, or fastened with metal or plastic corner braces.

2.2 COUNTERTOPS AND BACKSPLASH

2.2.1 High-Pressure Laminated Plastic Clad Countertops

Clad countertop and backsplash shall be constructed of 19 mm (3/4 inch) thick plywood or 19 mm (3/4 inch) thick, 20 kg (45 pound) density particle board core and shall be post formed cove type or fully formed type. Fully formed type or square edge shall be a unit with shaped edges using wood nose molding at counter edge and shall include a separate backsplash. Backsplash shall be not less than 90 mm (3-1/2 inches) high. Edging and trim shall consist of plastic laminate cut and fitted to all exposed edges. End splashes constructed of 19 mm (3/4 inch) plywood or 19 mm (3/4 inch) thick, 20 kg (45 pound) density particle board core shall be supplied. Continuous sheets of longest lengths practicable shall be provided. Joints in surface sheeting shall be tight and flush and held to a practicable minimum. When the countertop and backsplash are two separate units, GP50 plastic laminate shall be used. When the countertop and backsplash are one unit, PF42 plastic laminate shall be used. Plastic laminate shall conform to the requirements of NEMA LD 3 and plastic laminate adhesive shall be contact type applied to both surfaces. For fully formed and cove type countertops, the post-forming plastic laminate shall not be bent to a radius smaller than the limit recommended by the plastic manufacturer.

2.2.2 Solid Polymer Countertops

Countertop and backsplash shall be constructed with integral sink and lavatory of sheet material for sink/lavatory cutout; as shown. Material shall be 19 mm (3/4 inch) thickness, cast, and filled nonporous solid surfacing composed of acrylic polymer, mineral fillers, and pigments. Superficial damage to a depth of 0.25 mm (0.010 inch) shall be repairable by sanding or polishing. Material shall comply with the following performance requirements.

a. Tensile Strength; 18.3 N/mm^2 (4100 psi), when tested in accordance with ASTM D 638.

b. Hardness; Barcol Impressor 50 when tested in accordance with ASTM D 2583.

c. Flammability; rated Class I with a flame spread of 25 maximum and a smoke developed of 100 maximum when tested in accordance with ASTM E 84.

d. Boiling water resistance; no effect when tested in accordance with NEMA LD 3.

e. High temperature; no effect when tested in accordance with NEMA LD 3.

f. Liquid absorption; 0.06% maximum (24 hours) when tested in accordance with ASTM D 570.

g. Sanitation; National Sanitation Foundation approval for food contact in accordance with Standard 51 and approval for food area applications.

h. Impact resistance; no failure for ball drop when tested in accordance with NEMA LD 3.

2.2.3 Solid Polyester Resin Cultured Marble Counter Tops

Countertop and backsplash shall be constructed with integral sink and lavatory of sheet material for sink/lavatory cutout; as shown. Material shall be 12.7 mm (1/2 inch) thickness, cast, and filled nonporous solid surfacing composed of polyester resin crushed marble, glass frit, mineral fillers and pigments. Material shall comply with ANSI Z124.3 and the following performance requirement. Flammability shall comply with Class I, flame spread of 25 maximum and a smoke developed of 100 maximum when tested in accordance with ASTM E 84.

2.3 Sink/Lavatory Rims

Sink/lavatory rims shall be of the corrosion resistant steel clamping type, sized to the sink, type as shown, and a standard product of a manufacturer regularly producing this type of equipment.

2.4 FINISH

2.4.1 Cabinet Finish

Cabinets shall be provided with a factory-applied durable finish in accordance with KCMA A161.1 requirements and of a type standard with the manufacturer. Natural finish wood doors, drawer fronts, cabinet fronts, and exposed cabinet sides shall be fabricated of wood which will be free of extreme color variations within each panel or between adjacent panels. Exposed exterior surfaces shall be hardwood or grade A-A hardwood veneer with natural stain and sprayed on factory applied finish or melamine plastic finish.

2.4.2 Melamine Laminated Interior Cabinet Finish

Plywood, particle board or tempered hardboard cabinet backs shall be finished with a melamine laminate on the exposed side. Particle board shelves shall be covered on both sides with a laminated melamine finish. Melamine laminate shall conform to the requirements of NEMA LD 3 and laminate adhesive shall be contact type applied to both surfaces.

2.4.3 Backer Sheets

Backer Sheets of high pressure plastic laminate, shall conform to NEMA LD 3, Grade BK20 and shall be applied to the underside of all core material.

2.5 HARDWARE

Hardware shall conform to BHMA A156.9, shall be suitable for kitchen cabinet use, and shall include all miscellaneous hardware for a complete installation. Door hinges shall be self-closing type. Drawer runners shall have nylon rollers standard with the manufacturer. Hardware and fastenings for doors and drawers with particle board cores shall be of the through-bolt type. The types and finishes of hardware shall be as shown on the drawings.

2.6 COLOR, TEXTURE, AND PATTERN

Design, color, and finish shall be as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Cabinets shall be installed level, plumb, and true to line, and shall be attached to the walls or floors with suitable devices to securely anchor each unit. Countertops, accessories, and hardware shall be installed as indicated on the drawings. Installation shall be in accordance with the manufacturer's approved printed instructions. The inner edge of sink cut-outs in laminated plastic tops shall be painted with a coat of semigloss enamel paint and sink flanges shall be set in a bed of sealant. Closer and filler strips and finish moldings shall be provided as required. Prior to final acceptance, doors shall be aligned, and hardware shall be adjusted.

3.2 CLEANING

Cabinet and countertop surfaces shall be cleaned in accordance with manufacturer's instructions.

SECTION 12490

WINDOW TREATMENT

TABLE OF CONTENTS

PART 1 WORK DESCRIPTION

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS AA-V-00200 (Rev B) Venetian Blinds

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 701 (1996) Methods of Fire Tests for Flame-Resistant Textiles and Films

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Approved Detail Drawings; G.

Drawings showing fabrication and installation details. Drawings shall show layout and locations of track, direction of draw, mounting heights, and details.

SD-03 Product Data

Window Treatments; G. Hardware; G.

Manufacturer's data composed of catalog cuts, brochures, product information, and maintenance instructions.

SD-04 Samples

Window Treatments; G.

Two samples of each type and color of window treatment. Blind slats or louvers shall be 150 mm (6 inches) in length for each color. Track shall be 150 mm (6 inches) in length. Shade material shall be minimum 150 x 150 mm (6 x 6 inches) in size.

1.3 GENERAL

Window treatment shall be provided, complete with necessary brackets, fittings, and hardware. Each window treatment type shall be a complete unit provided in accordance with paragraph WINDOW TREATMENT PLACEMENT SCHEDULE. Equipment shall be mounted and operated as indicated. Windows to receive a treatment shall be completely covered. The Contractor shall take measurements at the building and shall be responsible for the proper fitting and hanging of the equipment.

1.4 DELIVERY, STORAGE, AND HANDLING

Components shall be delivered to the jobsite in the manufacturer's original packaging with the brand or company name, item identification, and project reference clearly marked. Components shall be stored in a dry location that is adequately ventilated and free from dust, water, or other contaminants and shall have easy access for inspection and handling. Materials shall be stored flat in a clean dry area with temperature maintained above 10 degrees C (50 degrees F).

1.5 FIELD MEASUREMENTS

The Contractor shall become familiar with details of the work, verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.6 WARRANTY

Manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period shall be provided.

PART 2 PRODUCTS

2.1 WINDOW BLINDS

Each blind, including hardware, accessory items, mounting brackets and fastenings, shall be provided as a complete unit produced by one manufacturer. All parts shall be one color unless otherwise shown, and match the color of the blind slat. Steel features shall be treated for corrosion resistance.

2.1.1 Horizontal Blinds

Horizontal blinds shall conform to FS AA-V-00200, Type II 25 mm (1 inch) slats except as modified below. Blind units shall be capable of nominally 180 degree partial tilting operation and full-height raising. Blinds shall be inside or outside mount as shown.

2.1.1.1 Head Channel and Slats

Head channel shall be steel or aluminum nominal 0.61 mm (0.024 inch) for Type II. Slats shall be aluminum, not less than 0.152 mm (0.006 inch) thick, and of sufficient strength to prevent sag or bow in the finished blind. A sufficient amount of slats shall be provided to assure proper control, uniform spacing, and adequate overlap.

2.1.1.2 Controls

The slats shall be tilted by a transparent tilting wand, hung vertically by its own weight, and shall swivel for easy operation. The tilter control shall be of enclosed construction. Moving parts and mechanical drive shall be made of compatible materials which do not require lubrication during normal expected life. The tilter shall tilt the slats to any desired angle and hold them at that angle so that any vibration or movement of ladders and slats will not drive the tilter and change the angle of slats. A mechanism shall be included to prevent over tightening. The wand shall be of sufficient length to reach to within 1500 mm (5 feet) of the floor.

2.1.1.3 Intermediate Brackets

Intermediate brackets shall be provided for installation of blinds over 1200 or 1500 mm (48 or 60 inches) wide and shall be installed as recommended by the manufacturer.

2.1.1.4 Hold-Down Brackets

Universal type hold-down brackets for sill or jamb mount shall be provided.

2.1.2 Vertical Blinds

Vertical blind units shall be capable of nominally 180 degree partial tilting operation and full stackback. The blinds shall be listed by the manufacturer as designed for heavy duty strength applications including heavy duty hardware. Vertical blinds shall be ceiling or wall mounted with outside or inside brackets as shown. Blinds shall be sill or floor length. Outside mount type installation shall provide adequate overlap to control light and privacy.

2.1.2.1 Louvers

Solid vinyl louvers shall be fire resistant, UV stable, impact resistant, and shall not emit corrosive fumes in a fire. Louvers shall have a bottom chain. Fabric louvers shall be inherently flame retardant. The louvers shall have straight, flat, unfrayed edges and shall be flat, without noticeable twists. A weight shall be provided at the bottom of the louver. The insert shall not discolor the fabric. Louvers shall have a bottom chain. Groovers shall be extruded from solid vinyl with clear non-yellowing channel lips to accept fabric inserts. Fabric inserts shall be flame retardant and colorfast. 88.9 mm (3-1/2 inch) louvers shall overlap not less than 10 mm 3/8 inch or 50 mm (2 inch) louvers shall overlap not less than 6 mm (1/4 inch) and shall be dimensionally stable.

2.1.2.2 Carriers

Carriers shall be provided to support each louver. Carriers shall be of molded plastic and shall transverse on self-fabricated wheels for smooth, easy operation. The hook of the carrier shall have an automatic latch to permit easy installation and removing of the louver, and shall securely lock the louver for tilting and traversing.

2.1.2.3 Headrail System

Headrail system shall be not less than 1.19 mm (0.047 inch) thickness and shall be made of anodized aluminum alloy or 0.635 mm (0.027 inch) thick phosphate treated steel with a baked on ivory gloss enamel paint finish. The headrail shall extend the full width of the blind and each end shall be closed with an end cap. One cap shall contain the traversing and tilting controls. The opposite cap shall house the pulley for the traversing cord.

2.1.2.4 Cornice, Fascia, or Valance

Manufacturers standard cornice, fascia, or valance shall be attached to the headrail by metal or plastic holders which grip the top and bottom edge of the valance and shall accept an insert of the same material as the slats. There shall be sufficient clearance behind the valance to permit the louvers to tilt without interference. The headrail cover shall extend the full width of the blind. Returns shall be formed of a single piece where the end of the head is visible.

2.1.2.5 Controls

Tilting control and traversing controls shall hang compactly at the right or left side of the blinds and shall reach within 1500 mm (5 feet) of the floor. The tilt/traverse control baton, or bead chain tilting control shall tilt all vanes simultaneously to any desired angle and hold them at that angle. The louvers shall traverse one way to the right or left, or two-way split. The traversing control cord shall be minimum 1.78 mm (0.070 inch) in diameter with a minimum breaking strength of 556 N (125 pounds). The cord shall be anchored to a lead carrier which shall be linked to all adjacent carriers. The louvers shall be traversed along the headrail by pulling one side of the looped cord. A weighted pulley shall be provided at the bottom of the cord or a fiberglass wand shall tilt the louvers by turning the wand and shall traverse the louvers by using the wand as a drapery baton.

2.1.2.6 Connectors and Spacers

The connector shall be flexible, smooth and flat to slide unhindered when carriers move independently of each other, and to nest compactly when carriers are stacking. The length of the links shall relate to the louver width in order to equally space the traversing louvers, to maintain uniform and adequate overlap of louvers, and to fully cover the width of the opening.

2.1.2.7 Intermediate Brackets

Intermediate installation brackets shall be furnished for blinds over 1575 mm (62 inches) wide.

2.2 WINDOW SHADES

Roller tube shall operate smoothly and be of sufficient diameter and thickness to prevent excessive deflection. Brackets shall be provided that are appropriate for inside, outside or ceiling mount. The shade cloth shall meet the performance described in NFPA 701, small scale test. Steel features shall be treated for corrosion resistance.

2.2.1 Light Filtering Shades

Light filtering shades shall conform to the following: Roller tube shall be wood or steel and shall operate by spring or clutch and bead operation mechanism. Fascia mounting brackets shall be steel to support roller tube and fascia panel. The fascia panel shall be channel shaped extruded aluminum with standard enamel finish. The shade shall be made from a single piece of pvc coated fiberglass cloth.

2.2.2 Room Darkening Shades

Room darkening (black-out) window shades shall conform to the following: Roller tube shall be aluminum and shall be controlled by webbing tape or crank operated gear box with steel rods. Light traps shall be shop fabricated, and shall consist of a head box to house the shade roller, and U-shaped channels to serve as guides for the shade along the sides and to receive the bottom edge of the shade along the sill. Light trap shall be made of sheet steel having a minimum thickness of 0.85 mm (22 gauge) or anodized, extruded, aluminum. The legs of the channels shall be not less than 44 mm (1-3/4 inches) long and separated by the minimum distance that will permit free operation of the shade. Edges of light trap coming into contact with the shade cloth shall be smooth pile light seal. The exposed face of the head box shall be hinged or removable for access to the shade roller. The interior or unexposed surfaces of the light trap shall have a finish coat of flat black enamel. The exposed portions of the light trap shall have a factory-applied anodized bronze or clear finish as shown. Shade roller shall be manufacturer's standard product. Cloth shall be of type for blackout purposes. The shade shall be made from a single piece of canvas duck cloth laminated to vinyl. When not finished with a selvage, the vertical edges of the shade shall be bound or hemmed using a high-grade thread. Needle holes shall be made lightproof by applying a suitable filler. The bottom edge of the shade shall be fitted with a steel operating bar. Shades will engage positively with bottom rail through operating bar or chain pull. Bars shall be painted with flat black enamel. Pull cords shall be made of No. 4 braided nylon or beaded chain having not less than 335 N (175 pounds) breaking strength.

2.3 COLOR

Color shall be as shown on the drawings.

PART 3 EXECUTION

3.1 WINDOW TREATMENT PLACEMENT SCHEDULE

Window covering shall be provided as indicated.

3.2 INSTALLATION

Installation shall be in accordance with the approved detail drawings and manufacturer's installation instructions. Units shall be level, plumb, secure, and at proper height and location relative to window units. The Contractor shall furnish and install supplementary or miscellaneous items in total, including clips, brackets, or anchorages incidental to or necessary for a sound, secure, and complete installation. Installation shall not be initiated until completion of room painting and finishing operations. Upon completion of the installation, window treatments shall be adjusted for form and appearance, shall be in proper operating condition, and shall be free from damage or blemishes. Damaged units shall be repaired or replaced by the Contractor as directed by the Contracting Officer.

STANDARD TECHNICAL SPECIFICATIONS

FOR

O&MA PROJECTS, KOREA

Volume III

October 1, 2003

DEPARTMENT OF THE ARMY
INSTALLATION MANAGEMENT AGENCY
KOREA REGION OFFICE

DIVISION 13 SPECIAL CONSTRUCTION

SECTION 13202

FUEL STORAGE SYSTEMS
(for supplying fuel oil to oil-burning appliance and equipment)

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-16 (1996) Standard Specifications for Highway Bridges

AMERICAN PETROLEUM INSTITUTE (API)

API RP 1110 (1997) Pressure Testing of Liquid Petroleum Pipelines

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36/A 36M	(2001) Carbon Structural Steel
ASTM A 194/A 194M	(2001a) Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
ASTM A 307	(2000) Carbon Steel Bolts and Studs, 60000 PSI Tensile Strength
ASTM C 33	(2001a) Concrete Aggregates
ASTM F 436 436M	(1993; R 2000) Hardened Steel Washers
ASTM F 1172	(1988; R 1998) Specification for Fuel Oil Meters of the Volumetric Positive Displacement Type
ASTM F 1199	(1988; R 1998) Cast (All Temperature and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)

ASME INTERNATIONAL (ASME)

ASME B31.3	(2002) Process Piping
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element
ASME BPV IX	(2001) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications

AMERICAN WELDING SOCIETY (AWS)

AWS A5.1	(1991)Carbon Steel Electrodes for Shielded Metal Arc Welding

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C203	(1997; Addenda C203a - 1999) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines – Enamel and Tape – Hot-Applied

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1993) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(1996) Pipe Hangers and Supports - Selection and Application

NACE INTERNATIONAL (NACE)

NACE RP0169	(1996) Control of External Corrosion on Underground or Submerged Metallic Piping Systems
NACE RP0185	(1996) Extruded, Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe

NACE RP0190	(1995) External Protective Coatings for Joints, Fittings, and Valves on Metallic Underground or Submerger PipeLines and Piping Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1997) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2000) Flammable and Combustible Liquids Code
NFPA 31	(2001) Standard for the Installation of Oil-Burning Equipment
NFPA 70	(2002) National Electrical Code

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6	(1994) Commercial Blast Cleaning

STEEL TANK INSTITUTE (STI)

STI F921	(1998) Standard for Aboveground Tanks with Integral Secondary Containment
STI R931	(2001) Double Wall Aboveground Storage Tank Installation & Testing Instructions

UNDERWRITERS LABORATORIES (UL)

UL Gas&Oil Dir	(2000) Gas and Oil Equipment Directory
UL 142	(1993; Rev Jul 1998) Steel Aboveground Tanks for Flammable and Combustible Liquids
UL 971	(1995) Standard for Nonmetallic Underground Piping for Flammable Liquids

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1503	(1999) Steel welding pipe flanges
KS B 1527	(2001) Pipe Supports
KS B 1531	(1997) Screwed Type Malleable Cast Iron Pipe Fittings
KS B 1533	(2000) Screwed Type Steel Pipe Fittings
KS B 1541	(1992) Steel Butt-Welding Pipe Fittings
KS B 1542	(1990) Steel Socket-Welding Pipe Fittings

KS B 1543	(1986) Steel Plate Butt-Welding Pipe Fittings
KS B 2308	(2002) Ball Valve
KS B 2361	(1991) Cast Steel Flanged Valves
KS D 3503	(1998) Rolled Steel For General Structural Purpose
KS D 3562	(1989) Carbon Steel Pipes For Pressure Service
KS D 3710	(2001) Carbon Steel Forging
KS D 4107	(1991) Steel Castings For High Temperature And High Pressure Service
KS M 3404	(2001) Unplasticized Polyvinyl Chloride Pipes for General Service
KS M 3410	(1997) Unplasticized Polyvinyl Chloride Pipe Fittings for Drain

1.2 SYSTEM DESCRIPTION

The work shall include the design, fabrication and installation of the aboveground fuel storage tank and piping in conformance with pertinent federal, state, and local code requirements. The completed installation shall conform to NFPA 30 and NFPA 31 as applicable.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fueling System; G

Detail drawings including a complete list of equipment and materials. Detail drawings shall contain:

a. Complete piping and wiring drawings and schematic diagrams of the overall system.

b. Equipment layout and anchorage.

c. Clearances required for maintenance and operation.

d. Any other details required to demonstrate that the system has been coordinated and will properly function as a unit.

Monitoring Systems; G

Detail drawings of the monitoring system including a complete list of equipment and materials. Drawings shall contain:

a. An overview drawing which details the leak detection system operation.

b. An overview drawing which details the liquid level and setpoint monitoring.

c. Single line diagrams of the system.

d. Panel layout along with panel mounting and support details.

SD-03 Product Data

Fueling System; G

Manufacturer's standard catalog data, prior to the purchase or installation of the particular component, highlighted to show brand name, model number, size, and options, etc., in sufficient detail to demonstrate compliance with contract requirements on all parts and equipment.

Spare Parts Data; G

Spare parts data for each different item of equipment specified, after approval of detail drawings and not later than 2 months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Installation

Manufacturer's installation instructions and procedures on all parts and equipment.

Framed Instructions; G

Framed instructions for posting, at least 2 weeks prior to construction completion.

Monitoring Systems; G

System diagrams for posting, at least 2 weeks prior to construction completion, including distance markings so that alarm indications can be correlated to leak location in plan view if a cable detection system is used. The diagrams shall include a piping and wiring display map with schematic diagrams from the leak detection system manufacturer. The diagrams shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

Tests

A letter, at least 10 working days in advance of each test, advising the Contracting Officer of the test. Individual letters shall be provided for each test specified herein.

Demonstrations

A letter, at least 14 working days prior to the proposed training date, scheduling a proposed date for conducting the onsite training.

Experience

A letter listing prior projects, the date of construction, a point of contact for each prior project, the scope of work of each prior project, and a detailed list of work performed. The letter shall also provide evidence of prior manufacturer's training, state licensing, and other related information.

Welding

A letter listing the qualifying procedures for each welder. The letter shall include supporting data such as test procedures used, what was tested to, etc., and a list of the names of all qualified welders and their identification symbols.

Verification of Dimensions

A letter stating the date the site was visited and a listing of all discrepancies found.

Fuel Supply

A letter, at least 120 days prior to fuel delivery, stating the amount of fuel required for testing, flushing, cleaning, or startup of the system. The letter shall define the required dates of each fuel delivery necessary.

Exterior Coating for Belowground Steel Piping

Certification, prior to performing the exterior coating tests, from the tester manufacturer of the electric holiday detector's latest calibration date and crest voltage testing.

SD-06 Test Reports

Tests; G

Six copies of each test containing the information described below in bound letter-size booklets. Individual reports shall be provided for the storage tank tests, the piping tests, the system performance tests, the high level alarm test, and the system leak tests. Drawings shall be folded blue lines, with the title block visible.

a. The date the tests were performed.

b. A list of equipment used, with calibration certifications.

c. A copy of measurements taken.

d. The parameters to be verified.

e. The condition specified for the parameter.

f. The inspection results, signed, dated, and certified by the installer. The certification shall state that required procedures were accomplished, that the procedures were conducted in compliance with the plans and specifications.

g. A description of adjustments performed.

SD-07 Certificates

Service Organization; G

A certified list of qualified permanent service organizations, which includes their addresses and qualifications, for support of the equipment.

SD-10 Operation and Maintenance Data

Operation Manuals; G

Six complete copies of operation manuals in bound letter-size booklets listing step-by-step procedures required for system startup, operation, and shutdown at least two weeks prior to the demonstrations. The manuals shall include the manufacturer's name, model number, service manual, a brief description of each piece of equipment, and the basic operating features of each piece of equipment. The manuals shall include procedures necessary for annual tightness testing of the storage tanks and secondary containment piping.

Maintenance Manuals; G

Six complete copies of maintenance manuals in bound letter-size booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide at least 2 weeks prior to the demonstrations. The manuals shall include piping, equipment layouts, and simplified wiring and control diagrams of the system as installed.

1.4 QUALIFICATIONS

1.4.1 Experience

Each installation Contractor shall have successfully completed at least 3 projects of the same scope and the same size or larger within the last 6 years. Each installation Contractor shall demonstrate specific installation experience in regard to the specific system installation to be performed. Each installation Contractor shall have taken, if applicable, manufacturer's training courses on the installation of piping, leak detection, and tank management systems and meet the licensing requirements in the state.

1.4.2 Welding

Welding shall be in accordance with qualifying procedures using performance qualified welders and welding operators. Welding tests shall be performed at the work site. Procedures and welders shall be qualified in accordance with ASME BPV IX. Each welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Structural members shall be welded in accordance with Section 05090 WELDING, STRUCTURAL.

1.5 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather and contamination. Proper protection and care of material before, during, and after installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Verification of Dimensions

After becoming familiar with all details of the project, the Contractor shall verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.6.2 Fuel Supply

Fuel required for the flushing, cleaning, and testing of materials, equipment, piping, meters, instruments, etc., as specified in this section shall be provided by the Contracting Officer. The Contractor shall provide the labor, equipment, appliances, and materials required for the flushing, cleaning, and testing operations. Systems shall not be flushed, cleaned, or tested with any fuel or liquid not intended for final system operation. Fuel used in the system shall remain the property of the Government. Fuel shortages not attributable to normal handling losses shall be reimbursed to the Government.

1.6.3 Safety Requirements

Exposed moving parts, parts that produce high operating temperatures and pressures, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract. System components shall be environmentally suitable for the indicated locations. The completed installation shall conform to the applicable requirements of NFPA 30 and NFPA 31.

2.2 NAMEPLATES

Parts and equipment specified herein shall have an attached nameplate to list the manufacturer's name, address, component type or style, model or serial number, catalog number, capacity or size, and the system which is controlled. Plates shall be durable and legible throughout equipment life and made of anodized aluminum or stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

Electrical equipment, motors, and wiring shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Electrical bonding of materials shall be performed in accordance with NFPA 70.

2.4 MATERIALS IN CONTACT WITH FUEL

Galvanized materials (zinc coated) shall not be allowed in direct contact with any fuel.

2.5 TANK

Tank shall be cylindrical double-wall construction. Tank system shall include a primary storage tank and an integral fully-enclosed secondary containment reservoir. Tank system shall be in accordance with NFPA 30 and NFPA 31. Tank system shall be designed and manufactured for horizontal installation in accordance with Steel Tank Institute Publication No. F921. Primary storage tank shall be constructed of single wall steel in accordance with UL 142. Containment reservoir shall be single-wall steel conforming to UL 142. The volume of the containment reservoir shall be greater than or equal to 110 percent of the primary tank volume. The primary storage tank shall be supported within the containment reservoir with steel tank saddles, or other similar supports, fabricated and attached by the tank manufacturer. Containment reservoir shall be equipped with a 75 mm (3 inch) drain that includes a full line size carbon steel drainage line and a full line size plug valve. Tank system shall be skid mounted and provided with lifting lugs which allow tank system relocation. Tank system shall include a 19 L (5 gallon) powder coated UL listed overfill containment which contains spillage of fuel during tank filling. The spill containment shall include normally closed valve to release spilled product into the primary steel tank. The tank system shall be provided with the manufacturer's standard ladder and platform assembly, except as modified herein. The assembly shall be constructed of structural steel and shall allow access to the top of the tank system. A molded neoprene isolation pad shall be provided under the skid.

2.5.1 Tank Exterior Protective Coating

Tank exterior protective coating shall be in accordance with Section 09900 PAINTINGS AND COATINGS.

2.5.2 Tank Interior Protective Coating

Tank shall be provided with an interior protective coating in accordance with API RP 1631 from the tank bottom up to 1 m (3 feet) off the bottom.

2.5.3 Tank Manway

Tank manway shall be provided with a manway cover and an interior tank ladder. Tank manway shall have an internal diameter of 760 mm (30 inches)for tanks of 3,780 to 45,430 L (1000 to 12,000 gallons) capacity and 915 mm (36 inch) for tanks larger than 45,430 L (12,000 gallons). Tank manway shall be provided with a matching flanged watertight manway cover. Manway covers shall be constructed of cast steel in accordance with ASTM A 27/A 27M, grade 60-30 as a minimum. Manhole covers shall be for nontraffic. Pipe connections to a tank through a manway cover shall be through welded-in-place double tapered NPT couplings. Tanks 3,780 L (1,000 gallons) and larger shall be provided with 1 tank manway to allow for internal tank access. Tanks larger than 18,900 L (5,000 gallons) shall be provided with 2 tank manways (1 manway for access, without piping penetrating through access manway). Interior tank ladder shall be constructed of either fiberglass or steel. If steel, the ladder shall be completely coated in the same fashion as the interior tank bottom coating. The two stringers shall be a minimum 10 mm (3/8 inch) thick and a minimum 50 mm (2 inches) wide. The rungs shall be a minimum 20 mm (3/4 inch) rod on 300 mm (12 inch) centers. Members of the ladder shall be securely affixed. Ladder shall be of sufficient length to extend from the bottom of the tank to the top surface of the tank. Ladder shall be rigidly connected to the tank bottom in accordance with the tank manufacturer's standard. Ladder shall be connected to the top of the tank with pipe guides or slip bars to accommodate expansion of the two stringers.

2.5.4 Tank Piping Penetrations

The number and size of tank piping penetrations shall be provided as indicated. Pipe penetrations shall enter through the top of a tank. Drains shall not be located at the bottom of a primary storage tank. Nylon dielectric bushings shall be provided on all pipe connections to a tank. Pipe connections to a tank shall be through welded-in-place double tapped NPT couplings. The termination of fill lines within a tank shall be cut at a 45 degree angle with the open end facing the long dimension of the tank and shall be provided with an anti-splash deflector.

2.5.5 Tank Cleanout and Gauge Connection

Tank shall be provided with a combination cleanout and gauge connection. The connection shall consist of a 50 mm (2 inch) pipe extending downward through the top of the tank to within 75 mm (3 inches) of the tank bottom. The entire length of pipe inside the tank shall be provided with 13 mm (1/2 inch) wide by 300 mm (12 inches) long slots at alternate locations. The top of the pipe shall be provided with a bronze top-seal type adapter with a corresponding locking type cap. Tank shall have an interior striker/impact plate attached directly under the cleanout and gauge connection. The striker/impact plate shall be a minimum of 6 mm (1/4) inch in thickness, be larger in diameter than the tank penetration, and fit the curvature of the tank bottom.

2.5.6 Tank Atmospheric Venting

Vent pipe shall be in accordance with NFPA 30, NFPA 31, and UL 142. Vent pipe sizing shall be as indicated, not less than 32 mm (1-1/4 inches) nominal inside diameter.

2.5.7 Tank Emergency Venting

2.5.7.1 For tanks 18,900 L (5,000 gallons) or less, vent shall be the rupture disc type calibrated to burst at 13.8 kPa (2 psig) pressure, and operate at 80 percent of burst setting. Vent shall comply with NFPA 30. There is no vacuum relief requirement but the disc may be subjected to 1.3 kPa (3 ounces) of vacuum. Discs shall be provided with a flanged end connection. Disc holder shall have a nameplate showing design rating.

2.5.7.2 For tanks above 18,900 L (5,000 gallons), vent shall be the emergency venting, tank manway type designed to relieve at a 13.8 kPa (2 psig) pressure. Vent shall comply with NFPA 30. Each manway shall have a watertight, self-closing type manway cover.

2.5.8 Tank Overfill Alarm System

Tank shall be provided with an overfill alarm system combined with the monitoring system of paragraph 2.9. The system shall include a mechanically-actuated float actuator and an audible alarm mounted on the monitoring panel cover. The float actuator shall be field adjustable. The monitoring panel cover shall include an alarm light, an audible alarm, and reset capabilities. The alarm system shall initiate a minimum 70 decibel audible alarm when the liquid level within a tank reaches the 90 percent full level. The alarm system shall conform to the requirements of paragraph MONITORING SYSTEM.

2.6 TANK GAUGES

2.6.1 Stick Gauge

Tank shall be provided with a stick gauge graduated in feet, inches, and eighths of an inch. Stick gauge shall be of wood and treated after graduating to prevent swelling or damage from the fuel being stored.

2.6.2 Tank Calibration Charts

Tank shall be furnished with a copy of calibrated chart which indicates the liquid contents in gallons for each 1/8 inch of tank depth.

2.6.3 Digital Tank Gauge System

Digital tank gauge system shall be combined with the monitoring system of paragraph 2.9. Tank level transmitter assembly shall be mechanically or electronically actuated and include a sending unit that transmits a digital signal to the electric monitoring panel. The monitoring panel shall be capable of providing a liquid level readout for each tank in terms of gallons. Tank level transmitter assembly shall be accurate to plus or minus 2 mm (1/16 inch) and be capable of measuring a tank's liquid level over a tank's full usable liquid level range. Tank level transmitter assembly shall be compatible with the fuel to be handled. Tank level transmitter assembly shall be capable of measuring water accumulation in inches from 3/4 to 5 inches off the bottom of a storage tank. Tank level transmitter assembly shall be capable of constantly sensing the fuel level in a storage tank as well as acknowledging 2 programmable liquid level setpoints. The electronic panel shall activate an audible and visual alarm when each setpoint is monitored. The 2 liquid level setpoints to be monitored shall include a tank's 90 percent liquid level (Setpoint 1) and a tank's 95 percent liquid level (Setpoint 2). The panel shall have a means of delineating between the individual setpoints and the individual tanks. Digital tank gauge system shall conform to the requirements of paragraph MONITORING SYSTEM. Tank level transmitter assembly shall be PNEUMACATOR Model Number 2-412W (with water detection) or approved equal.

2.7 ADAPTERS AND COUPLERS

2.7.1 Tight-Fit Fill Adapter

Adapter shall be bronze and be fitted with a Buna-N or Viton gasket. Adapter shall be the API standard 75 or 100 mm (3 or 4 inch) size as required. Adapter shall be a top seal or side seal adapter and provide a tight-fit connection to prevent vapor emissions during filling. The adapter shall be provided with a locking cap. The cap shall mate with the adapter and have a latching mechanism which provides a water tight seal. The cap shall provide some type of locking provision and be easily attachable and removable.

2.7.2 Dry-Break Coupler

Coupler shall be an API standard and provide a tight-fit connection to prevent vapor emissions during fuel transfer. Coupler shall be compatible with the fuel product being handled and be a female connection. Seals within the coupler shall be Buna-N or Viton. Coupler shall have an internal manually operated shutoff valve. The valve shall have an external operating handle with the valve's position (open or close) clearly labeled. The internal valve shall not be capable of being manually opened unless the coupler is properly connected to a tank truck's tight-fit adapter.

2.8 SUPPLEMENTAL COMPONENTS

2.8.1 Earthwork

Excavation and backfilling for tanks and piping shall be as specified in Section 02316 EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS, except as modified herein.

2.8.1.1 Pea Gravel

Pea gravel shall be between 3 and 20 mm (1/8 and 3/4 inch) diameter.

2.8.1.2 Crushed Stone

Crushed stone shall be between 3 and 13 mm (1/8 and 1/2 inch) in diameter in accordance with ASTM C 33 or KS F 2527.

2.8.1.3 Sand

Sand shall be fine sand aggregate in accordance with ASTM C 33, KS F 2526, or KS F 2527, washed and thoroughly dried, contain no more than 500 PPM chlorides, contain no more than 500 PPM sulfates, and have a pH greater than 7.

2.8.2 Street Manway Assembly

Round street manhole frames and covers shall be the straight traffic type. Frames and covers shall be constructed of cast iron in accordance with ASTM A 27/A 27M, grade 60-30 as a minimum or aluminum in accordance with ASTM B 26/B 26M, with the cover being a minimum of 8 mm (5/16 inch) thick. Covers shall be the solid plate type with a checker pattern. Covers shall form a watertight seal with the manhole frame to prevent surface water inflow. Frame and cover assembly shall be rated to withstand H-20 highway loading as defined by AASHTO HB-16.

2.8.3 Piping Containment Sump

Sump shall be constructed of fiberglass reinforced plastic and be chemically compatible with the fuels to be handled. Sump shall not be connected in any way to the street manway cover or concrete above. The top of a containment sump shall be capped with a watertight access cover. Cover shall be constructed of polyethylene. Cover shall have a minimum diameter of 550 mm (22 inches). Cover shall be easily removable through the street manway above. Rainfall drainage from the street manhole above shall not drain into a sump. Sump shall be capable of withstanding underground burial loads to be encountered. The sides of a containment sump shall allow the penetration of carrier pipes, exterior containment pipes, and conduits. Penetrations in the containment sump sides shall be booted or sealed to ensure that liquid will not escape from the sump in the event that the liquid level within the sump rises above the pipe penetration. Boots and seals used shall be compatible with the fuel to be handled. Boots and seals shall be water resistant to the influx of ground water. Boots and seals shall be designed and installed to accommodate the anticipated amount of thermal expansion and contraction in the piping system. All underground secondary containment piping shall be continuously sloped to sumps. Sumps for underground piping shall be provided at all low points, all joints and connections, and all aboveground to belowground transitions.

2.8.4 Fuel Oil Meter

Meter shall be the volumetric positive displacement type in accordance with ASTM F 1172, except as modified herein. Meter shall indicate the fuel oil flow rate in gpm. Meter shall be provided with overspeed protection and a water escape hole. If meter is not mounted in-line with the piping, then the

Contractor shall provide an appropriate pedestal for mounting. Meter installation shall be in accordance with manufacturer's recommendations.

2.8.5 Concrete Anchor Bolts

Concrete anchor bolts shall be group II, Type A, class 2 in accordance with ASTM A 307.

2.8.6 Bolts

Bolts shall be in accordance with ASTM A 193/A 193M, Grade B8.

2.8.7 Nuts

Nuts shall be in accordance with ASTM A 194/A 194M, Grade 8.

2.8.8 Washers

Washers shall be in accordance with ASTM F 436M, ASTM F 436, flat circular stainless steel. Washers shall be provided under each bolt head and nut.

2.8.9 Exterior Coating of Miscellaneous Items

Steel surfaces to be externally coated or painted shall be cleaned to a commercial grade blast cleaning finish in accordance with SSPC SP 6 prior to the application of the coating. Exterior surfaces, other than stainless steel pipe and flexible connectors, which are not otherwise painted and do not require the application of an exterior coating, as well as all items supplied without factory-applied finish paint, not including primer only items, shall be painted as specified in Section 09900PAINTINGS AND COATINGS.

2.8.10 Buried Utility Tape

Detectable aluminum foil plastic-backed tape or detectable magnetic plastic tape shall be provided for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Tape shall be provided in minimum 75 mm (3 inch) width rolls, color coded for the utility involved, with warning identification imprinted in bold black letters continuously and repeatedly over entire tape length. Permanent code and letter coloring shall be used which is unaffected by moisture and other substances contained in trench backfill material.

2.9 MONITORING SYSTEM

2.9.1 Aboveground Vaulted Tanks

The interstitial space of each vaulted tank shall be continuously and automatically monitored to detect breaches in the integrity of the primary tank and the exterior vaulted shell. The interstitial space shall be monitored by an electronic capacitance type liquid sensor capable of distinguishing the difference between hydrocarbons and water. Sensors shall be intrinsically safe for use in Class 1, Division 1, Group D environment as defined by NFPA 70. Sensors shall be easily removed from the tank. Sensors shall be compatible with the electronic monitoring panel. Sensors shall be PNEUMACATOR Model Number 9-902 or approved equal.

2.9.2 Belowground Piping System

Belowground piping systems shall be continuously and automatically monitored by single point float type liquid sensors. Sensors shall be intrinsically safe for use in a class 1, division 1, group D environment as defined by NFPA 70. Sensors shall have a probability of detection of 95 percent and a probability of false alarm of 5 percent. Sensors shall be compatible with the electronic monitoring panel. Liquid sensors shall be installed in all piping containment sumps. Sensors shall be PNEUMACATOR Model Number LS600LD-BN or approved equal.

2.9.3 Electronic Monitoring Panel

Panel shall be tank-mounted or remotely-mounted where indicated and shall be capable of providing an audible and visual alarm in the event of a detected leak. Audible alarms shall be a buzzer sounding at 70 decibels or greater. Each visual alarm shall indicate the type and location of the alarm condition. Visual alarms shall be capable of delineating between individual alarm conditions. Panel shall provide a means of delineating between individual alarm conditions. Outdoor panel shall be housed in a NEMA 4 rated enclosure in accordance with NEMA 250 and indoor panel shall be housed in a standard industrial enclosure. Panel shall have a hinged door to swing left or right (doors shall not swing up or down). Panel using computer memory shall be capable of maintaining current programmable information in the event of a power failure. Panel shall be provided with a manual acknowledge switch which shall be capable of deactivating the audible alarm. The acknowledge switch shall not be capable of deactivating subsequent audible alarms unless depressed manually again for each occurrence. Under no circumstance shall this acknowledgement switch extinguish the visual alarms until the alarm condition has been corrected. Switches shall be an integral component located on the front panel and be either a key switch or push button. Panel shall be suitable for operation at minus 40 to 122 degrees F. Panel shall be PNEUMACATOR Model Number E-700-1 or approved equal.

2.10 PIPING COMPONENTS

2.10.1 Aboveground Piping

Aboveground piping routinely carrying fuel shall be steel.

2.10.2 Belowground Piping

Belowground piping shall be of secondarily contained construction with the flexible internal pipe being the primary product pipe and the flexible exterior pipe being a secondary access/containment pipe as defined herein. Piping system shall be a factory manufactured piping system designed/listed in compliance with UL 971 and NFPA 30.

2.10.2.1 Primary Product Piping

Primary product piping routinely carrying fuel shall be of a fully bonded, multi-layer, flexible thermoplastic, synthetic fiber reinforcement, seamless construction with a smooth bore inner core tube and a minimum working pressure of 250 psig. All pipe materials shall be compatible with petroleum fuels (including JP-8) and the underground environment. Product piping shall be reinforced with a fully twisted fiber braid and shall be constructed of materials that are resistant to stress cracking. The primary pipe shall have a minimum bend radius of 12 inches. All product piping connections shall be contained within piping sumps and be retractable and completely accessible from the surface for inspection, repair, or replacement without requiring excavation.

2.10.2.2.Secondary Access/Containment Piping

Secondary access/containment piping shall be chemically compatible with the type of fuel to be handled. Access/containment piping shall be of a crush resistant, fully bonded, double-wall, co-extruded tight corrugations with a semi-smooth inner liner, and shall be approved for installation in underground applications. Access/containment piping shall be capable of withstanding a minimum 35 kPa (5 psi) air pressure. Access/containment piping shall allow for normal draining as well as the installation of any necessary leak detection equipment or cables. Fuel oil supply line and return line may be inserted into a common containment pipe to provide retractable access to, and containment of, the fuel lines.

2.10.3 Vent Piping

Piping shall be single wall steel as defined herein.

2.10.4 Steel Pipe

Carbon steel pipe shall be in accordance with KS D 3562. Pipe smaller than 65 mm (2-1/2 inches) shall be Schedule 80. Pipe 65 mm (2-1/2 inches) and larger shall be Schedule 40.

2.10.4.1 Connections for Steel Pipe

Connections for pipe or fittings smaller than 65 mm (2-1/2 inches) shall be socket weld type conforming to KS B 1542. Connections for pipe or fittings 65 mm (2-1/2 inches) and larger shall be butt weld type conforming to KS B 1541 or 1543 of the same wall thickness as the adjoining pipe. Piping in inaccessible locations, such as product piping inside of containment piping, shall be welded.

2.10.4.2 Welding Electrodes

Welding electrodes shall be E70XX low hydrogen type conforming to AWS A5.1 or KS D 7006.

2.10.4.3 Threaded Connections

Threaded connections shall only be used on piping 50 mm (2 inches) in nominal size or smaller and only where indicated. Connections shall be in accordance with KS B1531. Threaded connections shall be sealed tightly with a thread sealant or lubricant which is compatible with the fuel to be handled.

2.10.5 Valves

Portions of a valve coming in contact with fuel shall be compatible with the fuel to be handled. Valves shall have bodies, bonnets, and covers constructed of cast steel conforming to KS D 4107, SCPH 2. Each valve shall have stainless steel stem and trim. Valves shall be suitable for a working pressure of 1900 kPa (275 psig)at 38 degrees C (100 degrees F) with a weatherproof housing and be provided with flanged end connections unless indicated otherwise. Seats, body seals, and stem seals shall be Viton or Buna-N.

2.10.5.1 Gate

Valve shall be in accordance with KS B 2361. Valve shall be of the flexible wedge disc type, conduit disc type, or double disc type. Valve shall be of the rising stem type with closed yoke, or the non-rising stem type equipped with a device to give positive visual indication of the valve's position.

2.10.5.2 Swing Type Check

Valve shall be swing type conforming to KS B 2361. Check valves shall be the tilting disc, non-slam type. Discs and seating rings shall be renewable without removing from the line. The disc shall be guided and controlled to contact the entire seating surface.

2.10.5.3 Ball

Valves shall conform to KS B 2308. The ball shall be stainless steel. Valve shall be non-lubricated and operate from fully open to fully closed with 90 degree rotation of the ball.

2.10.5.4 Globe

Valve shall conform to KS B 2361.

2.10.6 Accessories

2.10.6.1 Foot Valve

Foot valve shall be compatible with the fuel to be handled and with the working pressure of the system. Foot valve shall be the double-poppet design. Foot valve shall be provided with a minimum 20 mesh screen on the intake. Foot valve seats shall be the replaceable type. Foot valve shall be capable of passing through a 75 mm (3 inch) pipe or tank flange.

2.10.6.2 Flanges

Flanges installed on equipment, fittings, or pipe shall be in accordance with KS B 1503, class 10k. Flanges shall be the 1.6 mm (1/16 inch) raised face type. Carbon steel flanges shall conform to KS D 3710.

2.10.6.3 Flange Gaskets

Gaskets shall be made of non-asbestos material. Gaskets shall be flat, 1.6 mm (1/16 inch) thick, and contain Aramid fibers bonded with Styrene Butadiene Rubber (SBR) or Nitro Butadiene Rubber (NBR). Gaskets used for hydrocarbon service shall be bonded with NBR. Ring gaskets shall be provided for raised-face flanged pipe joints.

2.10.6.4 Steel Coupling

Coupling shall be in accordance with KS B 1542, seamless, extra heavy, wrought steel with recessed ends.

2.10.6.5 Threaded Nipple

Nipple shall be in accordance with KS B 1533.

2.10.6.6 Threaded Union

Threaded unions shall only be used on cast steel piping 50 mm (2 inches) in nominal size or smaller and only where indicated. Union shall be in accordance with KS B1531.

2.10.6.7 Joint Compound

Joint compounds for any type of piping system shall be resistant to water and suitable for use with fuel containing 40 percent aromatics.

2.10.6.8 Flexible Connector

Connectors shall conform to KS B 1539 and be the flexible metal hose, corrugated type with braided wire sheath covering. Connectors shall have close-pitch annular corrugations and be rated for a working pressure of at least 1900 kPa (275 psig) at 38 degrees C (100 degrees F). Connectors shall have a minimum 300 mm (12 inch) live length with flanged end connections. Metal for hose and braided wire sheath shall be stainless steel in accordance with KS D 3698.

2.10.6.9 Strainer

Strainer shall be in accordance with ASTM F 1199, except as modified herein. Strainer shall be the cleanable, basket or "Y" type, and be the same size as the pipeline. Strainer body shall be fabricated of cast steel or brass with the bottom drilled and tapped. The body shall have arrows clearly cast on the sides indicating the direction of flow. Strainer shall be equipped with a removable cover and sediment screen. Strainer screen shall be wire screen constructed of brass sheet or monel with small perforations numbering not less than 60 per square centimeter (400 per square inch) to provide a net free area through the basket of at least 3.3 times that of the entering pipe. Flow shall be into the screen and out through the perforations.

2.10.6.10 Pipe Hangers and Supports

Hangers and supports shall be of the adjustable type and conform to MSS SP-58, MSS SP-69 and KS B 1527, except as modified herein. The finish of rods, nuts, bolts, washers, hangers, and supports shall be hot-dipped galvanized. Nuts, bolts, washers, and screws shall be Type 316 stainless steel when located under any pier. Miscellaneous metal shall be in accordance with ASTM A 36/A 36M or KS D 3503, standard mill finished structural steel shapes, hot-dipped galvanized.

a. Pipe Protection Shields. Shields shall conform to MSS SP-58 and MSS SP-69, Type 40, except material shall be Type 316 stainless steel. Shields shall be provided at each slide type pipe hanger and support.

b. Low Friction Supports. Supports shall have self-lubricating anti-friction bearing elements composed of 100 percent virgin tetrafluoroethylene polymer and reinforcing aggregates, prebonded to appropriate backing steel members. The coefficient of static friction between bearing elements shall be 0.06 from initial installation for both vertical and horizontal loads and deformation shall not exceed 0.05 mm (0.002 inch) under allowable static loads. Bonds between material and steel shall be heat cured, high temperature epoxy. Design pipe hangers and support elements for the loads applied. Anti-friction material shall be a minimum of 2.3 mm (0.09 inch)thick. Steel supports shall be hot-dipped galvanized. Units shall be factory designed and manufactured.

2.10.6.11 Exterior Coating for Aboveground Steel Piping

Aboveground steel piping shall be painted as specified in Section 09900 PAINTINGS AND COATINGS. Paint shall be rated for use on hot metal surfaces up to 230 degrees C (450 degrees F) and for surfaces exposed to the weather. Color of the finish coat shall be aluminum or light gray.

2.10.6.12 Pressure Gauge

Gauge shall conform to ASME B40.1. Gauge shall be single style pressure gauge for fuel with 115 mm (4-1/2 inch) dial, have brass or aluminum case, bronze tube, stainless steel ball valve, pressure snubbers, and scale range for the intended service.

PART 3 EXECUTION

3.1 INSTALLATION

Storage tanks shall be handled with extreme care to prevent damage during placement and shall be installed in accordance with the manufacturer's installation instructions and NFPA 30 and NFPA 31. The exterior surface of each tank shall be inspected for obvious visual damage prior to and proceeding the placement of each storage tank. Surface damage to a storage tank shall be corrected according manufacturer's requirements before proceeding with the system installation.

3.1.1 Equipment

Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions. Supports shall be provided for equipment, appurtenances, and pipe as required. Anchors, bolts, nuts, washers, and screws shall be installed where required for securing the work in place. Sizes, types, and spacings of anchors and bolts not indicated or specified shall be as required for proper installation.

3.1.2 Piping

Piping shall be inspected, tested, and approved before burying, covering, or concealing. Piping shall be installed straight and true to bear evenly on supports. Piping shall be free of traps, shall not be embedded in concrete pavement, and shall drain toward the corresponding storage tank. Any pipe, fittings, or appurtenances found defective after installation shall be replaced. Piping connections to equipment shall be as indicated or as required by the equipment manufacturer. Pipe and accessories shall be handled carefully to assure a sound, undamaged condition. The interior of the pipe shall be thoroughly cleaned of foreign matter and shall be kept clean during installation. The pipe shall not be laid in water or stored outside unprotected when weather conditions are unsuitable. When work is not in progress, open ends of pipe and fittings shall be securely closed so that water, earth, or other substances cannot enter the pipe or fittings. Cutting pipe, when necessary, shall be done without damage to the pipe. Pipe shall be reamed to true internal diameter after cutting to remove burrs. Changes in pipe sizes shall be made through tapered reducing pipe fittings. Fuel supply and return piping from a storage tank shall extend to within 150 mm (6 inches) of the tank's bottom.

3.1.2.1 Aboveground Piping

Pipe sections shall be installed as indicated and be complete prior to performing any piping tests. FRP shall not be used aboveground.

3.1.2.2 Belowground Piping

Nonmetallic pipe shall be installed in accordance with pipe manufacturer's instructions. Belowground piping shall be laid with a minimum pitch of 25 mm per 6 m (l inch per 25 feet). Horizontal sections of pipe shall be installed with a minimum of 450 mm (18 inches) of backfill between the top of the pipe and the ground surface. The full length of each section of belowground pipe shall rest solidly on the pipe bed. Joints in secondary piping shall not be made until inner pipe is successfully pressure tested.

3.1.2.3 Pipe Hangers and Supports

Additional hangers and supports shall be installed for concentrated loads in piping between hangers and supports, such as for valves. Miscellaneous steel shapes as required shall be installed in accordance with ASTM A 36/A 36M or KS D 3503. Pipe supports shall be installed in accordance with MSS SP-58, MSS SP-69 and KS B 1527.

Pipe spacing shall be as follows:

Nominal Pipe Size (mm)	25 and Under	40	50	80	100	150	200	250	300
Maximum Hanger Spacing (m)	2.1	2.7	3	3.7	4.3	5.2	5.8	6.7	7.0

Nominal Pipe Size (Inches)	1 and Under	1.5	2	3	4	6	8	10	12
Maximum Hanger Spacing (Feet)	7	9	10	12	14	17	19	22	23

3.1.2.4 Pipe Sleeve

Piping passing through concrete or masonry construction shall be fitted with sleeves. Sleeve shall be of sufficient length to pass through the entire thickness of the associated structural member and be large enough to provide a minimum clear distance of 13 mm (l/2 inch) between the pipe and sleeve. Sleeves through concrete shall be 0.91 mm (20 gauge) steel, fiberglass, or other material as approved by the Contracting Officer. Sleeves shall be accurately located on center with the piping and securely fastened in place. The space between a sleeve and a pipe shall be caulked and sealed as specified in Section 07900 JOINT SEALING. In fire walls and fire floors, both ends of a pipe sleeve shall be caulked with UL listed fill, void, or cavity material.

3.1.2.5 Pipe Anchor

Where steel piping is to be anchored, the pipe shall be welded to the structural steel member of the anchor and the abraded area shall be patched with protective coating or covering as specified.

3.1.3 Buried Utility Tape

Bury tape with the printed side up at a depth of 300 mm (12 inches) below the top surface of earth or the top surface of the subgrade under pavements.

3.1.4 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory, shall be painted and have identification markings applied as specified in Section 09900 PAINTINGS AND COATINGS. Stainless steel and aluminum surfaces shall not be painted. Prior to any painting, surfaces shall be cleaned to remove dust, dirt, rust, oil, and grease.

3.1.5 Framed Instructions

Framed instructions shall include equipment layout, wiring and control diagrams, piping, valves, control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The framed instructions shall be framed under glass or laminated plastic and be posted where directed by the Contracting Officer. The framed instructions shall be posted before acceptance testing of the system.

3.2 TESTS

3.2.1 Aboveground Storage Tank Tightness Tests

A tightness test shall be performed on each aboveground storage tank. The tests shall be performed prior to making piping connections. Tests shall be capable of detecting a 0.1 mL/s (0.1 gph) leak rate from any portion of the tank while accounting for effects of thermal expansion or contraction. Gauges used in the tightness tests shall have a scale with a maximum limit of 69 kPa (10 psig). Each storage tank shall be pressurized with air to 35 kPa (5 psig) and monitored for a drop in pressure over a 2-hour period during which there shall be no drop in pressure in the tank greater than that allowed for pressure variations due to thermal effects. This pressure shall be maintained and soapsuds or equivalent material applied to the exterior of the tank. While applying the soapsuds, the entire tank shall be visually inspected, including the bottom surfaces, for leaks (bubble formations). Leaks discovered during either the 2-hour waiting period or the soapsuds tests shall be repaired in accordance with manufacturer's instructions. The pneumatic test shall be performed again in the event a leak is discovered.

Caution: Do not apply air pressure to the interstitial space between the walls of a double wall tank without air pressure in the primary tank. Do not apply air pressure to the interstitial space that is higher than the air pressure in the primary tank. Damage to the tank may result.

3.2.2 Manufacturer's Tank Tests

Following the tank tightness test, each storage tank shall be leak tested in accordance with the manufacturer's written test procedure if the manufacturer's test procedure is different from the tightness tests already performed. Any test failure shall require corrective action and retest.

3.2.3 Piping Pneumatic and Hydrostatic Tests

Testing shall comply with the applicable requirements of ASME B31.3, NFPA 30, and the requirements specified herein. Care shall be taken not to exceed pressure rating of various fittings. Hydrostatic testing shall be performed using fuel as the liquid. Water shall not be introduced into the system for testing. To facilitate the pneumatic and hydrostatic tests, various sections of the piping system may be isolated and tested separately. Where such sections terminate at flanged valve points, the line shall be closed by means of blind flanges in lieu of relying on the valve. Tapped flanges shall be provided to allow a direct connection between the piping and the air compressor and/or pressurizing pump. Tapped flanges shall also be used for gauge connections. Taps in the permanent line will not be permitted. Gauges shall be subject to testing and approval. In the event leaks are detected, the pipe shall be repaired and the test repeated. Following satisfactory completion of each pneumatic and hydrostatic test, the pressure shall be relieved and the pipe immediately sealed. Provision shall be made to prevent displacement of the piping during testing. Personnel shall be kept clear of the piping during pneumatic testing. Equipment such as pumps, tanks, and meters shall be isolated from the piping system during the testing.

3.2.3.1 Pneumatic Procedures for Product and Vent Piping

Piping to be installed underground shall not receive field applied covering at the joints or be covered by backfill until the piping has passed the pneumatic test described herein. A pneumatic test pressure shall be applied in increments. A preliminary 170 kPa (25 psig) test shall be applied. The pressure shall be maintained while soapsuds or equivalent materials are applied to the exterior of the piping. While applying the soapsuds, the entire run of piping, including the bottom surfaces, shall be visually inspected for leaks (bubble formations). Leaks discovered shall be repaired in accordance with manufacturer's instructions and retested. Following the preliminary test, the piping shall be tested at a pressure of 340 kPa (50 psig) for not less than 2 hours, during which time there shall be no drop in pressure in the pipe greater than that allowed for thermal expansion and contraction. The pressure source shall be disconnected during the final test period. Any leaks revealed by the test shall be repaired and the test repeated.

3.2.3.2 Pneumatic Procedures for Exterior Containment Piping

Exterior containment piping shall undergo a minimum pneumatic pressure of 35 kPa (5 psig). Pressure in secondary piping shall be maintained for at least 1 hour while soapsuds or equivalent materials are applied to the exterior of the piping. While applying the soapsuds, the entire run of piping, including the bottom surfaces, shall be visually inspected for leaks (bubble formations). Leaks discovered shall be repaired in accordance with manufacturer's instructions and retested. This testing shall be in compliance with the manufacturer's published installation instructions.

3.2.3.3 Hydrostatic Procedures for Product Piping

Upon completion of pneumatic testing and after backfilling, each piping system shall be hydrostatically tested with fuel at not more than 1900 kPa (275 psig) in accordance with ASME B31.3 and API RP 1110, with no leakage or reduction in gauge pressure for 4 hours. The Contractor shall furnish electricity, instruments, connecting devices, and personnel for the test. Fuel will be furnished by the Government. Defects in work performed shall be corrected at the Contractor's expense, and the test repeated until the work is proven to be in compliance with the testing procedures. Any release of fuel (no matter the size) during testing shall be immediately contained, the pressure on the piping relieved, and the piping drained of fuel. The Contracting Officer shall be notified immediately of a fuel release, the exact location, an estimated quantity of release, and a discussion of the containment measures taken.

3.2.4 System Performance Tests

After all components of the system have been properly adjusted, the system shall be tested to demonstrate that the system meets the performance requirements for which it was designed. If any portion of the system or any piece of equipment fails to pass the tests, the Contractor shall make the necessary repairs or adjustments and the test shall be repeated until satisfactory performance is obtained from the Contracting Officer. The tests shall demonstrate the following:

a. The alarm and control panels are operational and perform as designed.

b. Each fuel meter is operating accurately.

c. Vent piping is clear of debris and each pressure/vacuum relief vent is operating properly.

3.2.5 High Liquid Level Alarm Test

Each storage tank shall be initially overfilled with the appropriate product in order to verify the high liquid level alarms in the remote alarm panel function as designed. The initial overfill shall also verify that the storage tank overfill protection device functions as designed. Tank overfill shall stop immediately once the overfill device operates. The Contractor shall not overfill any storage more than 98 percent level even if the leak detection and liquid level electronic panel and the overfill device do not function as designed. Any problems with the electronic panel or the overfill device shall be corrected and retested. The system shall be drained below the high liquid levels following all tests.

3.3 FLUSHING, CLEANING AND ADJUSTING

Following installation and equipment testing but prior to system performance testing, the following flushing, cleaning, and adjustments shall be performed.

3.3.1 Preparations for Flushing (Initial System Cleaning)

The interior of each fuel storage tank shall be visually inspected and cleaned free of debris before filling. In the event of entry into a storage tank, the Contractor shall ensure a safe atmosphere exists. Contractor shall remove all preservatives and foreign matter from valves, line strainers, and other equipment coming in contact with fuel. No fuel will be delivered to the system until the Contractor has satisfactorily completed this initial system cleaning.

3.3.2 System Flushing

3.3.2.1 Initial Fuel Supply

Following the preparations for flushing, each storage tank shall be filled to a 25 percent capacity with the proper fuel according to the fueling system's final operational requirements. Following the initial fuel supply, each storage tank's fuel temperature and liquid level shall be measured and recorded. The liquid level shall be measured using a manual tank gauge.

3.3.2.2 Disposal of Initial Fuel Supply

In the event the fuel contained in the piping system at the conclusion of the flushing operation is not considered by the Contracting Officer to be of satisfactory quality for the desired use, the Contractor shall be responsible for pumping out the entire fuel supply from the storage tanks and the piping system. The filter/separator and piping system shall be completely drained to the storage tank. Disposition of the fuel removed from the system shall be the responsibility of the Government.

3.3.3 Initial System Adjustments

Following the flushing and cleaning operations, each system component shall be initially adjusted, if necessary, to meet the system's final operational requirements. The sequence of control for each component shall be adjusted to meet the indicated system requirements. Following the initial system adjustments, the equipment tests shall be performed in order to determine any necessary final system adjustments.

3.4 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 24 hours of normal working time and shall start after the system is functionally completed but prior to final system acceptance. The field instructions shall cover all of the items contained in the operation and maintenance manuals as well as demonstrations of routine maintenance operations.

SECTION 13851

FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S3.41 (1990; R 1996) Audible Emergency Evacuation Signals

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15 Radio Frequency Devices

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P7825a (1998) Approval Guide Fire Protection

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2002) National Electrical Code
NFPA 72	(1999) National Fire Alarm Code
NFPA 90A	(1999) Installation of Air Conditioning and Ventilating Systems
NFPA 1221	(1999) Installation, Maintenance and Use of Public Fire Service Communication Systems

UNDERWRITERS LABORATORIES (UL)

UL 6	(1997) Rigid Metal Conduit
UL 38	(1999) Manually Actuated Signaling Boxes for Use with Fire-Protective Signaling Systems
UL 228	(1997, Rev Jan 1999) Door Closers-Holders, With or Without Integral Smoke Detectors
UL 268	(1996; Rev thru Jun 1998) Smoke Detectors for Fire Protective Signaling Systems
UL 268A	(1998) Smoke Detectors for Duct Applications
UL 464	(1996; Rev May 1999) Audible Signal Appliances
UL 521	(1999) Heat Detectors for Fire Protective Signaling Systems
UL 632	(2000) Electrically-Actuated Transmitters
UL 797	(1993; Rev thru Mar 1997) Electrical Metallic Tubing
UL 864	(1996; Rev thru Mar 1999) Control Units for Fire-Protective Signaling Systems
UL 1242	(1996; Rev Mar 1998) Intermediate Metal Conduit
UL 1971	(1995; Rev thru Apr 1999) Signaling Devices for the Hearing Impaired

KOREAN INDUSTRIAL STANDARDS (KS)

KS C 2302	(1986) Friction Tape
KS C 2306	(1999) Pressure Sensitive PVC Adhesive Tape
KS C 2347	(1986) Pressure Sensitive Polyester Adhesive Tape
KS C 3302	(1990) 600V PVC Insulated Wire, IV

KS C 3313	(2002) OW Wire
KS C 3315	(2002) DV Wire
KS C 3323	(1999) 600V PVC Insulated and Sheathed Cable, VV
KS C 3328	(2002) 600V PVC Insulated and Sheathed Cable, HIV
KS C 8401	(1997) Rigid Steel Conduit
KS C 8422	(2002) Steel Flexible Conduit
KS C 8431	(2001) Unplasticized Polyvinyl Chloride (UPVC) Conduit
KS C 8458	(2001) Outlet Boxes, Switch Boxes, Special Outlet Boxes, Box Covers for Rigid Metal Conduit
KS C 8459	(1997) Coupling, Connector for Flexible Conduit
KS C 8460	(2001) Bushing, Saddles, Locknuts, Couplings, Insulated Bushings for Rigid Metal Conduit
KS C 8461	(1997) Universal Fittings, Terminal Caps, Surface Switch Boxes, Circular Surface Boxes For Rigid Metal Conduit
KS D 8308	(2001) Zinc Coating (Hot Dipped) on Iron and Steel

1.2 RELATED REQUIREMENTS

Section 16050, "Basic Electrical Materials and Methods," applies to this section with the additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fire Alarm Reporting System; G

Detail drawings, prepared and signed by a Registered Professional Engineer with at least 2 years of current experience in the design of fire protection and detection systems, or licensed Fire Detection and Alarm System Engineer, Class 1, with 2 years of current experience in the design of fire protection and detection systems, consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Note that the contract drawings show layouts based on typical detectors. The Contractor shall check the layout based on the actual detectors to be installed and make any necessary revisions in the detail drawings. The detail drawings shall also contain complete wiring and schematic diagrams for the equipment furnished, equipment layout, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Detailed point-to-point wiring diagram shall be prepared and signed by a a Registered Professional Engineer with at least 2 years of current experience in the design of fire protection and detection systems, or licensed Fire Detection and Alarm System Engineer, Class 1, with 2 years of current experience in the design of fire protection and detection systems showing points of connection. Diagram shall include connections between system devices, appliances, control panels, supervised devices, and equipment that is activated or controlled by the panel.

SD-03 Product Data

Storage Batteries; G

Substantiating battery calculations for supervisory and alarm power requirements. Ampere-hour requirements for each system component and each panel component, and the battery recharging period shall be included.

Voltage Drop; G

Voltage drop calculations for notification appliance circuits to indicate that sufficient voltage is available for proper appliance operation.

Special Tools and Spare Parts;

Spare parts data for each different item of material and equipment specified, not later than 3 months prior to the date of beneficial occupancy. Data shall include a complete list of parts and supplies with the current unit prices and source of supply and a list of the parts recommended by the manufacturer to be replaced after 1 year of service.

Technical Data and Computer Software; G

Technical data which relates to computer software.

Training; G

Lesson plans, operating instructions, maintenance procedures, and training data, furnished in manual format, for the training courses. The operations training shall familiarize designated government personnel with proper operation of the fire alarm system. The maintenance training course shall provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system.

Testing; G

Detailed test procedures, prepared and signed by a Registered Professional Engineer with at least 2 years of current experience in the design of fire protection and detection systems, or licensed Fire Detection and Alarm System Engineer, Class 1, with 2 years of current experience in the design of fire protection and detection systems, for the fire detection and alarm system 7 days prior to performing system tests.

SD-06 Test Reports

Testing; G

Test reports, in booklet form, showing field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall document readings, test results and indicate the final position of controls. The Contractor shall include the NFPA 72 Certificate of Completion and NFPA 72 Inspection and Testing Form, with the appropriate test reports.

SD-07 Certificates

Equipment; G

Certified copies of current approvals or listings issued by an independent test lab if not listed by UL, FM or other nationally recognized testing laboratory, showing compliance with specified NFPA standards.

Qualifications; G

Proof of qualifications for required personnel.

SD-10 Operation and Maintenance Data

Technical Data and Computer Software; G

Four copies of operating manual outlining step-by-step procedures required for system startup, operation, and shutdown. The manual shall include the manufacturer's name, model number, service manual, parts list, and complete description of equipment and their basic operating features. Four copies of maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed. The manuals shall include complete procedures for system revision and expansion, detailing both equipment and software requirements. Original and backup copies of all software delivered for this project shall be provided, on each type of media utilized. Manuals shall be approved prior to training.

1.4 GENERAL REQUIREMENTS

1.4.1 Standard Products

Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that can provide service within 24 hours of notification.

1.4.2 Nameplates

Major components of equipment shall have the manufacturer's name, address, type or style, voltage and current rating, and catalog number on a noncorrosive and nonheat-sensitive plate which is securely attached to the equipment.

1.4.3 Keys and Locks

Locks shall be keyed alike. Four keys for the system shall be provided.

1.4.4 Tags

Tags with stamped identification number shall be furnished for keys and locks.

1.4.5 Verification of Dimensions

After becoming familiar with details of the work, the Contractor shall verify dimensions in the field and shall advise the Contracting Officer of any discrepancy before performing the work.

1.4.6 Compliance

The fire detection and alarm system and the central reporting system shall be configured in accordance with NFPA 72; exceptions are acceptable as directed by the Contracting Officer. The equipment furnished shall be compatible and be UL listed, FM approved, or approved or listed by a nationally recognized testing laboratory in accordance with the applicable NFPA standards.

1.4.7 Qualifications

1.4.7.1 Engineer and Technician

a. Registered Professional Engineer with verification of experience and at least 2 years of current experience in the design of the fire protection and detection systems.

b. Licensed Fire Detection and Alarm System Engineer, Class 1, with 2 years of current experience in the design of the fire protection and detection systems.

1.4.7.2 Installer

The Fire Alarm technicians installing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.5 SYSTEM DESIGN

1.5.1 Operation

The fire alarm and detection system shall be a complete, supervised fire alarm reporting system. The system shall be activated into the alarm mode by actuation of any alarm initiating device. The system shall remain in the alarm mode until the initiating device is reset and the fire alarm control panel is reset and restored to normal. Alarm initiating devices shall be connected to signal line circuits (SLC), Style 5, in accordance with NFPA 72. Alarm notification appliances shall be connected to notification appliance circuits (NAC), Style Z in accordance with NFPA 72. A looped conduit system shall be provided so that if the conduit and all conductors within are severed at any point, all NAC and SLC will remain functional. The conduit loop requirement is not applicable to the signal transmission link from the local panels (at the protected premises) to the Supervising Station (fire station, fire alarm central communication center). Textual, audible, and visual appliances and systems shall comply with NFPA 72. Fire alarm system components requiring power, except for the control panel power supply, shall operate on 24 Volts dc. Addressable system shall be microcomputer (microprocessor or microcontroller) based with a minimum word size of eight bits and shall provide the following features:

a. Sufficient memory to perform as specified and as shown for addressable system.

b. Individual identity of each addressable device for the following conditions: alarm; trouble; open; short; and appliances missing/failed remote detector - sensitivity adjustment from the panel for smoke detectors

c. Capability of each addressable device being individually disabled or enabled from the panel.

d. Each SLC shall be sized to provide 40 percent addressable expansion without hardware modifications to the panel.

1.5.2 Operational Features

The system shall have the following operating features:

a. Monitor electrical supervision of SLC, and NAC. Smoke detectors shall have combined alarm initiating and power circuits.

b. Monitor electrical supervision of the primary power (ac) supply, battery voltage, placement of alarm zone module (card, PC board) within the control panel, and transmitter tripping circuit integrity.

c. A trouble buzzer and trouble LED/LCD (light emitting diode/liquid crystal diode) to activate upon a single break, open, or ground fault condition which prevents the required normal operation of the system. The trouble signal shall also operate upon loss of primary power (ac) supply, low battery voltage, removal of alarm zone module (card, PC board), and disconnection of the circuit used for transmitting alarm signals off-premises. A trouble alarm silence switch shall be provided which will silence the trouble buzzer, but will not extinguish the trouble indicator LED/LCD. Subsequent trouble and supervisory alarms shall sound the trouble signal until silenced. After the system returns to normal operating conditions, the trouble buzzer shall again sound until the silencing switch returns to normal position, unless automatic trouble reset is provided.

d. A one person test mode. Activating an initiating device in this mode will activate an alarm for a short period of time, then automatically reset the alarm, without activating the transmitter during the entire process.

e. A transmitter disconnect switch to allow testing and maintenance of the system without activating the transmitter but providing a trouble signal when disconnected and a restoration signal when reconnected.

f. Evacuation alarm silencing switch which, when activated, will silence alarm devices, but will not affect the zone indicating LED/LCD nor the operation of the transmitter. This switch shall be over-ridden upon activation of a subsequent alarm from an unalarmed device and the NAC devices will be activated.

g. Electrical supervision for circuits used for supervisory signal services (i.e., sprinkler systems, valves, etc.). Supervision shall detect any open, short, or ground.

h. Confirmation or verification of all smoke detectors. The control panel shall interrupt the transmission of an alarm signal to the system control panel for a factory preset period. This interruption period shall be adjustable from 1 to 60 seconds and be factory set at 10 seconds. Immediately following the interruption period, a confirmation period shall be in effect during which time an alarm signal, if present, will be sent immediately to the control panel. Fire alarm devices other than smoke detectors shall be programmed without confirmation or verification.

i. The fire alarm control panel shall provide supervised addressable relays for HVAC shutdown. An override at the HVAC panel shall not be provided.

j. The fire alarm control panel shall provide the required monitoring and supervised control outputs needed to accomplish elevator recall.

k. The fire alarm control panel shall monitor the fire sprinkler system, or other fire protection extinguishing system.

l. The control panel and field panels shall be software reprogrammable to enable expansion or modification of the system without replacement of hardware or firmware. Examples of required changes are: adding or deleting devices or zones; changing system responses to particular input signals; programming certain input signals to activate auxiliary devices.

1.5.3 Alarm Functions

An alarm condition on a circuit shall automatically initiate the following functions:

a. Transmission of a signal over the station telephonic or radio fire reporting system.

b. Visual indications of the alarmed devices on the fire alarm control panel display and on the remote audible/visual display.

c. Continuous sounding or operation of alarm notification appliances throughout the building as required by ANSI S3.41.

d. Closure of doors held open by electromagnetic devices.

e. Operation of the smoke control system.

f. Deactivation of the air handling units throughout the building.

g. Shutdown of power to the data processing equipment in the alarmed area.

1.5.4 Primary Power

Operating power shall be provided as required by paragraph Power Supply for the System. Transfer from normal to emergency power or restoration from emergency to normal power shall be fully automatic and not cause transmission of a false alarm. Loss of ac power shall not prevent transmission of a signal via the fire reporting system upon operation of any initiating circuit.

1.5.5 Battery Backup Power

Battery backup power shall be through use of rechargeable, sealed-type storage batteries and battery charger.

1.5.6 Interface With Existing Fire Alarm Equipment

The equipment specified herein shall operate as an extension to an existing configuration. The new equipment shall be connected to an existing control panel in the existing part of the building and existing monitoring equipment at the Supervising Station. Existing control or monitoring equipment shall be expanded, modified, or supplemented as necessary to extend the existing control and monitoring functions to the new points or zones. New components shall be capable of merging with the existing configuration without degrading the performance of either system. The scope of the acceptance tests of paragraph Testing shall include aspects of operation that involve combined use of both new and existing portions of the final configuration.

1.5.7 Interface with other Equipment

Interfacing components shall be furnished as required to connect to subsystems or devices which interact with the fire alarm system, such as supervisory or alarm contacts in suppression systems, operating interfaces for smoke control systems, door releases, etc.

1.6 TECHNICAL DATA AND COMPUTER SOFTWARE

Technical data and computer software (meaning technical data which relates to computer software) which is specifically identified in this project, and which may be defined/required in other specifications, shall be delivered, strictly in accordance with the CONTRACT CLAUSES, and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. Data to be submitted shall include complete system, equipment, and software descriptions. Descriptions shall show how the equipment will operate as a system to meet the performance requirements of this contract. The data package shall also include the following:

a. Identification of programmable portions of system equipment and capabilities.

b. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.

c. Provision of operational software data on all modes of programmable portions of the fire alarm and detection system.

d. Description of Fire Alarm Control Panel equipment operation.

e. Description of auxiliary and remote equipment operations.

f. Library of application software.

g. Operation and maintenance manuals as specified in SD-19 of the Submittals paragraph.

1.7 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variation, dirt, dust, and any other contaminants.

PART 2 PRODUCTS

2.1 CONTROL PANEL

Control Panel shall comply with the applicable requirements of UL 864. Panel shall be modular, installed in a flush or surface or semi-flush mounted steel cabinet with hinged door and cylinder lock. Control panel shall be a clean, uncluttered, and orderly assembled panel containing components and equipment required to provide the specified operating and supervisory functions of the system. The panel shall have prominent rigid plastic, phenolic or metal identification plates for LED/LCDs, zones, SLC, controls, meters, fuses, and switches. Nameplates for fuses shall also include ampere rating. The LED/LCD displays shall be located on the exterior of the cabinet door or be visible through the cabinet door. Control panel switches shall be within the locked cabinet. A suitable means (single operation) shall be provided for testing the control panel visual indicating devices (meters or LEDs/LCDs). Meters and LEDs shall be plainly visible when the cabinet door is closed. Signals and LEDs/LCDs shall be provided to indicate by zone any alarm, supervisory or trouble condition on the system. Each IDC shall be powered and supervised so that a signal on one zone does not prevent the receipt of signals from other devices. Loss of power, including batteries, shall not require the manual reloading of a program. Upon restoration of power, startup shall be automatic, and shall not require any manual operation. The loss of primary power or the sequence of applying primary or emergency power shall not affect the transmission of alarm, supervisory or trouble signals. Visual annunciation shall be provided for LED/LCD visual display as an integral part of the control panel and shall identify with a word description and id number each device. Cabinets shall be provided with ample gutter space to allow proper clearance between the cabinet and live parts of the panel equipment. If more than one modular unit is required to form a control panel, the units shall be installed in a single cabinet large enough to accommodate units. Cabinets shall be painted red.

2.1.1 Remote System Audible/Visual Display

Audible appliance shall have a minimum sound level output rating of 85 dBA at 3.05 m (10 feet) and operate in conjunction with the panel integral display. The audible device shall be silenced by a system silence switch on the remote system. The audible device shall be silenced by the system silence switch located at the remote location, but shall not extinguish the visual indication. The remote LED/LCD visual display shall provide identification, consisting of the word description and id number for each device as displayed on the control panel. A rigid plastic, phenolic or metal identification sign which reads "Fire Alarm System Remote Display" shall be provided at the remote audible/visual display. The remote visual appliance located with the audible appliance shall not be extinguished until the trouble or alarm has been cleared.

2.1.3 Circuit Connections

Circuit conductors entering or leaving the panel shall be connected to screw-type terminals with each conductor and terminal marked for identification.

2.1.4 System Expansion and Modification Capabilities

Any equipment and software needed by qualified technicians to implement future changes to the fire alarm system shall be provided as part of this contract.

2.1.5 Addressable Control Module

The control module shall be capable of operating as a relay (dry contact form C) for interfacing the control panel with other systems, and to control door holders or initiate elevator fire service. The module shall be UL listed as compatible with the control panel. The indicating device or the external load being controlled shall be configured as a Style Y notification appliance circuits. The system shall be capable of supervising, audible, visual and dry contact circuits. The control module shall have both an input and output address. The supervision shall detect a short on the supervised circuit and shall prevent power from being applied to the circuit. The control module shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. The control module shall contain an integral LED that flashes each time the control module is polled.

2.1.6 Addressable Initiating Device Circuits Module

The initiating device being monitored shall be configured as a Style D initiating device circuits. The system shell be capable of defining any module as an alarm module and report alarm trouble, loss of polling, or as a supervisory module, and reporting supervisory short, supervisory open or loss of polling. The module shall be UL listed as compatible with the control panel. The monitor module shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. Monitor module shall contain an integral LED that flashes each time the monitor module is polled. Pull stations with a monitor module in a common backbox are not required to have an LED.

2.2 STORAGE BATTERIES

Storage batteries shall be provided and shall be sealed, lead-calcium type requiring no additional water. The batteries shall have ample capacity, with primary power disconnected, to operate the fire alarm system for a period of 72 hours. Following this period of battery operation, the batteries shall have ample capacity to operate all components of the system, including all alarm signaling devices in the total alarm mode for a minimum period of 15 minutes. Batteries shall be located at the bottom of the panel in a separate battery cabinet. Batteries shall be provided with overcurrent protection in accordance with NFPA 72. Separate battery cabinets shall have a lockable, hinged cover similar to the fire alarm panel. The lock shall be keyed the same as the fire alarm control panel. Cabinets shall be painted to match the fire alarm control panel.

2.3 BATTERY CHARGER

Battery charger shall be completely automatic with high/low charging rate, capable of restoring the batteries from full discharge (18 Volts dc) to full charge within 48 hours. A pilot light indicating when batteries are manually placed on a high rate of charge shall be provided as part of the unit assembly, if a high rate switch is provided. Charger shall be located in control panel cabinet or in a separate battery cabinet.

2.4 ADDRESSABLE MANUAL FIRE ALARM STATIONS

Addressable manual fire alarm stations shall conform to the applicable requirements of UL 38. Manual stations shall be connected into signal line circuits. Stations shall be installed on surface or semi-flush or flush mounted outlet boxes. Manual stations shall be mounted at minimum 1220 mm (48 inches). Stations shall be single action type. Stations shall be finished in red, with raised letter operating instructions of contrasting color. Stations requiring the breaking of glass or plastic panels for operation are not acceptable. Stations employing glass rods are acceptable. The use of a key or wrench shall be required to reset the station. Gravity or mercury switches are not acceptable. Switches and contacts shall be rated for the voltage and current upon which they operate. Addressable pull stations shall be capable of being field programmed, shall latch upon operation and remain latched until manually reset. Stations shall have a separate screw terminal for each conductor. Surface mounted boxes shall be matched and painted the same color as the fire alarm manual stations and mounting surface.

2.5 FIRE DETECTING DEVICES

Fire detecting devices shall comply with the applicable requirements of NFPA 72, NFPA 90A, UL 268, UL 268A, and UL 521. The detectors shall be provided as indicated. Detector base shall have screw terminals for making connections. No solder connections will be allowed. Detectors located in concealed locations (above ceiling, raised floors, etc.) shall have a remote visible indicator LED/LCD. Addressable fire detecting devices, except flame detectors, shall be dynamically supervised and uniquely identified in the control panel. All fire alarm initiating devices shall be individually addressable, except where indicated. Installed devices shall conform to NFPA 70 hazard classification of the area where devices are to be installed.

2.5.1 Heat Detectors

Heat detectors shall be designed for detection of fire by fixed temperature, combination fixed temperature and rate-of-rise principle or rate-compensating principle. Heat detector spacing shall be rated in accordance with UL 521. Detectors located in areas subject to moisture, exterior atmospheric conditions, or hazardous locations as defined by NFPA 70 and shall be types approved for such locations. Heat detectors located in attic spaces or similar concealed spaces below the roof shall be intermediate temperature rated.

2.5.1.1 Combination Fixed-Temperature and Rate-of-Rise Detectors

Detectors shall be designed for surface or semi-flush outlet box mounting and supported independently of wiring connections. Contacts shall be self-resetting after response to rate-of-rise principle. Under fixed temperature actuation, the detector shall have a permanent external indication which is readily visible. Detector units located in boiler rooms, showers, or other areas subject to abnormal temperature changes shall operate on fixed temperature principle only. The UL 521 test rating for the fixed temperature portion shall be 57.2 degrees C (135 degrees F) or as shown. The UL 521 test rating for the Rate-of-Rise detectors shall be rated for 15 by 15 m (50 by 50 ft).

2.5.1.3 Rate Compensating Detectors

Detectors shall be surface or flush mounted vertical or horizontal type, with outlet box supported independently of wiring connections. Detectors shall be hermetically sealed and automatically resetting. Rate Compensated detectors shall be rated for 15 by 15 m (50 by 50 ft).

2.5.1.4 Fixed Temperature Detectors

Detectors shall be designed for surface or semi-flush outlet box mounting and supported independently of wiring connections. Detectors shall be designed to detect high heat. The detectors shall have a specific temperature setting of 57.2 degrees C (135 degrees F) or as shown. The UL 521 test rating for the fixed temperature detectors shall be rated for 4.57 by 4.57 m (15 by 15 ft).

2.5.2 Smoke Detectors

Smoke detectors shall be designed for detection of abnormal smoke densities. Smoke detectors shall be ionization, photoelectric or projected beam type. Detectors shall contain a visible indicator LED/LCD that shows when the unit is in alarm condition. Detectors shall not be adversely affected by vibration or pressure. Detectors shall be the plug-in type in which the detector base contains terminals for making wiring connections. Detectors that are to be installed in concealed (above false ceilings, etc.) locations shall be provided with a remote indicator LED/LCD suitable for mounting in a finished, visible location.

2.5.2.1 Ionization Detectors

Ionization detectors with a dual chamber shall be responsive to both invisible and visible particles of combustion. One chamber shall be a reference chamber and the second a sampling chamber. Detectors containing radium shall not be provided. Detectors shall not cause an alarm condition due to anticipated fluctuations in relative humidity. The sensitivity of the detector shall be field adjustable to compensate for operating conditions. Detector shall require no replacement or readjustment to restore it to normal operation after an alarm condition. Each detector shall be capable of withstanding ambient air velocity up to 1.6 meters per second (300 fpm) in accordance with UL 268. Addressable smoke detectors shall be capable of having the sensitivity being remotely adjusted by the control panel.

2.5.2.2 Photoelectric Detectors

Detectors shall operate on a light scattering concept using an LED light source. Failure of the LED shall not cause an alarm condition. Detectors shall be factory set for sensitivity and shall require no field adjustments of any kind. Detectors shall have an obscuration rating in accordance with UL 268. Addressable smoke detectors shall be capable of having the sensitivity being remotely adjusted by the control panel.

2.5.2.3 Projected Beam Smoke Detectors

Detectors shall be designed for detection of abnormal smoke densities. Detectors shall consist of separate transmitter and receiver units. The transmitter unit shall emit an infrared beam to the receiver unit. When the signal at the receiver falls below a preset sensitivity, the detector shall initiate an alarm. The receiver shall contain an LED which is powered upon an alarm condition. Long-term changes to the received signal caused by environmental variations shall be automatically compensated. Detectors shall incorporate features to assure that they are operational; a trouble signal shall be initiated if the beam is obstructed, the limits of the compensation circuit are reached, or the housing cover is removed. Detectors shall have multiple sensitivity settings in order to meet UL listings for the different distances covered by the beam. In the event of beam interference for more than three seconds a trouble alarm shall be transmitted.

2.5.2.4 Duct Detectors

Duct-mounted photoelectric smoke detectors shall be furnished and installed where indicated and in accordance with NFPA 90A. Units shall consist of a smoke detector as specified in paragraph Photoelectric Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. Detectors shall have a manual reset. Detectors shall be rated for air velocities that include air flows between 2.5 and 20 m/s (500 and 4000 fpm) or as specified. Detectors shall be powered from the fire alarm panel. Sampling tubes shall run the full width of the duct. The duct detector package shall conform to the requirements of NFPA 90A, UL 268A, and shall be UL listed for use in air-handling systems. The control functions, operation, reset, and bypass shall be controlled from the fire alarm control panel. Lights to indicate the operation and alarm condition; and the test and reset buttons shall be visible and accessible with the unit installed and the cover in place. Detectors mounted above 1.83 m (6 feet) and those mounted below 1.83 m (6 feet) that cannot be easily accessed while standing on the floor, shall be provided with a remote detector indicator panel containing test and reset switches. Remote lamps and switches as well as the affected fan units shall be properly identified in etched plastic placards. Detectors shall have auxiliary contacts to provide control, interlock, and shutdown functions specified in Section 15950 HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS. The detectors shall be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

2.5.3 Combination Smoke and Heat Detectors

Combination smoke and heat detectors shall have an audible device (self-contained) and be designed for detection of abnormal smoke densities by the photoelectric principle and abnormal heat by a fixed temperature sensor. Smoke detectors shall be provided with an LED light source. Failure of the LED shall not cause an alarm condition and the sensitivity shall be factory set at a nominal 3 percent and require no field adjustments of any kind. Heat detector portion shall be fixed temperature sensor rated at 57 degrees C 135 degrees F). The audible appliances shall have a minimum sound output of at least 85 dBA at 3.05 m (10 feet). Detectors shall contain a visible indicator LED that shows when the unit is in alarm condition. Detectors shall not be adversely affected by vibration or pressure. Heat detectors shall connect to a control panel IDC.

2.5.4 Flame Detectors

The detectors shall comply with FM P7825a. The detectors shall be sensitive to the micron range best suited for their intended use. The detectors shall operate over electrically supervised wiring circuits and the loss of power to the detector shall result in a trouble signal. A self-test feature shall be provided for each detector to be individually tested.

2.5.4.1 Infrared (IR) Single Frequency Flame Detector

The detector shall be sensitive in the range as specified for the intended purpose.

2.5.4.2 Infrared (IR) Dual Frequency Flame Detector

The IR detector shall consist of two or more IR sensors, each selected for a different IR frequency. The primary sensor shall be sensitive in the range as specified for the intended purpose. Secondary sensors are tuned to different IR wavelengths to null out the effect of black body radiation to the primary sensor.

2.5.4.3 Ultraviolet (UV) Flame Detectors

UV flame detector shall be of the narrow band response type which operates on radiated ultraviolet energy and shall be sensitive in the range as specified for the intended purpose. The cone of vision shall be 80 degrees or greater. Each detector shall be completely insensitive to light sources in the visible frequency range.

2.5.4.4 Combination UV/IR Flame Detector

The UV/IR detector shall provide discrimination against false alarms by requiring both UV and IR flame detection before an alarm is sent. The UV sensor shall be sensitive in the range of 0.185 to 0.265 micrometers only. The IR sensor shall be sensitive in the range as specified for the intended purpose. Detectors shall be completely insensitive to light sources in the visible frequency range.

2.6 NOTIFICATION APPLIANCES

Audible appliances shall conform to the applicable requirements of UL 464. Devices shall be connected into notification appliance circuits. Devices shall have a separate screw terminal for each conductor. Audible appliances shall generate a unique audible sound from other devices provided in the building and surrounding area. Surface mounted audible appliances shall be painted red. Recessed audible appliances shall be installed with a grill that is painted red.

2.6.1 Alarm Bells

Bells shall be surface mounted with the matching mounting back box surface mounted or recessed. Bells shall be suitable for use in an electrically supervised circuit. Bells shall be the underdome type producing a minimum output rating of 85 dBA at 3.1 m (10 feet). Bells used in exterior locations shall be specifically listed or approved for outdoor use and be provided with metal housing and protective grilles. Single stroke, electrically operated, supervised, solenoid bells shall be used for coded applications.

2.6.2 Alarm Horns

Horns shall be surface mounted, with the matching mounting back box surface mounted or recessed vibrating type suitable for use in an electrically supervised circuit. Horns shall produce a sound rating of at least 85 dBA at 3.05 m (10 feet). Horns used in exterior locations shall be specifically listed or approved for outdoor use and be provided with metal housing and protective grilles.

2.6.3 Chimes

Chimes shall be electrically operated, supervised, electronic type, with an adjustable frequency of 800 to 1200 Hertz. Chimes shall have a minimum sound rating of 80 dBA at 3.05 m (10 feet).

2.6.4 Visual Notification Appliances

Visual notification appliances shall conform to the applicable requirements of UL 1971 and the contract drawings. Appliances shall have clear high intensity optic lens, xenon flash tubes, and output white light. Strobe flash rate shall be between 1 to 3 flashes per second and a minimum of 75 candela. Strobe shall be surface or semi-flush mounted.

2.6.5 Combination Audible/Visual Notification Appliances

Combination audible/visual notification appliances shall provide the same requirements as individual units except they shall mount as a unit in standard backboxes. Units shall be factory assembled. Any other audible notification appliance employed in the fire alarm systems shall be approved by the Contracting Officer.

2.7 FIRE DETECTION AND ALARM SYSTEM PERIPHERAL EQUIPMENT

2.7.1 Electromagnetic Door Hold-Open Devices

Devices shall be attached to the walls unless otherwise indicated. Devices shall comply with the appropriate requirements of UL 228. Devices shall operate on a specified power. Compatible magnetic component shall be attached to the door. Under normal conditions, the magnets shall attract and hold the doors open. When magnets are de-energized, they shall release the doors. Magnets shall have a holding force of 111.3 N (25 pounds). Devices shall be UL or FM approved. Housing for devices shall be brushed aluminum or stainless steel. Operation shall be fail safe with no moving parts. Electromagnetic door hold-open devices shall not be required to be held open during building power failure.

2.7.2 Conduit

Conduit and fittings shall comply with NFPA 70, UL 6, UL 1242, and UL 797 or KS C 8401, KS C 8422, KS C 8458, KS C 8459, KS C 8460, KS C 8461 and KS D 8308.

2.7.3 Wiring

Wiring shall conform to NFPA 70. Wiring for 120 Vac power shall be No. 12 AWG minimum. The SLC wiring shall be fiber optic or copper cable in accordance with the manufacturers requirements. Wiring for fire alarm dc circuits shall be No. 18 AWG minimum. Voltages shall not be mixed in any junction box, housing, or device, except those containing power supplies and control relays. Wiring shall conform to NFPA 70. Conductors shall be color coded. Conductors used for the same functions shall be similarly color coded. Wiring code color shall remain uniform throughout the circuit. Pigtail or T-tap connections to initiating device circuits, supervisory alarm circuits, and notification appliance circuits are prohibited. T-tapping using screw terminal blocks is allowed for style 5 addressable systems.

2.7.4 Special Tools and Spare Parts

Software, connecting cables and proprietary equipment, necessary for the maintenance, testing, and reprogramming of the equipment shall be furnished to the Contracting Officer. Two spare fuses of each type and size required shall be furnished. Two percent of the total number of each different type of detector, but no less than two each, shall be furnished. Spare fuses shall be mounted in the fire alarm panel.

2.8 TRANSMITTERS

2.8.1 Radio Alarm Transmitters

Transmitters shall be compatible with proprietary supervising station receiving equipment. Each radio alarm transmitter shall be the manufacturer's recognized commercial product, completely assembled, wired, factory tested, and delivered ready for installation and operation. Transmitters shall be provided in accordance with applicable portions of NFPA 72, NFPA 1221, and 47 CFR 15. Transmitter electronics module shall be contained within the physical housing as an integral, removable assembly. The proprietary supervising station receiving equipment and the transceiver shall be fully compatible with this equipment. At the contractors option, and if UL listed, the transmitter may be housed in the same panel as the fire alarm control panel.

2.8.1.1 Transmitter Power Supply

Each radio alarm transmitter shall be powered by a combination of locally available 120-volt ac power and a sealed, lead-calcium battery.

a. Operation: Each transmitter shall operate from 120-volt ac power. In the event of 120-volt ac power loss, the transmitter shall automatically switch to battery operation. Switchover shall be accomplished with no interruption of protective service, and shall automatically transmit a trouble message. Upon restoration of ac power, transfer back to normal ac power supply shall also be automatic.

b. Battery Power: Transmitter standby battery capacity shall provide sufficient power to operate the transmitter in a normal standby status for a minimum of 72 hours and be capable of transmitting alarms during that period.

2.8.1.3 Radio Alarm Transmitter Housing

Transmitter housing shall be NEMA Type 1. The housing shall contain a lock that is keyed identical to the fire alarm system for the building. Radio alarm transmitter housing shall be factory painted with a suitable priming coat and not less than two coats of a hard, durable weatherproof enamel.

2.8.1.4 Antenna

The Contractor shall provide omnidirectional for radio alarm transmitters with a driving point impedance to match transmitter output. The antenna and antenna mounts shall be corrosion resistant and designed to withstand wind velocities of 161 km/h (100 mph).

PART 3 EXECUTION

3.1 INSTALLATION

All work shall be installed as shown and in accordance with the manufacturer's diagrams and recommendations, unless otherwise specified. Smoke detectors shall not be installed until construction is essentially complete and the building has been thoroughly cleaned.

3.1.1 Power Supply for the System

A single dedicated circuit connection for supplying power from a branch circuit to each building fire alarm system shall be provided. The power shall be supplied as shown on the drawings. The power supply shall be equipped with a locking mechanism and marked in red with the words "FIRE ALARM CIRCUIT CONTROL".

3.1.3 Wiring

Conduit size for wiring shall be in accordance with NFPA 70. Wiring for the fire alarm system shall not be installed in conduits, junction boxes, or outlet boxes with conductors of lighting and power systems. Not more than two conductors shall be installed under any device screw terminal. The wires under the screw terminal shall be straight when placed under the terminal then clamped in place under the screw terminal. The wires shall be broken and not twisted around the terminal. Circuit conductors entering or leaving any mounting box, outlet box enclosure, or cabinet shall be connected to screw terminals with each terminal and conductor marked in accordance with the wiring diagram. Connections and splices shall be made using screw terminal blocks. The use of wire nut type connectors in the system is prohibited. Wiring within any control equipment shall be readily accessible without removing any component parts. The fire alarm equipment manufacturer's representative shall be present for the connection of wiring to the control panel.

3.1.4 Control Panel

The control panel and its assorted components shall be mounted so that no part of the enclosing cabinet is less than 300 mm (12 inches) nor more than 2000 mm (78 inches) above the finished floor. Manually operable controls shall be between 900 and 1100 mm (36 and 42 inches) above the finished floor. Panel shall be installed to comply with the requirements of UL 864.

3.1.5 Detectors

Detectors shall be located and installed in accordance with NFPA 72. Detectors shall be connected into signal line circuits or initiating device circuits as indicated on the drawings. Detectors shall be at least 300 mm (12 inches) from any part of any lighting fixture. Detectors shall be located at least 900 mm (3 feet) from diffusers of air handling systems. Each detector shall be provided with appropriate mounting hardware as required by its mounting location. Detectors which mount in open space shall be mounted directly to the end of the stubbed down rigid conduit drop. Conduit drops shall be firmly secured to minimize detector sway. Where length of conduit drop from ceiling or wall surface exceeds 900 mm (3 feet), sway bracing shall be provided.

3.1.6 Notification Appliances

Notification appliances shall be mounted 2003 mm (80 inches) above the finished floor or 150 mm (6 inches) below the ceiling, whichever is lower.

3.1.7 Annunciator Equipment

Annunciator equipment shall be mounted where indicated on the drawings.

3.1.7 Addressable Initiating Device Circuits Module

The initiating device circuits module shall be used to connect supervised conventional initiating devices (water flow switches, water pressure switches, manual fire alarm stations, high/low air pressure switches, and tamper switches). The module shall mount in an electrical box adjacent to or connected to the device it is monitoring and shall be capable of Style B supervised wiring to the initiating device. In order to maintain proper supervision, there shall be no T-taps allowed on style B lines. Addressable initiating device circuits modules shall monitor only one initiating device each. Contacts in suppression systems and other fire protection subsystems shall be connected to the fire alarm system to perform supervisory and alarm functions as specified in NFPA 72, and as indicated on the drawings and as specified herein.

3.1.8 Addressable Control Module

Addressable and control modules shall be installed in the outlet box or adjacent to the device they are controlling. If a supplementary suppression releasing panel is provided, then the monitor modules shall he mounted in a common enclosure adjacent to the suppression releasing panel and both this enclosure and the suppression releasing panel shall be in the same room as the releasing devices. All interconnecting wires shall be supervised unless an open circuit or short circuit abnormal condition does not affect the required operation of the fire alarm system. If control modules are used as interfaces to other systems, such as HVAC or elevator control, they shall be within the control panel or immediately adjacent to it. Control modules that control a group of notification appliances shall be adjacent to the first notification appliance in the notification appliance circuits. Control modules that connect to devices shall supervise the notification appliance circuits. Control modules that connect to auxiliary systems or interface with other systems (non-life safety systems) and where not required by NFPA 72, shall not require the secondary circuits to be supervised. Contacts in suppression systems and other fire protection subsystems shall be connected to the fire alarm system to perform required alarm functions as specified in NFPA 72, and as indicated on the drawings and as specified herein.

3.2 OVERVOLTAGE AND SURGE PROTECTION

3.2.1 Power Line Surge Protection

All equipment connected to alternating current circuits shall be protected from surges per IEEE C62.41 B3 combination waveform and NFPA 70. Fuses shall not be used for surge protection. The surge protector shall be rated for a maximum let thru voltage of 350 Volts ac (line-to-neutral) and 350 Volt ac (neutral-to-ground).

3.2.2 Low Voltage DC Circuits Surge Protection

All IDC, NAC, and communication cables/conductors, except fiber optics, shall have surge protection installed at each point where it exits or enters a building. Equipment shall be protected from surges per IEEE C62.41 B3 combination waveform and NFPA 70. The surge protector shall be rated to protect the 24 Volt dc equipment. The maximum dc clamping voltages shall be 36 V (line-to-ground) and 72 Volt dc (line-to-line).

3.2.3 Signal Line Circuit Surge Protection

All SLC cables/conductors, except fiber optics, shall have surge protection/isolation circuits installed at each point where it exits or enters a building. The circuit shall be protected from surges per IEEE C62.41 B3 combination waveform and NFPA 70. The surge protector/isolator shall be rated to protect the equipment.

3.3 GROUNDING

Grounding shall be provided by connecting to building ground system.

3.4 SUPERVISING STATION PROVISIONS

3.4.1 Revisions to Existing Facilities

Existing supervising components shall be modified as indicated on the drawings and programming shall be updated if required to accommodate the revised configuration. Acceptance testing shall include procedures that would demonstrate that operation of existing equipment has not been degraded and that the revised configuration plus interfacing components operates compatibly with the new fire alarm system at the protected premises. Work on existing equipment shall be performed in accordance with the manufacturer's instructions or under supervision of the manufacturer's representative.

3.4.2 Additions to Existing Facilities

Supplemental components shall be added to the existing supervising equipment as required to accommodate the new fire alarm system to be installed at the protected premises and/or as indicated on the drawings. All present functions shall be extended, including recording and storage in memory, and programming shall be updated if required to accommodate the revised configuration. Acceptance testing shall include procedures that would demonstrate that operation of existing equipment has not been degraded and that the expanded configuration operates compatibly with the new fire alarm system.

3.5 TESTING

The Contractor shall notify the Contracting Officer at least 10 days before the preliminary and acceptance tests are to be conducted. The tests shall be performed in accordance with the approved test procedures in the presence of the Contracting Officer. The control panel manufacturer's representative shall be present to supervise tests. The Contractor shall furnish instruments and personnel required for the tests.

3.5.1 Preliminary Tests

Upon completion of the installation, the system shall be subjected to functional and operational performance tests including tests of each installed initiating and notification appliance, when required. Tests shall include the meggering of system conductors to determine that the system is free from grounded, shorted, or open circuits. The megger test shall be conducted prior to the installation of fire alarm equipment. If deficiencies are found, corrections shall be made and the system shall be retested to assure that it is functional. After completing the preliminary testing the Contractor shall complete and submit the NFPA 72, Certificate of Completion.

3.5.2 Acceptance Test

Acceptance testing shall not be performed until the Contractor has completed and submitted the Certificate of Completion. Testing shall be in accordance with NFPA 72. The recommended tests in NFPA 72 shall be considered mandatory and shall verify that previous deficiencies have been corrected. The Contractor shall complete and submit the NFPA 72, Inspection and Testing Form. The test shall include all requirements of NFPA 72 and the following:

a. Test of each function of the control panel.

b. Test of each circuit in both trouble and normal modes.

c. Tests of each alarm initiating devices in both normal and trouble conditions.

d. Tests of each control circuit and device.

e. Tests of each alarm notification appliance.

f. Tests of the battery charger and batteries.

g. Complete operational tests under emergency power supply.

h. Visual inspection of wiring connections.

i. Opening the circuit at each alarm initiating device and notification appliance to test the wiring supervisory feature.

j. Ground fault

k. Short circuit faults

l. Stray voltage

m. Loop resistance

3.6 TRAINING

Training course shall be provided for the operations and maintenance staff. The course shall be conducted in the building where the system is installed or as designated by the Contracting Officer. The training period for systems operation shall consist of 1 training days (8 hours per day) and shall start after the system is functionally completed but prior to final acceptance tests.

SECTION 13852

FIRE ALARM REPORTING SYSTEM, RAADIO TYPE

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C135.30 (1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15 Radio Frequency Devices

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA ANSI/TIA/EIA-222-F(1996) Structural Standards for Steel Antenna Towers and Antenna Supporting Structures

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41 (1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(1993) Industrial Control and Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2002) National Electrical Code
NFPA 72	(1999) National Fire Alarm Code
NFPA 780	(1997) Installation of Lightning Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 6	(1997) Rigid Metal Conduit
UL 467	(1993; Rev thru Apr 1999) Grounding and Bonding Equipment
UL 797	(1993; Rev thru Mar 1997) Electrical Metallic Tubing
UL 1242	(1996; Rev Mar 1998) Intermediate Metal Conduit

KOREAN INDUSTRIAL STANDARDS (KS)

KS C 2302	(1986) Friction Tape
KS C 2306	(1999) Pressure Sensitive PVC Adhesive Tape
KS C 2347	(1986) Pressure Sensitive Polyester Adhesive Tape
KS C 3302	(1990) 600V PVC Insulated Wire, IV
KS C 3313	(2002) OW Wire
KS C 3315	(2002) DV Wire
KS C 3323	(1999) 600V PVC Insulated and Sheathed Cable, VV
KS C 3328	(2002) 600V PVC Insulated and Sheathed Cable, HIV
KS C 8401	(1997) Rigid Steel Conduit
KS C 8422	(2002) Steel Flexible Conduit
KS C 8431	(2001) Unplasticized Polyvinyl Chloride (UPVC) Conduit
KS C 8458	(2001) Outlet Boxes, Switch Boxes, Special Outlet Boxes, Box Covers for Rigid Metal Conduit
KS C 8459	(1997) Coupling, Connector for Flexible Conduit
KS C 8460	(2001) Bushing, Saddles, Locknuts, Couplings, Insulated Bushings for Rigid Metal Conduit
KS C 8461	(1997) Universal Fittings, Terminal Caps, Surface Switch Boxes, Circular Surface Boxes For Rigid Metal Conduit
KS D 8308	(2001) Zinc Coating (Hot Dipped) on Iron and Steel

1.2 RELATED REQUIREMENTS

Section 16050, "Basic Electrical Materials and Methods," applies to this section with the additions and modifications specified herein.

1.3 GENERAL REQUIREMENTS

1.3.1 Standard Products

Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.3.2 Nameplates

Major components of equipment shall have the manufacturer's name, address, type or style, voltage and current rating, and catalog number on a noncorrosive and nonheat-sensitive plate which is securely attached to the equipment.

1.3.3 Tags

Tags with stamped identification numbers shall be furnished for keys and locks.

1.3.4 Keys and Locks

Locks shall be keyed alike.

1.3.5 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.3.6 Compliance

The central reporting system shall comply with NFPA 72. The equipment furnished shall be listed by Underwriters Laboratories, or Factory Mutual Engineering and Research, or be approved or listed by a nationally recognized testing laboratory.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fire Alarm Reporting System; G.

Detail drawings, signed by the Qualified Engineer as defined below, consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Note that the contract drawings show layouts based on typical detectors. The contractor shall check the layout based on the actual detectors to be installed and make any necessary revisions in the detail drawings. Detail drawings shall also contain complete wiring and schematic diagrams for the equipment furnished, equipment layout, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit.

Wiring Diagrams; G

Detail point-to-point wiring diagram, signed by the Qualified Engineer as defined below, showing all points of connection. Diagram shall include connections between system devices, appliances, control panels, supervised devices, an all equipment that is activated or controlled by the panel.

SD-03 Product Data

Battery; G

Substantiating battery calculations for supervisory and alarm power requirements. Ampere-hour requirements for each system component, each panel component and the battery recharging period shall be included.

Spare Parts;

Spare parts data for each different item of material and equipment specified, after approval of detail drawings, and not later than 1 months prior to the date of beneficial occupancy. Data shall include a complete list of parts and supplies with the current unit prices and source of supply and a list of the parts recommended by the manufacturer to be replaced after 1 year of service.

Qualifications;

Qualifications, with verification of experience and license number, of a Registered Professional Engineer with at least 2 years of current experience in the design of fire protection and detection systems, or licensed Fire Detection and Alarm System Engineer, Class 1, with 2 years of current experience in the design of fire protection and detection systems. This engineer must perform the various specification items required by this section to be performed by a Registered Professional Engineer or Licensed Fire Detection and Alarm System Engineer.

Fire Alarm Reporting System; G

Four complete copies of operating instructions outlining step-by-step procedures required for system startup, operation, and shutdown. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Four copies of maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The instructions shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed. Instructions shall be approved prior to training.

Training; G

Training course for the operation and maintenance staff. The course shall be conducted in the building where the system is installed or as designated by the Contracting Officer. The training period shall consist of 1 training days (8 hours per day) and shall start after the system is functionally completed but prior to final acceptance tests. The instructions shall cover all of the items contained in the operating and maintenance instructions.

Test Procedures; G

Detailed test procedures for the fire alarm reporting system 7 days prior to performing system tests. The test procedures shall be signed by the Registered Professional Engineer or Fire Detection and Alarm System Engineer with at least 2 years of current experience in the design of the fire protection and detection systems.

SD-06 Test Reports

Testing; G

Test reports in booklet form showing all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall document all readings, test results and indicate the final position of controls.

SD-07 Certificates

Equipment; G

Certified copies of current applicable approvals or listings issued by UL, FM or other nationally recognized testing laboratory showing compliance with applicable NFPA standards.

1.5 DELIVERY AND STORAGE

All equipment delivered and placed in storage shall be protected from the weather, humidity and temperature variations, dirt, dust, and other contaminants.

1.6 SYSTEM OPERATION

The radio system shall report alarms to the radio fire alarm monitoring base station. The system shall be a completely supervised radio type fire alarm reporting system. The system shall indicate the area of alarm. The radio communication link shall be supervised and operated in accordance with NFPA 72.

1.7 ELECTRICAL SUPERVISION

Electrical supervision shall be provided for all circuits and for all positions of interface panel control switches.

PART 2 PRODUCTS

2.1 RADIO FIRE ALARM TRANSMITTER (TRANSCEIVER)

Radio Fire Alarm Transmitter (Transceiver) shall be compatible with the Radio Fire Alarm Monitoring Base Station. The transmitter shall be all solid state and comply with applicable portions of 47 CFR 15 governing type acceptance. All transmitters of a common configuration shall be interchangeable with the other devices furnished by the manufacturer. Each transmitter and interface device shall be the manufacturer's current commercial product completely assembled, wired, tested at the factory, and delivered ready for installation and operation.

2.1.1 Frequency Allocation

The transmitters shall operate on a frequency allocated by the location.

2.1.3 Power Requirements

Transmitters shall be powered by a combination of locally available 120 Vac, and sealed nickel-cadmium type batteries requiring no additional water. In the event of loss of 120 Vac power, the transmitter shall automatically switch to battery operation. The switchover shall be accomplished with no interruption of protective service, without adversely affecting the battery-powered capabilities, and shall cause the transmission of a trouble message. Upon restoration of ac power, transfer back to normal ac power supply shall be automatic and the battery shall be recharged. The converter/battery charger shall be installed within the transmitter housing. Power supply transient filtering shall be provided.

2.1.3.1 Battery Power

The battery package shall be capable of supplying all the power requirements for a given transmitter.

2.1.3.2 Battery Duration

Radio fire alarm transmitter standby battery capacity shall provide sufficient power to operate the transmitter in a normal standby status for a minimum of 72 hours and shall be capable of transmitting alarms during that period. The capacity for battery-only powered transmitters shall be 6 months before recharging is necessary.

2.1.3.3 Battery Supervision

Each radio fire alarm transmitter shall constantly monitor and supervise its own battery powered supply. A low-battery condition shall be reported when battery voltage falls below 85 percent of the rated voltage.

2.1.4 Functional Requirements

2.1.4.1 Interfacing Indicators and Controls

Transmitters shall incorporate the provisions for auxiliary interconnection to existing interior alarm systems.

2.1.4.2 Generation of Signals

Each transmitter shall be a standard design which allows the immediate transmission of all initiated signals.

2.1.4.3 Power Output

The radio frequency (RF) power output of each transmitter shall be sufficient for reliable alarm reporting. The minimum RF power output shall be 1 watt.

2.1.4.4 Memory

Transmitters shall have memory capability. Multiple, simultaneous alarms shall not result in the loss of any messages. Messages shall be stored until they are transmitted.

2.1.4.5 Transmission Confirmation

When a signal is initiated at a public box (push button or pull lever), the transmitter shall produce an audible or visual indication that the transmitter is operating and that a signal is being sent.

2.1.4.6 Transmitter Identity Code

Each transmitter shall transmit a distinct identity code number as part of all signals emanating from the transmitter. The identity code shall allow for no less than eight digit code selection and be transmitted not less than three complete rounds (cycles).

2.1.4.7 Message Designations

Each transmitter shall allow as a minimum no less than 10 distinct and individually identifiable message designations as to the types or causes of transmitter actuation.

a. Master Message: Master messages shall be transmitted upon automatic actuation of the transmitter. The building and zone causing actuation shall be individually identified as part of this transmission. The transmitter shall be capable of identifying and transmitting a minimum of specified master (zone) messages.

b. Test Message: Test message shall be capable of both manual and automatic actuation. When a transceiver method is employed, it shall provide for automatic interrogation at preselected periods or continuous automatic interrogation in accordance with the governing standard. Additionally, transceiver systems shall provide for selective interrogation at times determined by the user. Testing the automatic test actuation shall occur a minimum of once in each specified hour period, at an optionally preselected time. Stability of the electronic actuating device shall be plus or minus 1 minute per month within the temperature range stipulated for system operation. Actuation of the "Test" message designation, regardless of initiating means, shall cause no less than 1 complete message to be sent.

c. Tamper Message Designation: The tamper message shall be automatically transmitted when a tamper switch is tripped in the transmitter housing.

d. Trouble Message Designation: Trouble message shall be automatically transmitted in the event of a failure in excess of 1 minute of the main operating power source of the transmitter.

2.1.5 Transmitter Housings

The housings on transmitters shall be fabricated from corrosion-resistant cast metal or suitable substitute which has the physical strength sufficient to ward off physical damage normally expected to be received by vandalism. The housing shall be sealed against the entry of moisture, dust, dirt, insects, and other foreign objects. Exterior housings shall be NEMA 4X.

2.1.5.1 Lock

Internal components shall be protected from vandalism by a tamper-proof lock on the transmitter housing. The housing shall allow access to all internal components for testing, servicing, and replacement at the installation site.

2.1.5.2 Mounting

Transmitter housings shall be designed for universal mounting on walls, poles, or pedestals. Mounting shall utilize either lag bolts, anchor bolts, stainless steel banding, mounting brackets, or a shackle/bolt combination, as applicable to the specific installation.

2.1.5.3 Operating Panel

Each publicly accessible transmitter shall have an operating panel that incorporates a dedicated signal initiating device (pull hook or push button) clearly identified for the initiation of "FIRE" signals. The device shall be protected with a conventional spring-loaded, "fast-action" break-glass, or similar pull-type door that allows observation of the actuation device when in the closed position. The door shall be fabricated and finished in a manner consistent with that required of the main housing.

2.1.5.4 Labeling

Each publicly accessible transmitter shall be labeled on both sides and on the front surface with the word "FIRE." The label shall be white with red lettering.

2.1.6 Environmental Operating Requirements

The transmitter shall be designed for reliable outside operation in an ambient temperature range of -30 to 60 degrees C (-22 to 140 degrees F). Transmitters shall be corrosion-resistant and designed for reliable operation under adverse climatic conditions including 160.9 km/hour (100 mph) winds, ice, rain, and snow storms.

2.1.7 Painting

Radio fire alarm transmitter and interface housings shall be factory painted. The finish color shall be fire engine red. Painted surfaces damaged during installation shall be repainted to match existing paint.

2.2 RADIO TRANSMITTER INTERFACE DEVICE

The interface device shall provide a means of converting the signals that are available from the local control equipment into a form that is compatible with the transmitter inputs, while still maintaining electrical supervision of the entire system. Interface devices shall be utilized when direct connection between local control equipment and the transmitter is not possible. Interface devices shall be completely assembled, wired, tested at the factory, and delivered ready for installation and operation.

2.2.1 Enclosure

When furnished as an independent self-contained device, the interface device shall be incorporated into an enclosure conforming to NEMA ICS 1or other national standard as required by its location.

2.2.2 Indicators

Indicators shall be provided to indicate alarm and trouble conditions and shall consist of a red fire alarm and an amber trouble light. The indicators shall be designed to ensure visibility during daylight hours and to indicate the reporting zone.

2.2.3 Access

Switches and other controls shall not be accessible without the use of a key. Access to controls shall be by unlocking and opening a panel or door.

2.2.4 Mounting

Interface housings shall be designed for universal mounting on walls, poles, or pedestals. Mounting shall utilize either lag bolts, anchor bolts, stainless steel banding, mounting brackets, or a shackle/bolt combination, as applicable to the specific installation.

2.2.5 Inputs/Outputs

Each interface panel shall provide, as a minimum, the number of alarm circuit inputs and outputs indicated. Each input circuit shall be arranged so that the alarm signals shall override the trouble signals.

2.3 FIRE ALARM SYSTEM PERIPHERAL EQUIPMENT

2.3.1 Repeaters

Repeaters shall be provided where indicated or required to meet system requirements. The repeater shall receive and transmit on the frequency assigned. The receiver and transmitter sections shall conform to the requirements specified for transceivers. Two-way data transmission shall be relayed between the base station and remote stations. Repeater shall utilize a bandpass-type duplexer and one antenna, or multiple-bandpass cavity filters and multiple antennas. The duplexer or filter cavities shall isolate the receiver from transmitter spurious noise and prevent receiver desensitization. The duplexer or filter cavities shall be rated to handle the output power of the transmitter. Repeater shall be keyed with tone-encoded control circuit. A transmitter time-out circuit shall be provided to prevent system lockup.

2.3.2 Radio Fire Alarm Transmitter Box Location Light

Each indicated transmitter providing publicly accessible actuating functions shall be provided with a vapor-tight, incandescent type light fixture constructed of a flame retardant, nonplastic, polycarbonate material with a threaded ruby globe. The light shall be supported with 15 mm (1/2 inch) galvanized steel conduit and located approximately 300 mm (1 foot) above the box. The light shall be provided with an incandescent, 50-watt, 120-volt extended service lamp. Transmitters which are powered by battery only shall not be equipped with location lights.

2.3.3 Conduit

Conduit and fittings shall comply with UL 6, UL 1242, and UL 797 or KS C 8401, KS C 8422, KS C 8458, KS C 8459, KS C 8460, KS C 8461 and KS D 8308.

2.4.4 Ground Rods

Ground rods shall be of copper-clad steel conforming to UL 467 not less than 19 mm (3/4 inch) in diameter by 2.5 m (8 feet) in length.

2.3.5 Power Supply

The operating power for the system shall be single phase taken from the building electric service as specified in paragraph Power Supply for the System. Emergency backup power shall be provided by sealed nickel-calcium type batteries requiring no additional water. The charging system shall recharge fully discharged batteries within 12 hours and maintain the batteries in the fully charged state. The battery shall have the capacity to operate the system for not less than 72 hours under maximum normal load with the power supply to the charger disconnected.

2.3.6 Wiring

Wiring shall be in accordance with NFPA 70 and as indicated. Station wiring shall be color coded.

2.3.7 Special Tools and Spare Parts

Special tools necessary for the maintenance of the equipment shall be furnished. One spare set of fuses of each type and size required and 5 spare lamps of each type shall be furnished.

PART 3 EXECUTION

3.1 INSTALLATION

All work shall be installed as shown and in accordance with the manufacturer's recommendations, unless otherwise specified. Necessary interconnections, services, and adjustments required for a complete and operational system shall be provided. Electrical work shall be in accordance with NFPA 70.

3.1.1 Power Supply for the System

A single dedicated branch-circuit connection for supplying power to the fire alarm system shall be provided. The backup power supply shall be automatically energized upon failure of the normal power supply.

3.1.3 Wiring

Wiring for systems shall be installed in rigid conduit, intermediate metallic conduit, or electric metallic tubing. The conductors for the fire alarm system shall not be installed in conduits, junction boxes, or outlet boxes with conductors of lighting and power systems. The sum of the cross-sectional areas of individual conductors shall not exceed 40 percent of the interior cross-sectional area of the conduit. Conduit shall comply with NFPA 70. Ample gutter space to accommodate necessary wiring shall be provided.

3.2 OVERVOLTAGE AND SURGE PROTECTION

Equipment connected to alternating current circuits shall be protected from surges per IEEE C62.41 and NFPA 70. Cables and conductors which serve as communications links, except fiber optics, shall have surge protection circuits installed at each end. Fuses shall not be used for surge protection.

3.3 GROUNDING

Ground rods shall not protrude more than150 mm (6 inches) above grade. Noncurrent-carrying metallic parts associated with radio fire alarm equipment shall have a maximum resistance to solid "earth" ground not to exceed 25 ohms.

3.4 TESTING

The Contractor shall notify the Contracting Officer 7 days before the performance and acceptance tests are to be conducted. The tests shall be performed in the presence of the Contracting Officer under the supervision of the fire alarm system manufacturer's qualified representative. The Contractor shall furnish all instruments and personnel required for the tests.

3.4.1 Performance Testing

Upon completion of the installation, the system shall be subjected to a complete functional and operational performance test by the Contractor. Test shall determine that the system is free from grounded, shorted, or open circuits. When all corrections have been made, the system shall be retested to assure that it is functional. Copies of performance test reports shall be submitted in accordance with paragraph SUBMITTALS.

3.4.2 Acceptance Test

The testing shall be in accordance with NFPA 72. The recommended tests in NFPA 72 shall be considered mandatory and shall verify that all previous deficiencies have been corrected. The tests shall include the following:

a. Tests to indicate there are no grounded, shorted, or open circuits.

b. Tests of each radio fire alarm transmitter/receiver/transceiver/ repeater.

c. Tests of radio fire alarm monitoring base station for all required functions.

d. Tests of normal and emergency power supplies.

3.4.3 Training

The Contractor shall conduct a training course for operating staff in the building where the system is installed as designated by the Contracting Officer. The training period shall consist of 1 training day, 8 hours per day and shall start after the system is functionally completed but prior to the final acceptance tests. The field instructions shall cover all of the items contained in the approved operating and maintenance instructions.

SECTION 13930

WET PIPE SPRINKLER SYSTEM, FIRE PROTECITON

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 47/A 47M	(1999) Ferritic Malleable Iron Castings
ASTM A 183	(1983; R 1998) Carbon Steel Track Bolts and Nuts
ASTM A 536	(1984; R 1999el) Ductile Iron Castings

AMERICAN SOCIETY OF SANITARY ENGINEERING FOR PLUMBING AND SANITARY RESEARCH (ASSE)

ASSE 1015	(1993) Double Check Backflow Prevention Assembly

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA EWW	(1999) Standard Methods for the Examination of Water and Wastewater
AWWA B300	(1999) Hypochlorites
AWWA B301	(1992; addenda B301a - 1999) Liquid Chlorine
AWWA C203	(1997; addenda C203a - 1999) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines – Enamel and Tape – Hot-Applied
AWWA M20	(1973) Manual: Water Chlorination Principles and Practices

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P7825a	(1998) Approval Guide Fire Protection
FM P7825b	(1998) Approval Guide Electrical Equipment

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-71	(1997) Gray Iron Swing Check Valves, Flanges and Threaded Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13	(1999) Installation of Sprinkler Systems
NFPA 13R	(1999) Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height
NFPA 24	(1995) Installation of Private Fire Service Mains and Their Appurtenances

NFPA 230	(1999) Fire Protection of Storage
NFPA 1963	(1998) Fire Hose Connections

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7	(1995) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Automatic Sprinkler System Layout

UNDERWRITERS LABORATORIES (UL)

UL 668	(1995; Rev thru Dec 1998) Hose Valves For Fire Protection Service
UL Bld Mat Dir	(1999) Building Materials Directory
UL Fire Prot Dir	(1999) Fire Protection Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1004	(1990) Square Head Bolts
KS B 1012	(2001) Hexagon Nuts and Hexagon Thin Nuts
KS B 1531	(1997) Screwed Type Malleable Cast Iron Pipe Fitting
KS B 1533	(2000) Screwed Type Steel Pipe Fittings
KS B 1541	(1992) Steel But-Welding Pipe Fittings
KS B 1542	(1990) Steel Socket-Welding Pipe Fittings
KS D 3562	(1989) Carbon Steel Pipes for Pressure Service
KS D 4311	(1999) Ductile Iron Pipes Centrifugally Cast for Water Works
KS D 4316	(2002) Mortar Lining of Ductile Iron Pipes Centrifugally Cast for Water Works
KS M 1103	(2001) Liquid Chlorine

1.2 GENERAL REQUIREMENTS

Wet pipe sprinkler system shall be provided in areas indicated on the drawings. The sprinkler system shall provide fire sprinkler protection for the entire area. Except as modified herein, the system shall be designed and installed in accordance with NFPA 13 and NFPA 13R. Rack sprinklers shall be in accordance with NFPA 230. Pipe sizes which are not indicated on drawings shall be determined by hydraulic calculation. The Contractor shall design any portions of the sprinkler system that are not indicated on the drawings including locating sprinklers, piping and equipment, and size piping and equipment when this information is not indicated on the drawings or is not specified herein. The design of the sprinkler system shall be based on hydraulic calculations, and the other provisions specified herein.

1.2.1 Hydraulic Design

The system shall be hydraulically designed to discharge a minimum density over the hydraulically most demanding area in compliance with NFPA 13. The minimum pipe size for branch lines in gridded systems shall be 32 mm (1-1/4 inch). Hydraulic calculations shall be in accordance with the Area/Density Method of NFPA 13. Water velocity in the piping shall not exceed 6 m/s (20 ft/s). Only systems less than 140 square meters (1500 square feet) may be designed using the pipe schedule method of NFPA 13.

1.2.1.1 Hose Demand

An allowance for exterior hose streams shall be added to the sprinkler system demand at the fire hydrant shown on the drawings closest to the point where the water service enters the building. An allowance for interior hose stations shall also be added to the sprinkler system demand.

1.2.1.2 Basis for Calculations

The design of the system shall be based upon a water flow test results. Water supply shall be presumed available at the point of connection to existing or at the base of the riser as indicated. Hydraulic calculations shall be based upon the Hazen-Williams formula with a "C" value of 120 for steel piping, 150 for copper tubing, 140 for new cement-lined ductile-iron piping, and 100 for existing underground piping.

1.2.2 Sprinkler Spacing

Sprinklers shall be uniformly spaced on branch lines. Maximum spacing per sprinkler shall not exceed limits specified in NFPA 13.

1.3 COORDINATION OF TRADES

Piping offsets, fittings, and any other accessories required shall be furnished as required to provide a complete installation and to eliminate interference with other construction. Sprinkler shall be installed over and under ducts, piping and platforms when such equipment can negatively effect or disrupt the sprinkler discharge pattern and coverage.

1.4 DELIVERY AND STORAGE

All equipment delivered and placed in storage shall be housed in a manner to preclude any damage from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall either be capped or plugged until installed.

1.5 FIELD MEASUREMENTS

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Sprinkler System Shop Drawings; G

Four copies of the Sprinkler System Shop Drawings, no later than 21 days prior to the start of sprinkler system installation. The Sprinkler System Shop Drawings shall conform to the requirements established for working plans as prescribed in NFPA 13. Drawings shall include plan and elevation views demonstrating that the equipment will fit the allotted spaces with clearance for installation and maintenance. Each set of drawings shall include the following:

a. Descriptive index of drawings in the submittal with drawings listed in sequence by drawing number. A legend identifying device symbols, nomenclature, and conventions used.

b. Floor plans drawn to a scale not less than 1:100 (1/8"=1'-0") which clearly show locations of sprinklers, risers, pipe hangers, inspector's test connections, drains, and other applicable details necessary to clearly describe the proposed arrangement. Each type of fitting used and the locations of bushings, reducing couplings, and welded joints shall be indicated.

c. Actual center-to-center dimensions between sprinklers on branch lines and between branch lines; from end sprinklers to adjacent walls; from walls to branch lines; from sprinkler feed mains, cross-mains and branch lines to finished floor and roof or ceiling. A detail shall show the dimension from the sprinkler and sprinkler deflector to the ceiling in finished areas.

d. Longitudinal and transverse building sections showing typical branch line and cross-main pipe routing as well as elevation of each typical sprinkler above finished floor.

e. Details of each type of riser assembly; pipe hanger; restraint of underground water main at point-of-entry into the building, and electrical devices and interconnecting wiring.

As-Built Shop Drawings

As-built shop drawings, at least 14 days after completion of the Final Tests. The Sprinkler System Drawings shall be updated to reflect as-built conditions after all related work is completed and shall be on reproducible full-size mylar film.

SD-03 Product Data

Fire Protection Related Submittals; G

A list of the Fire Protection Related Submittals, no later than 7 days after the approval of the Fire Protection Specialist.

Components and Equipment Data; G

Manufacturer's catalog data included with the Sprinkler System Drawings for all items specified herein. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with all contract requirements. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided.

Hydraulic Calculations; G

Hydraulic calculations, including a drawing showing hydraulic reference points and pipe segments.

Spare Parts

Spare parts data shall be included for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. A list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor shall be included.

Preliminary Tests Procedures

Proposed procedures for Preliminary Tests, no later than 14 days prior to the proposed start of the tests.

Final Acceptance Test Procedures

Proposed procedures for Final Acceptance Test, no later than 14 days prior to the proposed start of the tests.

On-site Training Schedule

Proposed On-site Training schedule, at least 14 days prior to the start of related training.

Preliminary Tests

Proposed date and time to begin Preliminary Tests, submitted with the Preliminary Tests Procedures.

Final Acceptance Test

Proposed date and time to begin Final Acceptance Test, submitted with the Final Acceptance Test Procedures. Notification shall be provided at least 14 days prior to the proposed start of the test. Notification shall include a copy of the Contractor's Material & Test Certificates.

Fire Protection Specialist Qualifications

The name and documentation of certification of the proposed Fire Protection Specialists, no later than 14 days after the Notice to Proceed and prior to the submittal of the sprinkler system drawings and hydraulic calculations.

Sprinkler System Installer Qualifications

The name and documentation of certification of the proposed Sprinkler System Installer, concurrent with submittal of the Fire Protection Specialist Qualifications.

SD-06 Test Reports

Preliminary Tests Report; G

Three copies of the completed Preliminary Tests Reports, no later that 7 days after the completion of the Preliminary Tests. The Preliminary Tests Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Preliminary Tests Report shall be signed by the Fire Protection Specialist.

Final Acceptance Test Report; G

Three copies of the completed Final Acceptance Tests Reports, no later that 7 days after the completion of the Final Acceptance Tests. All items in the Final Acceptance Report shall be signed by the Fire Protection Specialist.

SD-07 Certificates

Fire Protection Specialist Inspection

Concurrent with the Final Acceptance Test Report, certification by the Fire Protection Specialist that the sprinkler system is installed in accordance with the contract requirements, including signed approval of the Preliminary and Final Acceptance Test Reports.

SD-10 Operation and Maintenance Data

Wet Pipe Sprinkler System; G

Six manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment.

1.7 HYDRAULIC CALCULATIONS

Hydraulic calculations shall be as outlined in NFPA 13 except that calculations shall be performed by computer using software intended specifically for fire protection system design using the design data shown on the drawings. Software that uses k-factors for typical branch lines is not acceptable. Calculations shall be based on the water supply data shown on the drawings. Calculations shall substantiate that the design area used in the calculations is the most demanding hydraulically. Water supply curves and system requirements shall be plotted on semi-logarithmic graph paper so as to present a summary of the complete hydraulic calculation. A summary sheet listing sprinklers in the design area and their respective hydraulic reference points, elevations, actual discharge pressures and actual flows shall be provided. Elevations of hydraulic reference points (nodes) shall be indicated. Documentation shall identify each pipe individually and the nodes connected thereto. The diameter, length, flow, velocity, friction loss, number and type fittings, total friction loss in the pipe, equivalent pipe length and Hazen-Williams coefficient shall be indicated for each pipe. For gridded systems, calculations shall show peaking of demand area friction loss to verify that the hydraulically most demanding area is being used. Also for gridded systems, a flow diagram indicating the quantity and direction of flows shall be included. A drawing showing hydraulic reference points (nodes) and pipe designations used in the calculations shall be included and shall be independent of shop drawings.

1.8 FIRE PROTECTION SPECIALIST

Work specified in this section shall be performed under the supervision of and certified by the Fire Protection Specialist. The Fire Protection Specialist shall be an individual who is a registered professional engineer and a Full Member of the Society of Fire Protection Engineers or who is certified as a Level III Technician by National Institute for Certification in Engineering Technologies (NICET) in the Automatic Sprinkler System Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7. The Fire Protection Specialist shall be regularly engaged in the design and installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.9 SPRINKLER SYSTEM INSTALLER QUALIFICATIONS

Work specified in this section shall be performed by the Sprinkler System Installer. The Sprinkler System Installer shall be regularly engaged in the installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.10 REGULATORY REQUIREMENTS

Compliance with referenced NFPA standards is mandatory. This includes advisory provisions listed in the appendices of such standards, as though the word "shall" had been substituted for the word "should" wherever it appears. In the event of a conflict between specific provisions of this specification and applicable NFPA standards, this specification shall govern. Reference to "authority having jurisdiction" shall be interpreted to mean the Contracting Officer.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.2 NAMEPLATES

All equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.3 REQUIREMENTS FOR FIRE PROTECTION SERVICE

Materials and Equipment shall have been tested by Underwriters Laboratories, Inc. and listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM P7825a and FM P7825b. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM P7825a and FM P7825b.

2.4 UNDERGROUND PIPING COMPONENTS

2.4.1 Pipe

Piping from a point 150 mm (6 inches) above the floor to a point 1500 mm (5 feet) outside the building wall shall be ductile iron conforming to KS D 4311, Class 1 with cement mortar lining conforming to KS D 4316. Piping more than 1500 mm (5 feet) outside the building walls shall comply with Section 02510 WATER DISTRIBUTION SYSTEM.

2.4.2 Fittings and Gaskets

Fittings shall be ductile iron conforming to KS D 4308. Gaskets shall be suitable in design and size for the pipe with which such gaskets are to be used. Gaskets for ductile iron pipe joints shall conform to KS D 4308.

2.4.3 Gate Valve and Indicator Posts

Gate valves for underground installation shall be of the inside screw type with counter-clockwise rotation to open. Where indicating type valves are shown or required, indicating valves shall be gate valves with an approved indicator post of a length to permit the top of the post to be located 900 mm (3 feet) above finished grade. Gate valves and indicator posts shall be listed in UL Fire Prot Dir or FM P7825a and FM P7825b.

2.5 ABOVEGROUND PIPING COMPONENTS

Aboveground piping shall be steel.

2.5.1 Steel Piping Components

2.5.1.1 Steel Pipe

Except as modified herein, steel pipe shall be black, or galvanized where indicated, as permitted by NFPA 13 and shall conform to applicable provisions of KS D 3562. Pipe in which threads or grooves are cut shall be Schedule 40 or shall be listed by Underwriters' Laboratories to have a corrosion resistance ratio (CRR) of 1.0 or greater after threads or grooves are cut. Pipe shall be marked with the name of the manufacturer, kind of pipe, and KS designation.

2.5.1.2 Fittings for Non-Grooved Steel Pipe

Fittings shall be steel conforming to KS B 1533, KS B 1541 or KS B 1542, or malleable iron conforming to KS B 1531. Galvanized fittings shall be used for piping systems or portions of piping systems utilizing galvanized piping. Fittings into which sprinklers, drop nipples or riser nipples (sprigs) are screwed shall be threaded type. Plain-end fittings with mechanical couplings, fittings that use steel gripping devices to bite into the pipe and segmented welded fittings shall not be used.

2.5.1.3 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 1200 kPa (175 psi) service and shall be the product of the same manufacturer. Fitting and coupling houses shall be malleable iron conforming to ASTM A 47/A 47M, Grade 32510; ductile iron conforming to ASTM A 536, Grade 65-45-12. Gasket shall be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A 183 and shall be cadmium plated or zinc electroplated.

2.5.1.4 Flanges

Flanges shall conform to NFPA 13 and KS D 4309. Gaskets shall be non-asbestos compressed material, 1.6 mm (1/16 inch) thick, and full face or self-centering flat ring type. Bolts shall be squarehead conforming to KS B 1004 and nuts shall be hexagon type conforming to KS B 1012.

2.5.2 Pipe Hangers

Hangers shall be listed in UL Fire Prot Dir or FM P7825a and FM P7825b and of the type suitable for the application, construction, and pipe type and sized to be supported.

2.5.3 Valves

2.5.3.1 Control Valve and Gate Valve

Manually operated sprinkler control valve and gate valve shall be outside stem and yoke (OS&Y) type and shall be listed in UL Bld Mat Dir or FM P7825a and FM P7825b.

2.5.3.2 Check Valve

Check valve 50 mm (2 inches) and larger shall be listed in UL Bld Mat Dir or FM P7825a and FM P7825b. Check valves 100 mm (4 inches) and larger shall be of the swing type with flanged cast iron body and flanged inspection plate, shall have a clear waterway and shall meet the requirements of MSS SP-71, for Type 3 or 4.

2.5.3.3 Hose Valve

Valve shall comply with UL 668 and shall have a minimum rating of 2070 kPa 300 psi. Valve shall be non-rising stem, all bronze, 90 degree angle type, with 65 mm 2-1/2 inch American National Standard Fire Hose Screw Thread (NH) male outlet in accordance with NFPA 1963. Hose valve shall be provided with 65 to 40 mm 2-1/2 to 1-1/2 inch reducer. Hose valves shall be equipped with lugged cap with drip drain, cap gasket and chain. Valve finish shall be polished brass.

2.6 ALARM CHECK VALVE ASSEMBLY

Assembly shall include an alarm check valve, standard trim piping, pressure gauges, bypass, retarding chamber, testing valves, main drain, and other components as required for a fully operational system.

2.7 WATERFLOW ALARM

2.7.1 Electric Alarm

Electrically operated, exterior-mounted, waterflow alarm bell shall be installed in accordance with NFPA 13. Waterflow alarm bell shall be rated 24 VDC and shall be connected to the Fire Alarm Control Panel(FACP).

2.7.2 Water Motor Alarm

Mechanically operated, exterior-mounted, water motor alarm assembly shall be installed in accordance with NFPA 13. Water motor alarm assembly shall include a body housing, impeller or pelton wheel, drive shaft, striker assembly, gong, wall plate and related components necessary for complete operation. Minimum 20 mm (3/4 inch) galvanized piping shall be provided between the housing and the alarm check valve. Drain piping from the body housing shall be minimum 25 mm (1 inch) galvanized and shall be arranged to drain to the outside of the building. Piping shall be galvanized both on the inside and outside surfaces.

2.8 ALARM INITIATING AND SUPERVISORY DEVICES

2.8.1 Sprinkler Waterflow Indicator Switch, Vane Type

Switch shall be vane type with a pipe saddle and cast aluminum housing. The electro-mechanical device shall include a flexible, low-density polyethylene paddle conforming to the inside diameter of the fire protection pipe. The device shall sense water movements and be capable of detecting a sustained flow of 38 L/min 10 gpm or greater. The device shall contain a retard device adjustable from 0 to 90 seconds to reduce the possibility of false alarms caused by transient flow surges. The switch shall be tamper resistant and contain two SPDT (Form C) contacts arranged to transfer upon removal of the housing cover, and shall be equipped with a silicone rubber gasket to assure positive water seal and a dustproof cover and gasket to seal the mechanism from dirt and moisture.

2.8.2 Sprinkler Pressure (Waterflow) Alarm Switch

Pressure switch shall include a metal housing with a neoprene diaphragm, SPDT snap action switches and a 15 mm 1/2 inch NPT male pipe thread. The switch shall have a maximum service pressure rating of 1207 kPa (175 psi). There shall be two SPDT (Form C) contacts factory adjusted to operate at 28 to 55 kPa (4 to 8 psi). The switch shall be capable of being mounted in any position in the alarm line trim piping of the alarm check valve.

2.8.3 Valve Supervisory (Tamper) Switch

Switch shall be suitable for mounting to the type of control valve to be supervised open. The switch shall be tamper resistant and contain one set of SPDT (Form C) contacts arranged to transfer upon removal of the housing cover or closure of the valve of more than two rotations of the valve stem.

2.9 FIRE DEPARTMENT CONNECTION

Fire department connection shall be projecting type with cast brass body, matching wall escutcheon lettered "Auto Spkr" with a polished brass finish. The connection shall have two inlets with individual self-closing clappers, caps with drip drains and chains. Female inlets shall have 65 mm (2-1/2 inch) diameter American National Fire Hose Connection Screw Threads (NH) per NFPA 1963.

2.10 SPRINKLERS

Sprinklers with internal O-rings shall not be used. Sprinklers shall be used in accordance with their listed spacing limitations. Temperature classification shall be as indicated. Sprinklers in high heat areas including attic spaces or in close proximity to unit heaters shall have temperature classification in accordance with NFPA 13. Orifice of extended coverage sprinklers shall not exceed 13.5 mm (17/32 inch). Sprinklers shall have a polished chrome finish unless otherwise indicated.

2.10.1 Concealed Sprinkler

Concealed sprinkler shall be white polyester quick-response type and shall have a nominal 12.7 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice as indicated.

2.10.2 Recessed Sprinkler

Upright sprinkler shall be white polyester quick-response type and shall have a nominal 12.7 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice as indicated.

2.10.3 Flush Sprinkler

Flush sprinkler shall be white polyester quick-response type and shall have a nominal 12.7 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice as indicated.

2.10.4 Pendent Sprinkler

Pendent sprinkler shall be of the fusible strut or glass bulb type, quick-response type with nominal 12.7 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice as indicated. Pendent sprinklers shall have a polished chrome finish.

2.10.5 Upright Sprinkler

Upright sprinkler shall be chrome plated quick-response type and shall have a nominal 12.7 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice as indicated.

2.10.6 Sidewall Sprinkler

Sidewall sprinkler shall have a nominal 12.7 mm (1/2 inch) orifice. Sidewall sprinkler shall have a white polyester finish. Sidewall sprinkler shall be the quick-response type.

2.10.7 Residential Sprinkler

Residential sprinkler shall have a nominal 12.7 mm (1/2 inch) orifice. Residential sprinkler shall have a polished chrome finish.

2.10.8 Intermediate Level Rack Sprinkler

Intermediate level rack sprinkler shall be of the upright or pendent type with nominal 12.7 mm (1/2 inch) orifice and minimum "K" factor of 5.5. The sprinkler shall be equipped with a deflector plate to shield the fusible element from water discharged above it.

2.10.9 Corrosion Resistant Sprinkler

Corrosion resistant sprinkler shall be installed in locations as indicated. Corrosion resistant coatings shall be factory-applied by the sprinkler manufacturer.

2.10.10 Dry Sprinkler Assembly

Dry sprinkler assembly shall be of the pendent, upright, sidewall, or 45-degree type as indicated. Assembly shall include an integral escutcheon. Maximum length shall not exceed maximum indicated in UL Fire Prot Dir. Sprinklers shall have a polished chrome finish.

2.11 DISINFECTING MATERIALS

2.11.1 Liquid Chlorine

Liquid chlorine shall conform to AWWA B301 or KS M 1103.

2.11.2 Hypochlorites

Calcium hypochlorite and sodium hypochlorite shall conform to AWWA B300.

2.12 ACCESSORIES

2.12.1 Sprinkler Cabinet

Spare sprinklers shall be provided in accordance with NFPA 13 and shall be packed in a suitable metal or plastic cabinet. Spare sprinklers shall be representative of, and in proportion to, the number of each type and temperature rating of the sprinklers installed. At least one wrench of each type required shall be provided.

2.12.2 Pendent Sprinkler Escutcheon

Escutcheon shall be one-piece metallic type with a depth of less than 20 mm (3/4 inch) and suitable for installation on pendent sprinklers. The escutcheon shall have a factory finish that matches the pendent sprinkler heads.

2.12.3 Pipe Escutcheon

Escutcheon shall be polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or set screw.

2.12.4 Sprinkler Guard

Guard shall be a steel wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards shall be provided on sprinklers as indicated or required.

2.12.5 Identification Sign

Valve identification sign shall be minimum 150 mm wide x 50 mm high (6 inches wide x 2 inches high) with enamel baked finish on minimum 1.214 mm (18 gauge steel) or 0.6 mm (0.024 inch) aluminum with red letters on a white background or white letters on red background. Wording of sign shall include, but not be limited to "main drain", "auxiliary drain", "inspector's test", "alarm test", "alarm line", and similar wording as required to identify operational components.

2.13 FIRE HOSE REEL ASSEMBLY

Assembly shall include nozzle, fire hose, reel, 40 mm (1-1/2 inch) valve, and bracket suitable for wall mounting. The assembly shall be semi-automatic type complete with Underwriters clip which permits controlled one-man operation whereby control valve can be opened, hose unreeled and clip released by pulling on hose. Valve shall be non-rising stem, all bronze, angle type with 40 mm (1-1/2 inch) American National Standard Fire Hose Screw Thread (NH) male outlet in accordance with NFPA 1963. Reel shall be of steel construction with red enamel finish and shall be equipped with 30 meters (100) feet of 40 mm (1-1/2 inch) rubber lined fire hose. Nozzle shall be of the industrial combination fog-straight stream type with shutoff. Components of the assembly shall be listed in UL Fire Prot Dir.

2.14 DOUBLE-CHECK VALVE BACKFLOW PREVENTION ASSEMBLY

Double-check backflow prevention assembly shall comply with ASSE 1015. The assembly shall have a bronze, cast-iron or stainless steel body with flanged ends. The assembly shall include pressure gauge test ports and OS&Y shutoff valves on the inlet and outlet, 2-positive-seating check valve for continuous pressure application, and four test cocks. Assemblies shall be rated for working pressure of 1034 kPa (150 psi. The maximum pressure loss shall be 40 kPa (6 psi) at a flow rate equal to the sprinkler water demand, at the location of the assembly. A test port for a pressure gauge shall be provided both upstream and downstream of the double check backflow prevention assembly valves.

PART 3 EXECUTION

3.1 FIRE PROTECTION RELATED SUBMITTALS

The Fire Protection Specialist shall prepare a list of the submittals from the Contract Submittal Register that relate to the successful installation of the sprinkler systems(s). The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the Fire Protection Specialist when submitted to the Government.

3.2 INSTALLATION REQUIREMENTS

The installation shall be in accordance with the applicable provisions of NFPA 13, NFPA 24 and publications referenced therein. Installation of in-rack sprinklers shall comply with applicable provisions of NFPA 230.

3.3 INSPECTION BY FIRE PROTECTION SPECIALIST

The Fire Protection Specialist shall inspect the sprinkler system periodically during the installation to assure that the sprinkler system is being provided and installed in accordance with the contract requirements. The Fire Protection Specialist shall witness the preliminary and final tests, and shall sign the test results. The Fire Protection Specialist, after completion of the system inspections and a successful final test, shall certify in writing that the system has been installed in accordance with the contract requirements. Any discrepancy shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered.

3.4 ABOVEGROUND PIPING INSTALLATION

3.4.1 Piping in Exposed Areas

Exposed piping shall be installed so as not to diminish exit access widths, corridors or equipment access. Exposed horizontal piping, including drain piping, shall be installed to provide maximum headroom.

3.4.2 Piping in Finished Areas

In areas with suspended or dropped ceilings and in areas with concealed spaces above the ceiling, piping shall be concealed above ceilings. Piping shall be inspected, tested and approved before being concealed. Risers and similar vertical runs of piping in finished areas shall be concealed.

3.4.3 Pendent Sprinklers

Drop nipples to pendent sprinklers shall consist of minimum 25 mm (1 inch) pipe with a reducing coupling into which the sprinkler shall be threaded. Hangers shall be provided on arm-overs to drop nipples supplying pendent sprinklers when the arm-over exceeds 300 mm (12 inches). Where sprinklers are installed below suspended or dropped ceilings, drop nipples shall be cut such that sprinkler ceiling plates or escutcheons are of a uniform depth throughout the finished space. The outlet of the reducing coupling shall not extend more than 25 mm (1 inch) below the underside of the ceiling. On pendent sprinklers installed below suspended or dropped ceilings, the distance from the sprinkler deflector to the underside of the ceiling shall not exceed 100 mm 4 inches. Recessed pendent sprinklers shall be installed such that the distance from the sprinkler deflector to the underside of the ceiling shall not exceed the manufacturer's listed range and shall be of uniform depth throughout the finished area.

3.4.3.1 Pendent Sprinkler Locations

Pendent sprinklers in suspended ceilings shall be a minimum of 150 mm (6 inches) from ceiling grid.

3.4.4 Upright Sprinklers

Riser nipples or "sprigs" to upright sprinklers shall contain no fittings between the branch line tee and the reducing coupling at the sprinkler. Riser nipples exceeding 750 mm (30 inches) in length shall be individually supported.

3.4.5 Pipe Joints

Pipe joints shall conform to NFPA 13, except as modified herein. Not more than four threads shall show after joint is made up. Welded joints will be permitted, only if welding operations are performed as required by NFPA 13 at the Contractor's fabrication shop, not at the project construction site. Flanged joints shall be provided where indicated or required by NFPA 13. Grooved pipe and fittings shall be prepared in accordance with the manufacturer's latest published specification according to pipe material, wall thickness and size. Grooved couplings and fittings shall be from the same manufacturer.

3.4.6 Reducers

Reductions in pipe sizes shall be made with one-piece tapered reducing fittings. The use of grooved-end or rubber-gasketed reducing couplings will not be permitted. When standard fittings of the required size are not manufactured, single bushings of the face type will be permitted. Where used, face bushings shall be installed with the outer face flush with the face of the fitting opening being reduced. Bushings shall not be used in elbow fittings, in more than one outlet of a tee, in more than two outlets of a cross, or where the reduction in size is less than 15 mm (1/2 inch).

3.4.7 Pipe Penetrations

Cutting structural members for passage of pipes or for pipe-hanger fastenings will not be permitted. Pipes that must penetrate concrete or masonry walls or concrete floors shall be core-drilled and provided with pipe sleeves. Each sleeve shall be Schedule 40 galvanized steel, ductile iron or cast iron pipe and shall extend through its respective wall or floor and be cut flush with each wall surface. Sleeves shall provide required clearance between the pipe and the sleeve per NFPA 13. The space between the sleeve and the pipe shall be firmly packed with mineral wool insulation. Where pipes penetrate fire walls, fire partitions, or floors, pipes shall be fire stopped in accordance with Section 07840 FIRESTOPPING. In penetrations that are not fire-rated or not a floor penetration, the space between the sleeve and the pipe shall be sealed at both ends with plastic waterproof cement that will dry to a firm but pliable mass or with a mechanically adjustable segmented elastomer seal.

3.4.8 Escutcheons

Escutcheons shall be provided for pipe penetration of ceilings and walls. Escutcheons shall be securely fastened to the pipe at surfaces through which piping passes.

3.4.9 Inspector's Test Connection

Unless otherwise indicated, test connection shall consist of 25 mm (1 inch) pipe connected to the remote branch line; a test valve located approximately 2 meters (7 feet) above the floor; a smooth bore brass outlet equivalent to the smallest orifice sprinkler used in the system; and a painted metal identification sign affixed to the valve with the words "Inspector's Test". The discharge orifice shall be located outside the building wall directed so as not to cause damage to adjacent construction or landscaping during full flow discharge.

3.4.10 Drains

Main drain piping shall be provided to discharge at a safe point outside the building unless otherwise indicated. Auxiliary drains shall be provided as indicated and as required by NFPA 13. When the capacity of trapped sections of pipe is less than 11 liters (3 gallons), the auxiliary drain shall consist of a valve not smaller than 15 mm (1/2 inch) and a plug or nipple and cap. When the capacity of trapped sections of piping is more than 11 liters (3 gallons), the auxiliary drain shall consist of two 25 mm (1 inch) valves and one 50x300 mm (2x12 inch) condensate nipple or equivalent, located in an accessible location. Tie-in drains shall be provided for multiple adjacent trapped branch pipes and shall be a minimum of 25 mm (1 inch) in diameter. Tie-in drain lines shall be pitched a minimum of 15 mm per 3 mm (1/2 inch per 10 feet).

3.4.11 Installation of Fire Department Connection

Connection shall be mounted on the exterior wall approximately 900 mm (3 feet) above finished grade. The piping between the connection and the check valve shall be provided with an automatic drip in accordance with NFPA 13 and arranged to drain to the outside.

3.4.12 Identification Signs

Signs shall be affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate or as required by NFPA 13. Hydraulic design data nameplates shall be permanently affixed to each sprinkler riser as specified in NFPA 13.

3.5 UNDERGROUND PIPING INSTALLATION

The fire protection water main shall be laid, and joints anchored, in accordance with NFPA 24. Minimum depth of cover shall be at least 300 mm (12 inches) plus the average local frost depth. The supply line shall terminate inside the building with a flanged piece, the bottom of which shall be set not less than 150 mm (6 inches) above the finished floor. A blind flange shall be installed temporarily on top of the flanged piece to prevent the entrance of foreign matter into the supply line. A concrete thrust block shall be provided at the elbow where the pipe turns up toward the floor. In addition, joints shall be anchored in accordance with NFPA 24 using pipe clamps and steel rods from the elbow to the flange above the floor and from the elbow to a pipe clamp in the horizontal run of pipe. Buried steel components shall be provided with a corrosion protective coating in accordance with AWWA C203. Piping more than 1500 mm (5 feet) outside the building walls shall meet the requirements of Section 02510 WATER DISTRIBUTION SYSTEM.

3.6 EARTHWORK

Earthwork shall be performed in accordance with applicable provisions of Section 02315 EXCAVATION, FILLING AND BACKFILLING FOR BUILDINGS.

3.7 ELECTRICAL WORK

Except as modified herein, electric equipment and wiring shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Wiring color code shall remain uniform throughout the system.

3.8 DISINFECTION

If sprinkler piping is not isolated from the domestic water piping systems by means of a reduced pressure backflow prevention assembly or if sprinkler piping in connected to the domestic water piping, after all system components are installed and hydrostatic test(s) are successfully completed, each portion of the sprinkler system to be disinfected shall be thoroughly flushed with potable water until all entrained dirt and other foreign materials have been removed before introducing chlorinating material. Flushing shall be conducted by removing the flushing fitting of the cross mains and of the grid branch lines, and then back-flushing through the sprinkler main drains. The chlorinating material shall be hypochlorites or liquid chlorine. Water chlorination procedure shall be in accordance with AWWA M20. The chlorinating material shall be fed into the sprinkler piping at a constant rate of 50 parts per million (ppm). A properly adjusted hypochlorite solution injected into the system with a hypochlorinator, or liquid chlorine injected into the system through a solution-fed chlorinator and booster pump shall be used. Chlorination application shall continue until the entire system if filled. The water shall remain in the system for a minimum of 24 hours. Each valve in the system shall be opened and closed several times to ensure its proper disinfection. Following the 24-hour period, no less than 25 ppm chlorine residual shall remain in the system. The system shall then be flushed with clean water until the residual chlorine is reduced to less than one part per million. Samples of water in disinfected containers for bacterial examination will be taken from several system locations which are approved by the Contracting Officer. Samples shall be tested for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA EWW. The testing method shall be either the multiple-tube fermentation technique or the membrane-filter technique. The disinfection shall be repeated until tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained. After successful completion, verify installation of all sprinklers and plugs and pressure test the system.

3.9 PIPE COLOR CODE MARKING

Color code marking of piping shall be as specified in Section 09900 PAINTING, GENERAL.

3.10 PRELIMINARY TESTS

The system, including the underground water mains, and the aboveground piping and system components, shall be tested to assure that equipment and components function as intended. The underground and aboveground interior piping systems and attached appurtenances subjected to system working pressure shall be tested in accordance with NFPA 13 and NFPA 24. Upon completion of specified tests, the Contractor shall complete certificates as specified in paragraph SUBMITTALS.

3.10.1 Underground Piping

3.10.1.1 Flushing

Underground piping shall be flushed in accordance with NFPA 24. This includes the requirement to flush the lead-in connection to the fire protection system at a flow rate not less that the calculated maximum water demand rate of the system.

3.10.1.2 Hydrostatic Testing

New underground piping shall be hydrostatically tested in accordance with NFPA 24. The allowable leakage shall be measured at the specified test pressure by pumping from a calibrated container. The amount of leakage at the joints shall not exceed 1.89 liters (2 quarts) per hour per 100 gaskets or joints, regardless of pipe diameter.

3.10.2 Aboveground Piping

3.10.2.1 Hydrostatic Testing

Aboveground piping shall be hydrostatically tested in accordance with NFPA 13 at not less than 1400 kPa (200 psi) or 350 kPa (50 psi) in excess of maximum system operating pressure and shall maintain that pressure without loss for 2 hours. There shall be no drop in gauge pressure or visible leakage when the system is subjected to the hydrostatic test. The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

3.10.2.2 Backflow Prevention Assembly Forward Flow Test

Each backflow prevention assembly shall be tested at system flow demand, including all applicable hose streams, as specified in NFPA 13. The Contractor shall provide all equipment and instruments necessary to conduct a complete forward flow test, including65 mm (2.5 inch) diameter hoses, playpipe nozzles, calibrated pressure gauges, and pitot tube gauge. The Contractor shall provide all necessary supports to safely secure hoses and nozzles during the test. At the system demand flow, the pressure readings and pressure drop (friction) across the assembly shall be recorded. A metal placard shall be provided on the backflow prevention assembly that lists the pressure readings both upstream and downstream of the assembly, total pressure drop, and the system test flow rate. The pressure drop shall be compared to the manufacturer's data.

3.10.3 Testing of Alarm Devices

Each alarm switch shall be tested by flowing water through the inspector's test connection. Each water-operated alarm devices shall be tested to verify proper operation. The connecting circuit to the building fire alarm system and to the base-wide fire report system shall be inspected and tested.

3.10.4 Main Drain Flow Test

Following flushing of the underground piping, a main drain test shall be made to verify the adequacy of the water supply. Static and residual pressures shall be recorded on the certificate specified in paragraph SUBMITTALS. In addition, a main drain test shall be conducted each time after a main control valve is shut and opened.

3.11 FINAL ACCEPTANCE TEST

Final Acceptance Test shall begin only when the Preliminary Test Report has been approved. The Fire Protection Specialist shall conduct the Final Acceptance Test and shall provide a complete demonstration of the operation of the system. This shall include operation of control valves and flowing of inspector's test connections to verify operation of associated waterflow alarm switches. After operation of control valves has been completed, the main drain test shall be repeated to assure that control valves are in the open position. In addition, the representative shall have available copies of as-built drawings and certificates of tests previously conducted. The installation shall not be considered accepted until identified discrepancies have been corrected and test documentation is properly completed and received.

3.12 ON-SITE TRAINING

The Fire Protection Specialist shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of 24 hours of normal working time and shall start after the system is functionally complete but prior to the Preliminary Tests and Final Acceptance Test. The On-Site Training shall cover all of the items contained in the approved Operating and Maintenance Instructions.

SECTION 13935

DRY PIPE SPRINKLER SYSTEM, FIRE PROTECTION

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 47/A 47M (1999) Ferritic Malleable Iron Castings

ASTM A 183 (1983; R 1998) Carbon Steel Track Bolts and Nuts

ASTM A 536 (1984; R 1999e1) Ductile Iron Castings

AMERICAN SOCIETY OF SANITARY ENGINEERING FOR PLUMBING AND SANITARY RESEARCH (ASSE)

ASSE 1015 (1993) Double Check Backflow Prevention Assembly

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA EWW (1999) Standard Methods for the Examination of Water and Wastewater

AWWA B300 (1992) Hypochlorites

AWWA B301 (1992; Addenda B301a - 1999) Liquid Chlorine

AWWA C203 (1997; Addenda C203a - 1999) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied

AWWA M20 (1973) Manual: Water Chlorination Principles and Practices

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P7825a (1998) Approval Guide Fire Protection

FM P7825b (1998) Approval Guide Electrical Equipment

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-71 (1997) Cast Iron Swing Check Valves, Flanges and Threaded Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13 (1999) Installation of Sprinkler Systems

NFPA 24 (1995) Installation of Private Fire Service Mains and Their Appurtenances

NFPA 1963 (1998) Fire Hose Connections

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7 (1995) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Automatic Sprinkler System Layout

UNDERWRITERS LABORATORIES (UL)

UL Bld Mat Dir (1999) Building Materials Directory

UL Fire Prot Dir (1999) Fire Protection Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1004 (1990) Square Head Bolts

KS B 1012 (2001) Hexagon Nuts and Hexagon Thin Nuts

KS B 1531 (1997) Screwed Type Malleable Cast Iron Pipe Fitting

KS B 1533 (2000) Screwed Type Steel Pipe Fittings

KS B 1541 (1992) Steel But-Welding Pipe Fittings

KS B 1542 (1990) Steel Socket-Welding Pipe Fittings

KS D 3562 (1989) Carbon Steel Pipes for Pressure Service

KS D 4311 (1999) Ductile Iron Pipes Centrifugally Cast for Water Works

KS D 4316 (2002) Mortar Lining of Ductile Iron Pipes Centrifugally Cast for Water Works

KS M 1103 (2001) Liquid Chlorine

1.2 GENERAL REQUIREMENTS

Dry pipe sprinkler system shall be provided in drawings. The sprinkler system shall provide fire sprinkler protection for the entire area. Except as modified herein, the system shall be designed and installed in accordance with NFPA 13. Pipe sizes which are not indicated on the drawings shall be determined by hydraulic calculation. Gridded systems shall not be used. The Contractor shall design any portion of the sprinkler system that are not indicated on the drawings including locating sprinklers, piping, and equipment, and size piping and equipment when this information is not indicated on the drawings or is not specified herein. The design of the sprinkler system shall be based on hydraulic calculations, and the other provisions specified herein.

1.2.1 Hydraulic Design

The system shall be hydraulically designed to discharge a minimum density over the hydraulically most demanding area in compliance with NFPA 13. Hydraulic calculations shall be provided in accordance with the Area/Density Method of NFPA 13. Water velocity in the piping shall not exceed 6 m/s (20 ft/s). Only systems less than 140 square meters (1500 square feet) may be designed using the pipe schedule method of NFPA 13.

1.2.1.1 Hose Demand

An allowance for exterior hose streams shall be added to the sprinkler system demand at the fire hydrant shown on the drawings closest to the point where the water service enters the building. An allowance for interior hose stations shall also be added to the sprinkler system demand.

1.2.1.2 Basis for Calculations

The design of the system shall be based upon a water flow test results. Water supply shall be presumed available at the point of connection to existing or at the base of the riser as indicated. Hydraulic calculations shall be based upon the Hazen-Williams formula with a "C" value of 120 for galvanized steel piping, 140 for new cement-lined ductile-iron piping, and 100 for existing underground piping.

1.2.2 Sprinkler Spacing

Sprinklers shall be uniformly spaced on branch lines. Maximum spacing per sprinkler shall not exceed limits specified in NFPA 13.

1.2.3 System Volume Limitations

Where the volume of any individual system piping volume exceeds 1890 liters (500 gallons), the dry pipe valve shall be provided with a quick-opening device. The maximum system capacity controlled by one dry pipe valve shall not exceed 2800 liters (750 gallons). The calculated volume of each system shall be indicated on the Sprinkler System Shop Drawings.

1.3 COORDINATION OF TRADES

Piping offsets, fittings, and any other accessories required shall be furnished as required to provide a complete installation and to eliminate interference with other construction. Sprinkler shall be installed over and under ducts, piping and platforms when such equipment can negatively effect or disrupt the sprinkler discharge pattern and coverage.

1.4 DELIVERY AND STORAGE

All equipment delivered and placed in storage shall be housed in a manner to preclude any damage from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall either be capped or plugged until installed.

1.5 FIELD MEASUREMENTS

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G

Four copies of the Sprinkler System Drawings, no later than 21 days prior to the start of sprinkler system installation. The Sprinkler System Drawings shall conform to the requirements established for working plans as prescribed in NFPA 13. Drawings shall include plan and elevation views demonstrating that the equipment will fit the allotted spaces with clearance for installation and maintenance. Each set of drawings shall include the following:

a. Descriptive index of drawings in the submittal with drawings listed in sequence by drawing number. A legend identifying device symbols, nomenclature, and conventions used.

b. Floor plans drawn to a scale not less than 1:100 (1/8"=1'-0") which clearly show locations of sprinklers, risers, pipe hangers, inspector's test connections, drains, and other applicable details necessary to clearly describe the proposed arrangement. Each type of fitting used and the locations of bushings, reducing couplings, and welded joints shall be indicated.

c. Actual center-to-center dimensions between sprinklers on branch lines and between branch lines; from end sprinklers to adjacent walls; from walls to branch lines; from sprinkler feed mains, cross-mains and branch lines to finished floor and roof or ceiling. A detail shall show the dimension from the sprinkler and sprinkler deflector to the ceiling in finished areas.

d. Longitudinal and transverse building sections showing typical branch line and cross-main pipe routing as well as elevation of each typical sprinkler above finished floor.

e. Details of each type of riser assembly; air supply system and piping; pipe hanger; restraint of underground water main at point-of-entry into the building, and electrical devices and interconnecting wiring.

As-Built Drawings

As-built shop drawings, at least 14 days after completion of the Final Tests. The Sprinkler System Drawings shall be updated to reflect as-built conditions after all related work is completed and shall be on reproducible full-size mylar film.

SD-03 Product Data

Fire Protection Related Submittals; G

A list of the Fire Protection Related Submittals, no later than 7 days after the approval of the Fire Protection Specialist.

Materials and Equipment; G

Manufacturer's catalog data included with the Sprinkler System Drawings for all items specified herein. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with all contract requirements. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided.

Hydraulic Calculations; G

Hydraulic calculations, including a drawing showing hydraulic reference points and pipe segments.

Spare Parts

Spare parts data shall be included for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. A list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor shall be included.

Preliminary Tests

Proposed procedures for Preliminary Tests, no later than 14 days prior to the proposed start of the tests. Proposed date and time to begin Preliminary Tests, submitted with the Preliminary Tests Procedures.

Final Acceptance Test

Proposed procedures for Final Acceptance Test, no later than 14 days prior to the proposed start of the tests. Proposed date and time to begin Final Acceptance Test, submitted with the Final Acceptance Test Procedures. Notification shall be provided at least 14 days prior to the proposed start of the test. Notification shall include a copy of the Contractor's Material & Test Certificates.

Fire Protection Specialist

The name and documentation of certification of the proposed Fire Protection Specialists, no later than 14 days after the Notice to Proceed and prior to the submittal of the sprinkler system shop drawings and hydraulic calculations.

Sprinkler System Installer Qualifications

The name and documentation of certification of the proposed Sprinkler System Installer, concurrent with submittal of the Fire Protection Specialist Qualifications.

Onsite Training

Proposed On-site Training schedule, at least 14 days prior to the start of related training.

SD-06 Test Reports

Preliminary Tests; G

Three copies of the completed Preliminary Tests Reports, no later that 7 days after the completion of the Preliminary Tests. The Preliminary Tests Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Preliminary Tests Report shall be signed by the Fire Protection Specialist.

Final Acceptance Test; G

Three copies of the completed Final Acceptance Tests Reports, no later that 7 days after the completion of the Final Acceptance Tests. All items in the Final Acceptance Report shall be signed by the Fire Protection Specialist.

SD-07 Certificates

Inspection by Fire Protection Specialist

Concurrent with the Final Acceptance Test Report, certification by the Fire Protection Specialist that the sprinkler system is installed in accordance with the contract requirements, including signed approval of the Preliminary and Final Acceptance Test Reports.

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions; G

Six manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment.

1.7 HYDRAULIC CALCULATIONS

Hydraulic calculations shall be as outlined in NFPA 13 except that calculations shall be performed by computer using software intended specifically for fire protection system design using the design data shown on the drawings. Software that uses k-factors for typical branch lines is not acceptable. Calculations shall be based on the water supply data shown on the drawings. Calculations shall substantiate that the design area used in the calculations is the most demanding hydraulically. Water supply curves and system requirements shall be plotted on semi-logarithmic graph paper so as to present a summary of the complete hydraulic calculation. A summary sheet listing sprinklers in the design area and their respective hydraulic reference points, elevations, actual discharge pressures and actual flows shall be provided. Elevations of hydraulic reference points (nodes) shall be indicated. Documentation shall identify each pipe individually and the nodes connected thereto. The diameter, length, flow, velocity, friction loss, number and type fittings, total friction loss in the pipe, equivalent pipe length and Hazen-Williams coefficient shall be indicated for each pipe. For gridded systems, calculations shall show peaking of demand area friction loss to verify that the hydraulically most demanding area is being used. Also for gridded systems, a flow diagram indicating the quantity and direction of flows shall be included. A drawing showing hydraulic reference points (nodes) and pipe designations used in the calculations shall be included and shall be independent of shop drawings.

1.8 FIRE PROTECTION SPECIALIST

Work specified in this section shall be performed under the supervision of and certified by the Fire Protection Specialist. The Fire Protection Specialist shall be an individual who is a registered professional engineer and a Full Member of the Society of Fire Protection Engineers or who is certified as a Level III Technician by National Institute for Certification in Engineering Technologies (NICET) in the Automatic Sprinkler System Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7. The Fire Protection Specialist shall be regularly engaged in the design and installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.9 SPRINKLER SYSTEM INSTALLER QUALIFICATIONS

Work specified in this section shall be performed by the Sprinkler System Installer. The Sprinkler System Installer shall be regularly engaged in the installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.10 REGULATORY REQUIREMENTS

Compliance with referenced NFPA standards is mandatory. This includes advisory provisions listed in the appendices of such standards, as though the word "shall" had been substituted for the word "should" wherever it appears. In the event of a conflict between specific provisions of this specification and applicable NFPA standards, this specification shall govern. Reference to "authority having jurisdiction" shall be interpreted to mean the Contracting Officer.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.2 NAMEPLATES

All equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.3 REQUIREMENTS FOR FIRE PROTECTION SERVICE

Materials and Equipment shall have been tested by Underwriters Laboratories, Inc. and listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM P7825a and FM P7825b. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM P7825a and FM P7825b.

2.4 UNDERGROUND PIPING COMPONENTS

2.4.1 Pipe

Piping from a point 150 mm (6 inches) above the floor to a point 1500 mm (5 feet) outside the building wall shall be ductile iron conforming to KS D 4311, Class 1, with cement mortar lining conforming to KS D 4316. Piping more than 1500 mm (5 feet) outside the building walls shall comply with Section 02510 WATER DISTRIBUTION SYSTEM.

2.4.2 Fittings and Gaskets

Fittings shall be ductile iron conforming to KS D 4308. Gaskets shall be suitable in design and size for the pipe with which such gaskets are to be used. Gaskets for ductile iron pipe joints shall conform to KS D 4308.

2.4.3 Gate Valve and Indicator Post

Gate valves for underground installation shall be of the inside screw type with counter-clockwise rotation to open. Where indicating type valves are shown or required, indicating valves shall be gate valves with an approved indicator post of a length to permit the top of the post to be located 900 mm (3 feet) above finished grade. Gate valves and indicator posts shall be listed in UL Fire Prot Dir or FM P7825a and FM P7825b.

2.5 ABOVEGROUND PIPING COMPONENTS

2.5.1 Steel Pipe

Except as modified herein, steel pipe shall be galvanized conforming to the applicable requirements of KS D 3562. Pipe in which threads or grooves are cut shall be Schedule 40 or shall be listed by Underwriters' Laboratories to have a corrosion resistance ratio (CRR) of 1.0 or greater after threads or grooves are cut. Pipe shall be marked with the name of the manufacturer, kind of pipe, and KS designation.

2.5.2 Fittings for Non-Grooved Steel Pipe

Fittings shall be galvanized steel conforming to KS B 1533, KS B 1541 or KS B 1542. Fittings that sprinklers, drop nipples or riser nipples (sprigs) are screwed into shall be threaded type. Plain-end fittings with mechanical couplings, fittings that use steel gripping devices to bite into the pipe and segmented welded fittings shall not be used.

2.5.3 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 1200 kPa (175 psi) service and shall be the product of the same manufacturer. Fitting and coupling houses shall be malleable iron conforming to ASTM A 47/A 47M, Grade 32510; ductile iron conforming to ASTM A 536, Grade 65-45-12. Gaskets shall be of silicon compound and approved for dry fire protection systems. Gasket shall be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A 183 and shall be cadmium plated or zinc electroplated.

2.5.4 Flanges

Flanges shall conform to NFPA 13 and KS D 4309. Gaskets shall be non-asbestos compressed material, 1.6 mm (1/16 inch) thick, and full face or self-centering flat ring type. Bolts shall be squarehead conforming to KS B 1004 and nuts shall be hexagon type conforming to KS B 1012.

2.5.5 Pipe Hangers

Hangers shall be listed in UL Fire Prot Dir or FM P7825a and FM P7825b and of the type suitable for the application, construction, and pipe type and size to be supported.

2.5.6 Valves

2.5.6.1 Control Valve and Gate Valve

Manually operated sprinkler control valve and gate valve shall be outside stem and yoke (OS&Y) type and shall be listed in UL Bld Mat Dir or FM P7825a and FM P7825b.

2.5.6.2 Check Valve

Check valve 50 mm (2 inches) and larger shall be listed in UL Bld Mat Dir or FM P7825a and FM P7825b. Check valves 100 mm (4 inches) and larger shall be of the swing type with flanged cast iron body and flanged inspection plate, shall have a clear waterway and shall meet the requirements of MSS SP-71, for Type 3 or 4.

2.6 DRY PIPE VALVE ASSEMBLY

The dry pipe valve shall be a latching differential type listed in UL Fire Prot Dir or FM P7825a and FM P7825b and shall be complete with trim piping, valves, fittings, pressure gauges, priming water fill cup, velocity drip check, drip cup, and other ancillary components as required for proper operation.

The assembly shall include a quick-opening device by the same manufacturer as the dry pipe valve for systems over 1890 liters 500 gallons in capacity.

2.7 SUPERVISORY AIR SYSTEM

Air supply system shall be in accordance with NFPA 13. The connection pipe from the air compressor shall not be less than 15 mm (1/2 inch) in diameter and shall enter the system above the priming water level of the dry pipe valve. A check valve shall be installed in the system supply air piping from the compressor. A shutoff valve of the renewable disc type shall be installed upstream of this check valve. The air supply system shall be sized to pressurize the sprinkler system to 275 kPa (40 psi) within 20 minutes.

2.7.1 Air Compressor

Compressor shall be single stage oil-free type, air-cooled, electric-motor driven, equipped with a check valve, shutoff valve and pressure switch for automatic starting and stopping. Unless otherwise indicated, pressure switch shall be factory set to start the compressor at 200 kPa (30 psi) and stop it at 300 kPa (40 psi). A safety relief valve, set to operate at 450 kPa, (65 psi), shall be provided.

2.7.2 Air Pressure Maintenance Device

Device shall be a pressure regulator that automatically reduces supply air to provide the pressure required to be maintained in the piping system. The device shall have a cast bronze body and valve housing complete with diaphragm assembly, spring, filter, ball check to prevent backflow, 1.6 mm (1/16 inch) restriction to prevent rapid pressurization of the system, and adjustment screw. The device shall be capable of reducing an inlet pressure of up to 680 kPa (100 psig) to a fixed outlet pressure adjustable to 70 kPa (10 psig).

2.7.3 Air Supply Piping System

System shall be configured so that each dry pipe system is equipped with a separate pressure maintenance device, air compressor, shutoff valve, bypass valve and pressure gauge. Piping shall be galvanized steel in accordance with KS D 3562, Schedule 40.

2.7.4 Low Air Pressure Alarm Device

Each dry pipe valve trim shall be provided with a local alarm device consisting of a metal enclosure containing an alarm horn or bell, silence switch, green power-on light, red low-air alarm light and amber trouble light. The alarm device shall be activated by the low air pressure switch. Upon reduction of sprinkler system pressure to approximately 70 kPa (10 psig) above the dry valve trip point pressure, the low air pressure switch shall actuate the audible alarm device and a red low-air alarm light. Restoration of system pressure shall cause the low-air alarm light to be extinguished and the audible alarm to be silenced. An alarm silence switch shall be provided to silence the audible alarm. An amber trouble light shall be provided which will illuminate upon operation of the silence switch and shall be extinguished upon return to its normal position.

2.8 WATERFLOW ALARM

2.8.1 Electric Alarm

Electrically operated, exterior-mounted, waterflow alarm bell shall be provided and installed in accordance with NFPA 13. Waterflow alarm bell shall be rated 24 VDC and shall be connected to the Fire Alarm Control Panel.

2.8.2 Water Motor Alarm

Mechanically operated, exterior-mounted, water motor alarm assembly shall be provided and installed in accordance with NFPA 13. Water motor alarm assembly shall include a body housing, impeller or pelton wheel, drive shaft, striker assembly, gong, wall plate and related components necessary for complete operation. Minimum 20 mm (3/4 inch) valve. Drain piping from the body housing shall be minimum 25 mm (1 inch) galvanized and shall be arranged to drain to the outside of the building. Piping shall be galvanized both on the inside and outside surfaces.

2.9 ALARM INITIATING AND SUPERVISORY DEVICES

2.9.1 Sprinkler Pressure (Waterflow) Alarm Switch

Pressure switch shall include a metal housing with a neoprene diaphragm, SPDT snap action switches and a 15 mm 1/2 inch NPT male pipe thread. The switch shall have a maximum service pressure rating of 1207 kPa (175 psi). There shall be two SPDT (Form C) contacts factory adjusted to operate at 28 to 55 kPa (4 to 8 psi). The switch shall be capable of being mounted in any position in the alarm line trim piping of the dry pipe valve.

2.9.2 Low Air Pressure Supervisory Switch

The pressure switch shall supervise the air pressure in system and shall be set to activate at 70 kPa (10 psi) above the dry pipe valve trip point pressure. The switch shall have an adjustable range between 35 kPa (5 psi) and 500 kPa (80 psi). The switch shall have screw terminal connection and shall be capable of being wired for normally open or normally closed circuit.

2.9.3 Valve Supervisory (Tamper) Switch

Switch shall be suitable for mounting to the type of control valve to be supervised open. The switch shall be tamper resistant and contain one set of SPDT (Form C) contacts arranged to transfer upon removal of the housing cover or closure of the valve of more than two rotations of the valve stem.

2.10 FIRE DEPARTMENT CONNECTION

Fire department connection shall be projecting type with cast brass body, matching wall escutcheon lettered "Auto Spkr" with a polished brass finish. The connection shall have two inlets with individual self-closing clappers, caps with drip drains and chains. Female inlets shall have 65 mm (2-1/2 inch) diameter American National Fire Hose Connection Screw Threads (NH) per NFPA 1963.

2.11 SPRINKLERS

Sprinklers with internal O-rings shall not be used. Sprinklers shall be used in accordance with their listed spacing limitations. Areas where sprinklers are connected to or are a part of the dry pipe system shall be considered unheated and subject to freezing. Temperature classification shall be as indicated. Sprinklers in high heat areas including attic spaces or in close proximity to unit heaters shall have temperature classification in accordance with NFPA 13. Orifice of extended coverage sprinklers shall not exceed 13.5 mm (17/32 inch).

2.11.1 Pendent Sprinkler

Pendent sprinkler heads shall be the dry pendent type, unless otherwise indicated. Pendent sprinkler shall be of the fusible strut or glass bulb type, quick-response type with nominal 12.7 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice as indicated. Pendent sprinklers shall have a polished chrome finish. Assembly shall include an integral escutcheon. Maximum length shall not exceed the maximum length indicated in UL Fire Prot Dir.

2.11.2 Upright Sprinkler

Upright sprinkler shall be chrome-plated quick-response type and shall have a nominal 12.7 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice as indicated.

2.11.3 Corrosion Resistant Sprinkler

Corrosion resistant sprinkler shall be installed in locations as indicated. Corrosion resistant coatings shall be factory-applied by the sprinkler manufacturer.

2.12 DISINFECTING MATERIALS

2.12.1 Liquid Chlorine

Liquid chlorine shall conform to AWWA B301 or KS M 1103.

2.12.2 Hypochlorites

Calcium hypochlorite and sodium hypochlorite shall conform to AWWA B300.

2.13 ACCESSORIES

2.13.1 Sprinkler Cabinet

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Spare sprinklers shall be provided in accordance with NFPA 13 and shall be packed in a suitable metal or plastic cabinet. Spare sprinklers shall be representative of, and in proportion to, the number of each type and temperature rating of the sprinklers installed. At least one wrench of each type required shall be provided.

2.13.2 Pendent Sprinkler Escutcheon

Escutcheon shall be one-piece metallic type with a depth of less than 20 mm (3/4 inch) and suitable for installation on pendent sprinklers. The escutcheon shall have a factory finish that matches the pendent sprinkler heads.

2.13.3 Pipe Escutcheon

Escutcheon shall be polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or set screw.

2.13.4 Sprinkler Guard

Guard shall be a steel wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards shall be provided on sprinklers as indicated.

2.13.5 Identification Sign

Valve identification sign shall be minimum 150 mm wide by 50 mm high (6 inches wide by 2 inches high) with enamel baked finish on minimum 1.214 mm (18 gauge) steel or 0.6 mm (0.024 inch) aluminum with red letters on a white background or white letters on red background. Wording of sign shall include, but not be limited to "main drain", "auxiliary drain", "inspector's test", "alarm test", "alarm line", and similar wording as required to identify operational components.

2.14 DOUBLE-CHECK VALVE BACKFLOW PREVENTION ASSEMBLY

Double-check backflow prevention assembly shall comply with ASSE 1015. The assembly shall have a bronze, cast-iron or stainless steel body with flanged ends. The assembly shall include pressure gauge test ports and OS&Y shutoff valves on the inlet and outlet, 2-positive-seating check valve for continuous pressure application, and four test cocks. Assemblies shall be rated for working pressure of 1034 kPa (150 psi). The maximum pressure loss shall be 40 kPa (6 psi) at a flow rate equal to the sprinkler water demand, at the location of the assembly. A test port for a pressure gauge shall be provided both upstream and downstream of the double check backflow prevention assembly valves.

PART 3 EXECUTION

3.1 FIRE PROTECTION RELATED SUBMITTALS

The Fire Protection Specialist shall prepare a list of the submittals from the Contract Submittal Register that relate to the successful installation of the sprinkler systems(s). The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the Fire Protection Specialist when submitted to the Government.

3.2 INSTALLATION REQUIREMENTS

The installation shall be in accordance with the applicable provisions of NFPA 13, NFPA 24 and publications referenced therein.

3.3 INSPECTION BY FIRE PROTECTION SPECIALIST

The Fire Protection Specialist shall inspect the sprinkler system periodically during the installation to assure that the sprinkler system installed in accordance with the contract requirements. The Fire Protection Specialist shall witness the preliminary and final tests, and shall sign the test results. The Fire Protection Specialist, after completion of the system inspections and a successful final test, shall certify in writing that the system has been installed in accordance with the contract requirements. Any discrepancy shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered.

3.4 ABOVEGROUND PIPING INSTALLATION

3.4.1 Protection of Piping Against Earthquake Damage

The system piping shall be protected against damage from earthquakes. Seismic protection shall include flexible and rigid couplings, sway bracing, seismic separation assemblies where piping crosses building seismic separation joints, and other features as required by NFPA 13 for protection of piping against damage from earthquakes.

3.4.2 Piping in Exposed Areas

Exposed piping shall be installed so as not diminish exit access widths, corridors, or equipment access. Exposed horizontal piping, including drain piping, shall be installed to provide maximum headroom.

3.4.3 Piping in Finished Areas

In areas with suspended or dropped ceilings and in areas with concealed spaces above the ceiling, piping shall be concealed above ceilings. Piping shall be inspected, tested and approved before being concealed. Risers and similar vertical runs of piping in finished areas shall be concealed.

3.4.4 Pendent Sprinklers Locations

Sprinklers installed in the pendent position shall be of the listed dry pendent type, unless otherwise indicated. Dry pendent sprinklers shall be of the required length to permit the sprinkler to be threaded directly into a branch line tee. Hangers shall be provided on arm-overs exceeding 300 mm (12 inches) in length. Dry pendent sprinkler assemblies shall be such that sprinkler ceiling plates or escutcheons are of the uniform depth throughout the finished space. Pendent sprinklers in suspended ceilings shall be a minimum of 150 mm (6 inches) from ceiling grid. Recessed pendent sprinklers shall be installed such that the distance from the sprinkler deflector to the underside of the ceiling shall not exceed the manufacturer's listed range and shall be of uniform depth throughout the finished area.

3.4.5 Upright Sprinklers

Riser nipples or "sprigs" to upright sprinklers shall contain no fittings between the branch line tee and the reducing coupling at the sprinkler. Riser nipples exceeding 750 mm 30 inches in length shall be individually supported.

3.4.6 Pipe Joints

Pipe joints shall conform to NFPA 13, except as modified herein. Not more than four threads shall show after joint is made up. Welded joints will be permitted, only if welding operations are performed as required by NFPA 13 at the Contractor's fabrication shop, not at the project construction site. Flanged joints shall be provided where indicated or required by NFPA 13. Grooved pipe and fittings shall be prepared in accordance with the manufacturer's latest published specification according to pipe material, wall thickness and size. Grooved couplings and fittings shall be from the same manufacturer.

3.4.7 Reducers

Reductions in pipe sizes shall be made with one-piece tapered reducing fittings. The use of grooved-end or rubber-gasketed reducing couplings will not be permitted. When standard fittings of the required size are not manufactured, single bushings of the face type will be permitted. Where used, face bushings shall be installed with the outer face flush with the face of the fitting opening being reduced. Bushings shall not be used in elbow fittings, in more than one outlet of a tee, in more than two outlets of a cross, or where the reduction in size is less than 15 mm (1/2 inch).

3.4.8 Pipe Penetrations

Cutting structural members for passage of pipes or for pipe-hanger fastenings will not be permitted. Pipes that must penetrate concrete or masonry walls or concrete floors shall be core-drilled and provided with pipe sleeves. Each sleeve shall be Schedule 40 galvanized steel, ductile iron or cast iron pipe and shall extend through its respective wall or floor and be cut flush with each wall surface. Sleeves shall provide required clearance between the pipe and the sleeve per NFPA 13. The space between the sleeve and the pipe shall be firmly packed with mineral wool insulation. Where pipes penetrate fire walls, fire partitions, or floors, pipes shall be fire stopped in accordance with Section 07840 FIRESTOPPING. In penetrations that are not fire-rated or not a floor penetration, the space between the sleeve and the pipe shall be sealed at both ends with plastic waterproof cement that will dry to a firm but pliable mass or with a mechanically adjustable segmented elastomer seal.

3.4.9 Escutcheons

Escutcheons shall be provided for pipe penetration of ceilings and walls. Escutcheons shall be securely fastened to the pipe at surfaces through which piping passes.

3.4.10 Inspector's Test Connection

Unless otherwise indicated, test connection shall consist of 25 mm (1 inch) pipe connected to the remote branch line; a test valve located approximately 2 meters (7 feet) above the floor; a smooth bore brass outlet equivalent to the smallest orifice sprinkler used in the system; and a painted metal identification sign affixed to the valve with the words "Inspector's Test". The discharge orifice shall be located outside the building wall directed so as not to cause damage to adjacent construction or landscaping during full flow discharge.

3.4.11 Drains

Main drain piping shall be provided to discharge at a safe point outside the building. Auxiliary drains shall be provided as indicated and as required by NFPA 13. When the capacity of trapped sections of pipe is less than 11 liters (3 gallons), the auxiliary drain shall consist of a valve not smaller than 15 mm (1/2 inch) and a plug or nipple and cap. When the capacity of trapped sections of piping is more than 11 liters (3 gallons), the auxiliary drain shall consist of two 25 mm (1 inch) valves and one 50x300 mm (2x12 inch) condensate nipple or equivalent, located in an accessible location. Tie-in drains shall be provided for multiple adjacent trapped branch pipes and shall be a minimum of 25 mm (1 inch) in diameter. Tie-in drain lines shall be pitched a minimum of 15 mm per 3 mm (1/2 inch per 10 feet).

3.4.12 Installation of Fire Department Connection

Connection shall be mounted on the exterior wall approximately 900 mm (3 feet) above finished grade. The piping between the connection and the check valve shall be provided with an automatic drip in accordance with NFPA 13 and arranged to drain to the outside.

3.4.13 Identification Signs

Signs shall be affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate or as required by NFPA 13. Hydraulic design data nameplates shall be permanently affixed to each sprinkler riser as specified in NFPA 13.

3.5 UNDERGROUND PIPING INSTALLATION

The fire protection water main shall be laid, and joints anchored, in accordance with NFPA 24. Minimum depth of cover shall be at least 300 mm (12 inches) plus the average local frost depth. The supply line shall terminate inside the building with a flanged piece, the bottom of which shall be set not less than 150 mm (6 inches) above the finished floor. A blind flange shall be installed temporarily on top of the flanged piece to prevent the entrance of foreign matter into the supply line. A concrete thrust block shall be provided at the elbow where the pipe turns up toward the floor. In addition, joints shall be anchored in accordance with NFPA 24 using pipe clamps and steel rods from the elbow to the flange above the floor and from the elbow to a pipe clamp in the horizontal run of pipe. Buried steel components shall be provided with a corrosion protective coating in accordance with AWWA C203. Piping more than 1500 mm (5 feet) outside the building walls shall meet the requirements of Section 02510 WATER DISTRIBUTION SYSTEM.

3.6 EARTHWORK

Earthwork shall be performed in accordance with applicable provisions of Section 02315 EXCAVATION, FILLING AND BACKFILLING FOR BUILDINGS.

3.7 ELECTRICAL WORK

Except as modified herein, electric equipment and wiring shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR.

3.8 DISINFECTION

If sprinkler piping is not isolated from the domestic water piping systems by means of a reduced pressure backflow prevention assembly or if sprinkler piping in connected to the domestic water piping, after all system components are installed and hydrostatic test(s) are successfully completed, each portion of the sprinkler system to be disinfected shall be thoroughly flushed with potable water until all entrained dirt and other foreign materials have been removed before introducing chlorinating material. Flushing shall be conducted by removing the flushing fitting of the cross mains and of the grid branch lines, and then back-flushing through the sprinkler main drains. The chlorinating material shall be hypochlorites or liquid chlorine. Water chlorination procedure shall be in accordance with AWWA M20. The chlorinating material shall be fed into the sprinkler piping at a constant rate of 50 parts per million (ppm). A properly adjusted hypochlorite solution injected into the system with a hypochlorinator, or liquid chlorine injected into the system through a solution-fed chlorinator and booster pump shall be used. Chlorination application shall continue until the entire system if filled. The water shall remain in the system for a minimum of 24 hours. Each valve in the system shall be opened and closed several times to ensure its proper disinfection. Following the 24-hour period, no less than 25 ppm chlorine residual shall remain in the system. The system shall then be flushed with clean water until the residual chlorine is reduced to less than one part per million. Samples of water in disinfected containers for bacterial examination will be taken from several system locations which are approved by the Contracting Officer. Samples shall be tested for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA EWW. The testing method shall be either the multiple-tube fermentation technique or the membrane-filter technique. The disinfection shall be repeated until tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained. After the successful completion, all sprinklers or plugs and gravity flush all drops or trapped piping.

3.9 PIPE COLOR CODE MARKING

Color code marking of piping shall be as specified in Section 09900 PAINTING, GENERAL.

3.10 PRELIMINARY TESTS

The system, including the underground water mains, and the aboveground piping and system components, shall be tested to assure that equipment and components function as intended. The underground and aboveground interior piping systems and attached appurtenances subjected to system working pressure shall be tested in accordance with NFPA 13 and NFPA 24. Upon completion of specified tests, the Contractor shall complete certificates as specified in paragraph SUBMITTALS.

3.10.1 Underground Piping

3.10.1.1 Flushing

Underground piping shall be flushed in accordance with NFPA 24. This includes the requirement to flush the lead-in connection to the fire protection system at a flow rate not less that the calculated maximum water demand rate of the system.

3.10.1.2 Hydrostatic Testing

New underground piping shall be hydrostatically tested in accordance with NFPA 24. The allowable leakage shall be measured at the specified test pressure by pumping from a calibrated container. The amount of leakage at the joints shall not exceed 2 liters (2 quarts) per hour per 100 gaskets or joints, regardless of pipe diameter.

3.10.2 Aboveground Piping

3.10.2.1 Hydrostatic Testing

Aboveground piping shall be hydrostatically tested in accordance with NFPA 13 at not less than 1400 kPa (200 psi) or 350 kPa (50 psi) in excess of maximum system operating pressure and shall maintain that pressure without loss for 2 hours. There shall be no drop in gauge pressure or visible leakage when the system is subjected to the hydrostatic test. The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

3.10.2.2 Air Pressure Test

As specified in NFPA 13, an air pressure leakage test at 350 kPa (50 psi) shall be conducted for 24 hours. There shall be no drop in gauge pressure in excess of 10 kPa (1.5 psi) for the 24 hours. This air pressure test is in addition to the required hydrostatic test.

3.10.2.3 Backflow Prevention Assembly Forward Flow Test

Each backflow prevention assembly shall be tested at system flow demand, including all applicable hose streams, as specified in NFPA 13. The Contractor shall provide all equipment and instruments necessary to conduct a complete forward flow test, including 65 mm (2.5 inch) diameter hoses, playpipe nozzles, calibrated pressure gauges, and pitot tube gauge. The Contractor shall provide all necessary supports to safely secure hoses and nozzles during the test. At the system demand flow, the pressure readings and pressure drop (friction) across the assembly shall be recorded. A metal placard shall be provided on the backflow prevention assembly that lists the pressure readings both upstream and downstream of the assembly, total pressure drop, and the system test flow rate. The pressure drop shall be compared to the manufacturer's data.

3.10.3 Testing of Alarm Devices

Each alarm initiating device, including pressure alarm switch, low air pressure switch, valve supervisory switch, and electrically-operated switch shall be tested for proper operation. Water motor alarm shall be tested. The connecting circuit to the building fire alarm system and to the base-wide fire report system shall be inspected and tested.

3.10.4 Trip Tests of Dry Pipe Valves

Each dry pipe valve shall be trip-tested by reducing normal system air pressure through operation the inspector's test connection. Systems equipped with quick opening devices shall be first tested without the operation of the quick opening device and then with it in operation. Test results will be witnessed and recorded. Test results shall include the number of seconds elapsed between the time the test valve is opened and tripping of the dry valve; trip-point air pressure of the dry pipe valve; water pressure prior to valve tripping; and number of seconds elapsed between time the inspector's test valve is opened and water reaches the orifice.

3.10.5 Main Drain Flow Test

Following flushing of the underground piping, a main drain test shall be made to verify the adequacy of the water supply. Static and residual pressures shall be recorded on the certificate specified in paragraph SUBMITTALS. In addition, a main drain test shall be conducted each time after a main control valve is shut and opened.

3.11 FINAL ACCEPTANCE TEST

Final Acceptance Test shall begin only when the Preliminary Test Report has been approved. The Fire Protection Specialist shall conduct the Final Acceptance Test and shall provide a complete demonstration of the operation of the system. This shall include operation of control valves and flowing of inspector's test connections to verify operation of associated waterflow alarm switches. After operation of control valves has been completed, the main drain test shall be repeated to assure that control valves are in the open position. Each system shall be completely drained after each trip test. The system air supply system shall be tested to verify that system pressure is restored in the specified time. In addition, the Fire Protection Specialist shall have available copies of as-built drawings and certificates of tests previously conducted. The installation shall not be considered accepted until identified discrepancies have been corrected and test documentation is properly completed and received. After the system has been tested and drained, the system shall be drained periodically for at least 2 weeks until it can be assured that water from the system has been removed.

3.12 ONSITE TRAINING

The Fire Protection Specialist and Manufacturer's Representative shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. . Training shall be provided for a period of 24 hours of normal working time and shall start after the system is functionally complete but prior to the Preliminary Tests and Final Acceptance Test. The Onsite Training shall cover all of the items contained in the approved Operating and Maintenance Instructions.

SECTION 13945

PREACTION AND DELUGE SPRINKLER SYSTEMS, FIRE PROTECTION

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 47/A 47M	(1999) Ferritic Malleable Iron Castings
ASTM A 183	(1998) Carbon Steel Track Bolts and Nuts
ASTM A 536	(1984; R 1999e1) Ductile Iron Castings

AMERICAN SOCIETY OF SANITARY ENGINEERING FOR PLUMBING AND SANITARY RESEARCH (ASSE)

ASSE 1015	(1999) Double Check Backflow Prevention Assembly

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA EWW	(1999) Standard Methods for the Examination of Water and Wastewater
AWWA B300	(1999) Hypochlorites
AWWA B301	(1992; Addenda B301a - 1999) Liquid Chlorine
AWWA C203	(1997; Addenda C203a - 1999) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape – Hot-Applied
AWWA M20	(1973) Manual: Water Chlorination Principles and Practices

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P7825a	(1998) Approval Guide Fire Protection
FM P7825b	(1998) Approval Guide Electrical Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-71	(1997) Cast Iron Swing Check Valves, Flanges and Threaded Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13	(1999) Installation of Sprinkler Systems
NFPA 24	(1995) Installation of Private Fire Service Mains and Their Appurtenances
NFPA 70	(2002) National Electrical Code
NFPA 72	(1999) National Fire Alarm Code
NFPA 1963	(1998) Fire Hose Connections

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7	(1995) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Automatic Sprinkler System Layout

UNDERWRITERS LABORATORIES (UL)

UL Bld Mat Dir	(1999) Building Materials Directory UL Fire Prot Dir (1999) Fire Protection Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 1004	(1990) Square Head Bolts
KS B 1012	(2001) Hexagon Nuts and Hexagon Thin Nuts
KS B 1531	(1997) Screwed Type Malleable Cast Iron Pipe Fitting
KS B 1533	(2000) Screwed Type Steel Pipe Fittings
KS B 1541	(1992) Steel But-Welding Pipe Fittings
KS B 1542	(1990) Steel Socket-Welding Pipe Fittings
KS D 3562	(1989) Carbon Steel Pipes for Pressure Service
KS D 4311	(1999) Ductile Iron Pipes Centrifugally Cast for Water Works
KS D 4316	(2002) Mortar Lining of Ductile Iron Pipes Centrifugally Cast for Water Works
KS M 1103	(2001) Liquid Chlorine

1.2 GENERAL REQUIREMENTS

Preaction or Deluge sprinkler system shall be provided in areas indicated on the drawings. The sprinkler system shall provide fire sprinkler protection for the entire area. Except as modified herein, the system shall meet the requirements of NFPA 13 and NFPA 72. The sprinkler system shall be a single interlocked system that requires the actuation of an alarm initiating device to open the water control (deluge) valve. The Contractor shall design any portion of the sprinkler system that are not indicated on the drawings including locating sprinklers, piping, and equipment, and size piping and equipment when this information is not indicated on the drawings or is not specified herein. Pipe sizes which are not indicated on the drawings shall be determined by hydraulic calculations.

1.2.1 Hydraulic Design

The system shall be hydraulically designed to discharge a minimum density over the hydraulically most demanding area in compliance with NFPA 13. The minimum pipe size for branch lines in gridded systems shall be 32 mm (1-1/4 inch). Hydraulic calculations shall be in accordance with the Area/Density Method of NFPA 13. Water velocity in the piping shall not exceed 6 m/s (20 ft/s).

1.2.1.1 Hose Demand

An allowance for exterior hose streams shall be added to the sprinkler system demand at the fire hydrant shown on the drawings closest to the point where the water service enters the building. An allowance for interior hose stations shall also be added to the sprinkler system demand.

1.2.1.2 Basis for Calculations

The design of the system shall be based on a water flow test results. Water supply shall be presumed available at the point of connection to existing or at the base of the riser. Hydraulic calculations shall be based upon the Hazen-Williams formula with a "C" value of 120 for galvanized steel piping, 140 for new cement-lined ductile-iron piping, and 100 for existing underground piping.

1.2.2 Sprinkler Spacing

Sprinklers shall be uniformly spaced on branch lines. Maximum spacing per sprinkler shall not exceed limits specified in NFPA 13.

1.2.3 Control System

The control system shall meet the requirements of NFPA 72. The control panel shall be listed in UL Fire Prot Dir or FM P7825a and FM P7825b for "Releasing Device Service". The control panel and the solenoid valve that activates the water control valves shall be compatible with each other. Compatibility shall be per specific UL listing or FM approval of the control equipment.

1.2.3.1 Power Supply

The primary operating power shall be provided from two single-phase 120 VAC circuits. Transfer from normal to backup power and restoration from backup to normal power shall be fully automatic and shall not initiate a false alarm. Loss of primary power shall not prevent actuation of the respective automatic water control valve upon activation of any alarm initiating device. Backup power shall be provided through use of rechargeable, sealed, lead calcium storage batteries.

1.2.3.2 Circuit Requirements

Alarm initiating devices shall be connected to initiating device circuits (IDC), Style D or to signal line circuits (SLC), Style 6, as indicated, in accordance with NFPA 72. Alarm notification or indicating appliances shall be connected to indicating appliance circuit (IAC), Style Z in accordance with NFPA 72. A separate circuit shall be provided for actuation of each individual automatic water control valve. The circuits that actuate the water control valves shall be fully supervised so that the occurrence of a single open or a single ground fault condition in the interconnecting conductors shall be indicated at the control panel.

1.3 SYSTEM OPERATIONAL FEATURES

The system shall include a heat detection system, manual actuation stations, supervisory and alarm switches, alarm notification appliances, control panel and associated equipment. Preaction sprinkler system piping shall be provided with supervisory air pressure not to exceed 210 kPa (30 psig).

1.3.1 System Actuation

Activation of any single heat detector or 2 heat detectors, as indicated, or a single manual actuation station shall actuate alarm zone circuits of the control panel that, in turn, shall actuate the corresponding automatic water control valve. Actuation of the automatic water control valve shall cause water to fill the preaction system piping and be discharged from fused sprinklers or discharge from the open sprinklers of the deluge system.

1.3.2 Alarm Functions

Activation of any heat detector or sprinkler pressure alarm switch or manual actuation station shall cause the illumination of the respective zone annunciator, activation of the building fire alarm system, and transmission of the alarm to the base-wide fire reporting system. Valve tamper alarm shall be monitored by the system control panel and transmitted to the building fire alarm system as a trouble alarm.

1.3.3 Supervisory Functions

The reduction of supervisory air pressure within the sprinkler system piping to less than 70 kPa (10 psi) or the occurrence of a single open or a single ground fault in any alarm initiating device circuit, in the automatic water control valve actuation circuit, in any alarm indicating appliance circuit or in other electrically supervised circuit shall cause the individually labelled control panel trouble light to be illuminated, the audible trouble alarm to be activated, and a trouble alarm to be transmitted to the building fire alarm control panel and to base-wide fire reporting system.

1.4 COORDINATION OF TRADES

Piping offsets, fittings, and any other accessories required shall be furnished as required to provide a complete installation and to eliminate interference with other construction. Sprinkler shall be installed over and under ducts, piping and platforms when such equipment can negatively effect or disrupt the sprinkler discharge pattern and coverage.

1.5 DELIVERY AND STORAGE

All equipment delivered and placed in storage shall be housed in a manner to preclude any damage from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall either be capped or plugged until installed.

1.6 FIELD MEASUREMENTS

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.7 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G

Four copies of the Sprinkler System Drawings, no later than 21 days prior to the start of sprinkler system installation. The Sprinkler System Drawings shall conform to the requirements established for working plans as prescribed in NFPA 13. Drawings shall include plan and elevation views demonstrating that the equipment will fit the allotted spaces with clearance for installation and maintenance. Each set of drawings shall include the following:

a. Descriptive index of drawings in the submittal with drawings listed in sequence by drawing number. A legend identifying device symbols, nomenclature, and conventions used.

b. Floor plans drawn to a scale not less than 1:100 (1/8"=1'-0") which clearly show locations of sprinklers, risers, pipe hangers, inspector's test connections, drains, and other applicable details necessary to clearly describe the proposed arrangement. Each type of fitting used and the locations of bushings, reducing couplings, and welded joints shall be indicated.

c. Actual center-to-center dimensions between sprinklers on branch lines and between branch lines; from end sprinklers to adjacent walls; from walls to branch lines; from sprinkler feed mains, cross-mains and branch lines to finished floor and roof or ceiling. A detail shall show the dimension from the sprinkler and sprinkler deflector to the ceiling in finished areas.

d. Longitudinal and transverse building sections showing typical branch line and cross-main pipe routing as well as elevation of each typical sprinkler above finished floor.

e. Details of each type of riser assembly; pipe hanger; restraint of underground water main at point-of-entry into the building, and electrical devices and interconnecting wiring.

f. Complete point-to-point wiring diagram of the detection and control system. Indicate the detailed interconnection of control panel modules to the devices, the number and size of conductors in each conduit, and size of conduit. Connection points shall be indicated and coordinated with the terminal identification marked on the devices. Complete internal wiring schematic of the control panel and each electrical device shall be provided. Detailed description of the functions of the control panel and each module shall be provided.

As-Built Drawings

As-built drawings, at least 14 days after completion of the Final Tests. The Sprinkler System Drawings shall be updated to reflect as-built conditions after all related work is completed and shall be on reproducible full-size mylar film.

SD-03 Product Data

Fire Protection Specialist

The name and documentation of certification of the proposed Fire Protection Specialists, no later than 14 days after the Notice to Proceed and prior to the submittal of the sprinkler system shop drawings and hydraulic calculations. The name and documentation of certification of the proposed Fire Protection Specialists, no later than 14 days after the Notice to Proceed and prior to the submittal of the sprinkler system shop drawings and hydraulic calculations.

Sprinkler System Installer Qualifications

The name and documentation of certification of the proposed Sprinkler System Installer, concurrent with submittal of the Fire Protection Specialist Qualifications. The name and documentation of certification of the proposed Sprinkler System Installer, concurrent with submittal of the Fire Protection Specialist Qualifications.

Fire Protection Related Submittals; G

A list of the Fire Protection Related Submittals, no later than 7 days after the approval of the Fire Protection Specialist.

Materials and Equipment; G

Manufacturer's catalog data included with the Sprinkler System Drawings for all items specified herein. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with all contract requirements. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided.

Hydraulic Calculations; G

Hydraulic calculations, including a drawing showing hydraulic reference points and pipe segments.

Storage Batteries; G

Calculations to substantiate the total requirements for supervisory and alarm power. Ampere-hour requirements for each system component and each control panel component or module, under both normal and alarm conditions shall be included. The battery recharging period shall be included with the calculations.

Spare Parts

Spare parts data shall be included for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. A list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor shall be included.

Preliminary Tests

Proposed procedures for Preliminary Tests, no later than 14 days prior to the proposed start of the tests. Proposed date and time to begin Preliminary Tests, submitted with the Preliminary Tests Procedures.

Final Acceptance Tests

Proposed procedures for Final Acceptance Tests, no later than 14 days prior to the proposed start of the tests. Proposed date and time to begin Final Acceptance Tests, submitted with the Final Acceptance Test Procedures. Notification shall be provided at least 14 days prior to the proposed start of the test. Notification shall include a copy of the Contractor's Material & Test Certificates.

On-site Training Schedule

Proposed On-site Training schedule, at least 14 days prior to the start of related training.

SD-06 Test Reports

Preliminary Tests; G

Three copies of the completed Preliminary Tests Reports, no later that 7 days after the completion of the Preliminary Tests. The Preliminary Tests Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Preliminary Tests Report shall be signed by the Fire Protection Specialist.

Final Acceptance Tests; G

Three copies of the completed Final Acceptance Tests Reports, no later that 7 days after the completion of the Final Acceptance Tests. All items in the Final Acceptance Report shall be signed by the Fire Protection Specialist.

SD-07 Certificates

Inspection by Fire Protection Specialist

Concurrent with the Final Acceptance Test Report, certification by the Fire Protection Specialist that the sprinkler system is installed in accordance with the contract requirements, including signed approval of the Preliminary, Detection and Control Systems, and Final Acceptance Test Reports.

SD-10 Operation and Maintenance Data

Preaction and Deluge Sprinkler System; G

Six manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment.

1.8 HYDRAULIC CALCULATIONS

Hydraulic calculations shall be as outlined in NFPA 13 except that calculations shall be performed by computer using software intended specifically for fire protection system design using the design data shown on the drawings. Software that uses k-factors for typical branch lines is not acceptable. Calculations shall be based on the water supply data shown on the drawings. Calculations shall substantiate that the design area used in the calculations is the most demanding hydraulically. Water supply curves and system requirements shall be plotted on semi-logarithmic graph paper so as to present a summary of the complete hydraulic calculation. A summary sheet listing sprinklers in the design area and their respective hydraulic reference points, elevations, actual discharge pressures and actual flows shall be provided. Elevations of hydraulic reference points (nodes) shall be indicated. Documentation shall identify each pipe individually and the nodes connected thereto. The diameter, length, flow, velocity, friction loss, number and type fittings, total friction loss in the pipe, equivalent pipe length and Hazen-Williams coefficient shall be indicated for each pipe. For gridded systems, calculations shall show peaking of demand area friction loss to verify that the hydraulically most demanding area is being used. Also for gridded systems, a flow diagram indicating the quantity and direction of flows shall be included. A drawing showing hydraulic reference points (nodes) and pipe designations used in the calculations shall be included and shall be independent of shop drawings.

1.9 FIRE PROTECTION SPECIALIST

Work specified in this section shall be performed under the supervision of and certified by the Fire Protection Specialist. The Fire Protection Specialist shall be an individual who is a registered professional engineer and a Full Member of the Society of Fire Protection Engineers or who is certified as a Level III Technician by National Institute for Certification in Engineering Technologies (NICET) in the Automatic Sprinkler System Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7. The Fire Protection Specialist shall be regularly engaged in the design and installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.10 SPRINKLER SYSTEM INSTALLER QUALIFICATIONS

Work specified in this section shall be performed by the Sprinkler System Installer. The Sprinkler System Installer shall be regularly engaged in the installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.11 REGULATORY REQUIREMENTS

Compliance with referenced NFPA standards is mandatory. This includes advisory provisions listed in the appendices of such standards, as though the word "shall" had been substituted for the word "should" wherever it appears. Applicable material and installation standards referenced in Appendix A of NFPA 13 and NFPA 24 shall be considered mandatory the same as if such referenced standards were specifically listed in this specification. In the event of a conflict between specific provisions of this specification and applicable NFPA standards, this specification shall govern. All requirements that exceed the minimum requirements of NFPA 13 shall be incorporated into the design. Reference to "authority having jurisdiction" shall be interpreted to mean the Contracting Officer.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.2 NAMEPLATES

All equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.3 REQUIREMENTS FOR FIRE PROTECTION SERVICE

Materials and equipment shall have been tested by Underwriters Laboratories, Inc. and listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM P7825a and FM P7825b. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM P7825a and FM P7825b.

2.4 UNDERGROUND PIPING SYSTEMS

2.4.1 Pipe

Piping from a point 150 mm (6 inches) above the floor to a point 1500 mm (5 feet) outside the building wall shall be ductile iron with a rated working pressure of 1034 kPa (150 psi) conforming to KS D 4311, with cement mortar lining conforming to KS D 4316. Piping more than 1500 mm (5 feet) outside the building walls shall comply with Section 02510 WATER DISTRIBUTION SYSTEM.

2.4.2 Fittings and Gaskets

Fittings shall be ductile iron conforming to KS D 4308. Gaskets shall be suitable in design and size for the pipe with which such gaskets are to be used. Gaskets for ductile iron pipe joints shall conform to KS D 4308.

2.4.3 Gate Valve and Indicator Posts

Gate valves for underground installation shall be of the inside screw type with counter-clockwise rotation to open. Where indicating type valves are shown or required, indicating valves shall be gate valves with an approved indicator post of a length to permit the top of the post to be located 900 mm (3 feet) above finished grade. Gate valves and indicator posts shall be listed in UL Fire Prot Dir or FM P7825a and FM P7825b.

2.5 ABOVEGROUND PIPING COMPONENTS

2.5.1 Steel Pipe

Except as modified herein, steel pipe shall be galvanized conforming to the applicable requirements of KS D 3562. Pipe in which threads or grooves are cut shall be Schedule 40 or shall be listed by Underwriters' Laboratories to have a corrosion resistance ratio (CRR) of 1.0 or greater after threads or grooves are cut. Pipe shall be marked with the name of the manufacturer, kind of pipe, and KS designation.

2.5.2 Fittings for Non-Grooved Steel Pipe

Fittings shall be galvanized steel conforming to KS B 1533, KS B 1541 or KS B 1542. Fittings that sprinklers, drop nipples or riser nipples (sprigs) are screwed into shall be threaded type. Plain-end fittings with mechanical couplings, fittings that use steel gripping devices to bite into the pipe and segmented welded fittings shall not be used.

2.5.3 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 1200 kPa (175 psi) service and shall be the product of the same manufacturer. Fitting and coupling houses shall be malleable iron conforming to ASTM A 47/A 47M, Grade 32510; ductile iron conforming to ASTM A 536, Grade 65-45-12. Gaskets shall be of silicon compound and approved for dry fire protection systems. Gasket shall be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A 183 and shall be cadmium plated or zinc electroplated.

2.5.4 Flanges

Flanges shall conform to NFPA 13 and KS D 4309. Gaskets shall be non-asbestos compressed material, 1.6 mm (1/16 inch) thick, and full face or self-centering flat ring type. Bolts shall be squarehead conforming to KS B 1004 and nuts shall be hexagon type conforming to KS B 1012.

2.5.5 Pipe Hangers

Hangers shall be listed in UL Fire Prot Dir or FM P7825a and FM P7825b and of the type suitable for the application, construction, and pipe type and size to be supported.

2.5.6 Valves

2.5.6.1 Control Valve and Gate Valve

Manually operated sprinkler control valve and gate valve shall be outside stem and yoke (OS&Y) type and shall be listed in UL Bld Mat Dir or FM P7825a and FM P7825b.

2.5.6.2 Check Valves

Check valve 50 mm (2 inches) and larger shall be listed in UL Bld Mat Dir or FM P7825a and FM P7825b. Check valves 100 mm (4 inches) and larger shall be of the swing type with flanged cast iron body and flanged inspection plate, shall have a clear waterway and shall meet the requirements of MSS SP-71, for Type 3 or 4.

2.6 AUTOMATIC WATER CONTROL VALVE (DELUGE VALVE)

Automatic water control valve (deluge valve) shall be electrically-actuated and rated for a working pressure of 1207 kPa (175 psi). Valve shall be capable of being reset without opening the valve. Electrical solenoid valve used to actuate the water control valve shall be an integral component of the valve or shall be approved for use by the water control valve manufacturer. Solenoid valve shall be rated at 24 volts direct current, and shall be normally closed type that operates when energized. Solenoid valves shall be rated for a maximum pressure differential of 1207 kPa (175 psi). Water control valve shall be equipped with a means to prevent the valve from returning to the closed position until being manually reset. Assembly shall be complete with the valve manufacturer's standard trim piping, drain and test valves, pressure gauges, and other required appurtenances. Each assembly shall include an emergency release device for manually tripping the water control valve in the event of a power or other system failure. Device shall be a standard accessory component of the valve manufacturer and shall be labeled as to its function and method of operation. Valves located in hazardous locations shall be approved for the hazard classification of the area where located.

2.7 SUPERVISORY AIR SYSTEM

2.7.1 Air Compressor

Air compressor shall be single stage oil less type, air cooled, electric-motor driven, equipped with a check valve, centrifugal pressure and moisture unloader, pressure switch for automatic starting and stopping. Unless otherwise indicated, pressure switch shall be set to start the compressor at 140 kPa (20 psi) and stop it at 200 kPa (30 psi). A safety relief valve, set to operate at 450 kPa (65 psi), shall be provided. The compressor shall be sized to pressurize the system to 200 kPa (30 psi) within 30 minutes.

2.7.2 Air Pressure Maintenance Device

Device shall be a pressure regulator that automatically reduces supply air pressure to the minimum pressure required to be maintained in the piping system. The device shall have a cast bronze body and valve housing complete with diaphragm assembly, spring, filter, ball check to prevent backflow, 1.6 mm (1/16 inch) restriction to prevent rapid pressurization of the system, and adjustment screw. The device shall be capable of reducing maximum inlet pressure of 680 kPa (100 psi) to a fixed outlet pressure adjustable to 70 kPa (10 psi).

2.7.3 Air Supply Piping System

Each preaction system shall be equipped with a separate pressure maintenance device, shutoff valve, bypass valve and pressure gauge. Piping shall be galvanized steel in accordance with KS D 3562, Schedule 40.

2.7.4 Low Air Pressure Switch

Each preaction system shall be provided with an air pressure switch connected to the control panel. Upon reduction of supervisory air pressure to approximately 70 kPa (10 psi), the low air pressure switch shall actuate the audible alarm device and a red low-air alarm light on the control panel annunciator.

2.8 WATER MOTOR ALARM ASSEMBLY

Assembly shall include a body housing, impeller wheel, drive shaft, striker assembly, gong, wall plate and related components necessary for complete operation. Minimum 20 mm (3/4 inch) galvanized piping shall be provided between the housing and the automatic water control valve. Drain piping from the body housing shall be minimum 25 mm (1 inch) galvanized steel and shall be arranged to drain to the outside of the building. Piping shall be galvanized both on the inside and on the outside surfaces.

2.9 FIRE DEPARTMENT CONNECTION

Fire department connection shall be projecting type with cast brass body, matching wall escutcheon lettered "Auto Spkr" with a polished brass finish. The connection shall have two inlets with individual self-closing clappers, caps with drip drains and chains. Female inlets shall have 65 mm (2-1/2 inch) diameter American National Fire Hose Connection Screw Threads (NH) per NFPA 1963.

2.10 SPRINKLERS

Sprinklers for preaction systems shall be automatic, fusible solder or glass bulb type; sprinklers for deluge systems shall be open type without the fusible element. Sprinklers with internal O-rings shall not be used. Sprinklers shall be used in accordance with their listed spacing limitations. Temperature classification shall be as indicated. Sprinklers in high heat areas including attic spaces or in close proximity to unit heaters shall have temperature classification in accordance with NFPA 13. Orifice of extended coverage sprinklers shall not exceed 13.5 mm (17/32 inch).

2.10.1 Pendent Sprinkler

Pendent sprinkler shall be of the fusible strut or glass bulb type, quick-response type with nominal 12.7 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice as indicated. Pendent sprinklers shall have a polished chrome finish.

2.10.2 Upright Sprinkler

Upright sprinkler shall be chrome-plated quick-response type and shall have a nominal 12.7 mm (1/2 inch) or 13.5 mm (17/32 inch) orifice as indicated.

2.10.3 Corrosion Resistant Sprinkler

Corrosion resistant sprinkler shall be installed in locations as indicated. Corrosion resistant coatings shall be factory-applied by the sprinkler manufacturer.

2.11 DISINFECTING MATERIALS

2.11.1 Liquid Chlorine

Liquid chlorine shall conform to AWWA B301 or KS M 1103.

2.11.2 Hypochlorites

Calcium hypochlorite and sodium hypochlorite shall conform to AWWA B300.

2.12 ACCESSORIES

2.12.1 Sprinkler Cabinet

Spare sprinklers shall be provided in accordance with NFPA 13 and shall be packed in a suitable metal or plastic cabinet. Spare sprinklers shall be representative of, and in proportion to, the number of each type and temperature rating of the sprinklers installed. At least one wrench of each type required shall be provided.

2.12.2 Pendent Sprinkler Escutcheon

Escutcheon shall be one-piece metallic type with a depth of less than 20 mm (3/4 inch) and suitable for installation on pendent sprinklers. The escutcheon shall have a factory finish that matches the pendent sprinkler heads.

2.12.3 Pipe Escutcheon

Escutcheon shall be polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or set screw.

2.12.4 Sprinkler Guard

Guard shall be a steel wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards shall be provided on sprinklers as indicated.

2.12.5 Identification Sign

Valve identification sign shall be minimum 150 mm wide by 50 mm high (6 inches wide by 2 inches high) with enamel baked finish on minimum 1.214 mm (18 gauge) steel or 0.6 mm (0.024 inch) aluminum with red letters on a white background or white letters on red background. Wording of sign shall include, but not be limited to "main drain", "auxiliary drain", "inspector's test", "alarm test", "alarm line", and similar wording as required to identify operational components.

2.13 DOUBLE-CHECK VALVE BACKFLOW PREVENTION ASSEMBLY

Double-check backflow prevention assembly shall comply with ASSE 1015. The assembly shall have a bronze, cast-iron or stainless steel body with flanged ends. The assembly shall include pressure test gauge ports and OS&Y shutoff valves on the inlet and outlet, 2-positive-seating check valve for continuous pressure application, and four test cocks. Assemblies shall be rated for working pressure of 1034 kPa (150 psi). The maximum pressure loss shall be 40 kPa (6 psi) at a flow rate equal to the sprinkler water demand, at the location of the assembly. A test port for a pressure gauge shall be provided both upstream and downstream of the double check backflow prevention assembly valves.

2.14 CONTROL PANEL

Panel shall be UL listed or FM approved for "Releasing Device Service" or shall have modules approved for this purpose. Panel shall contain all components and equipment required to provide the specified operational and supervisory functions of the system. Components shall be housed in a surface or flush-mounted steel cabinet with hinged door and cylinder lock. Control panel shall be a clean, uncluttered, and orderly factory assembled and wired unit. Panel shall include integral "power on", "alarm", and "trouble" lamps with annunciation of each alarm, supervisory and trouble signal. The panel shall have prominent rigid plastic or metal identification plates for lamps, zones, controls, meters, fuses, and switches. Nameplates for fuses shall also include ampere rating. Control panel switches shall be within the locked cabinet. A suitable means shall be provided for testing the working condition and accuracy of the control panel visual indicating devices (meter and lamps). Meters and lamps shall be plainly visible when the cabinet door is closed. Signals shall be provided to indicate by zone any alarm, supervisory or trouble condition on the system. Upon restoration of power, startup shall be automatic, and shall not require any manual operation. The loss of primary power or the sequence of applying primary or emergency power shall not affect the transmission of alarm, supervisory or trouble signals.

2.14.1 Zone Annunciator

A separate alarm and trouble lamp shall be provided for each active and spare zone and shall be located on exterior of cabinet door or be visible through the cabinet door. A minimum of two spare alarm zones that are fully operational shall be provided. Each lamp shall provide specific identification of the zone by means of a permanently attached rigid plastic or metal sign with either raised or engraved letters. Zone identification shall consist of a unique zone number as well as a word description of the zone.

2.14.2 System Zoning

The system shall be zoned as indicated.

2.14.3 Primary Power Supply

Primary power and trouble alarm power to the Control Panel shall be supplied from two 120 VAC circuits. Power to the control panel shall be as indicated. Panel shall be permanently marked "PREACTION SPRINKLER SYSTEM" or “DELUGE SPRINKLER SYSTEM".

2.14.4 Emergency Power Supply

Emergency power shall be provided for system operation in the event of failure of the primary power supply and shall consist of rechargeable storage battery system. Transfer from normal to emergency power or restoration from emergency to normal power shall be automatic and shall not cause transmission of a false alarm.

2.14.4.1 Storage Batteries

Storage Batteries shall be sealed, lead-calcium type requiring no additional water. The batteries shall have ample capacity, with primary power disconnected, to operate the system for a period of 90 hours. Following this period of operation via batteries, the batteries shall have ample capacity to operate all alarm indicating devices in the alarm mode for a minimum period of 15 minutes. Battery cabinet shall be a separate compartment at the bottom of the control panel. The battery cabinet shall have adequate space for spare duplicate storage batteries. Batteries shall be mounted on a noncorrosive and nonconductive base or pad.

2.14.4.2 Battery Charger

Battery charger shall be completely automatic, with high/low charging rate, capable of restoring the batteries from full discharge to full charge within 12 hours using the high charging rate. A separate ammeter shall be provided for indicating rate of charge. A separate voltmeter shall be provided to indicate the state of the battery charge. A pilot light indicating when batteries are manually placed on a high rate of charge shall be provided as part of the unit assembly. The charger shall be located in control panel cabinet.

2.15 ALARM INITIATING DEVICES

2.15.1 Heat Detectors

Detectors located in areas subject to moisture, exterior atmospheric conditions or hazardous locations as defined in NFPA 70 shall be approved for such locations. Detectors shall be listed or approved for 15 m (50 foot) spacing between detectors. The detector shall be equipped with an alarm indicating light in its base that lights when the detector is in an alarm condition. Five spare detectors of each type and temperature rating shall be provided.

2.15.1.1 Rate Compensation Detector

Detector shall be of the vertical spot type with a temperature classification rating of ordinary as defined by NFPA 72. Detectors listed or approved as "rate anticipation" type will be accepted. Detector shall automatically reset when temperature drops below detector temperature rating. Detector shall be hermetically sealed.

2.15.1.2 Combination Fixed-Temperature and Rate-of-Rise Heat Detector

Detector shall consist of two independently operated thermal elements. The rate-of-rise portion of the detector shall consist of an air chamber, flexible metal diaphragm and a moisture-proof calibrated vent which will respond to a temperature rise exceeding 8 degrees C (15 degrees F) per minute. This portion of the detector shall be self-restoring after actuation. The fixed temperature portion of the detector shall consist of a fusible alloy that will melt and cause an alarm when the surrounding air rises above the temperature rating of the detector. The detector shall provide an external indication when the fixed temperature portion of the detector actuates. Detector shall have a temperature classification rating of ordinary as defined by NFPA 72.

2.15.1.3 Fixed-Temperature Heat Detector

Detector shall have a fusible alloy that will melt and cause an alarm when the surrounding air rises above the temperature rating of the detector. The detector shall provide an external indication upon actuation of the detector. Detector shall provide a temperature classification rating as indicated.

2.15.2 Manual Actuation Station

Station shall be mounted at 1000 mm (42 inches) above the floor, unless otherwise shown. Station shall be arranged to activate the deluge system. Station shall be dual-action type requiring two separate operations in order to cause system discharge. Station shall be colored lime yellow or a unique color dissimilar to color used for manual fire alarm system as indicated. Station shall be provided with a positive visible indication of operation of the station. Station shall be weatherproof type and shall be provided with an engraved label indicating DELUGE SYSTEM.

2.15.3 Sprinkler Pressure Alarm Switch (Waterflow Alarm)

Pressure switch shall include a metal housing with a neoprene diaphragm, SPDT snap action switches. The switch shall have a service pressure rating of 1200 kPa (175 psi). There shall be two SPDT (Form C) contacts factory adjusted to operate at 30 to 60 kPa (4 to 8 psi). The switch shall be capable of being mounted in any position in the alarm line trim piping of the alarm check valve.

2.15.4 Valve Supervisory (Tamper) Switch

Switch shall be suitable for mounting to the type of control valve to be supervised open. The switch shall be tamper resistant and contain one set of SPDT (Form C) contacts arranged to transfer upon removal of the housing cover or closure of the valve of more than two rotations of the valve stem.

2.16 NOTIFICATION APPLIANCES

Notification appliances shall be suitable for connection to supervised alarm indicating circuits. Appliance shall have a separate screw terminal for each conductor. The surface of the appliance shall be red in color.

2.16.1 Alarm Bell

Bell shall be 250 mm (10 inch diameter), surface-mounted vibrating type with matching back box. Sound output shall be a minimum of 85 DBA at 3000 mm (10 feet). Bell shall operate on nominal 24 VDC. Bells shall have screw terminals for in-out wiring connection. Bells used in exterior locations shall be specifically listed or approved for outdoor use and be provided with metal housing and protective grilles.

2.16.2 Alarm Horn

Horn shall be surface mounted, with the matching mounting back box surface mounted, single projector, grill and vibrating type suitable for use in an electrically supervised circuit. Horns shall operate on nominal 24 VDC and have screw terminals for in-out wiring connection. Sound output shall be a minimum of 85 DBA at 3000 mm (10 feet). Horns used in exterior locations shall be specifically listed or approved for outdoor use and be provided with metal housing and protective grills.

2.17 WIRING

Wiring for alternating current (AC) circuits shall be 12 AWG minimum. Wiring for low voltage direct current (DC) circuits shall be No. 14 AWG minimum. Power wiring (over 28 volts) and control wiring shall be isolated. Wiring shall conform to NFPA 70. System field wiring shall be solid copper and installed in rigid metallic conduit, except rigid plastic conduit may be used under slab-on-grade. Conductors shall be color coded. Conductors used for the same function shall be similarly color coded. Wiring color code shall remain uniform throughout the circuit. Pigtail or T-tap connections to alarm initiating, alarm indicating, supervisory, and actuation circuits are prohibited.

PART 3 EXECUTION

3.1 FIRE PROTECTION RELATED SUBMITTALS

The Fire Protection Specialist shall prepare a list of the submittals from the Contract Submittal Register that relate to the successful installation of the sprinkler systems(s). The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the Fire Protection Specialist when submitted to the Government.

3.2 INSTALLATION REQUIREMENTS

The installation shall be in accordance with the applicable provisions of publications referenced herein.

3.3 INSPECTION BY FIRE PROTECTION SPECIALIST

The Fire Protection Specialist shall inspect the sprinkler system periodically during the installation to assure that the sprinkler system installed in accordance with the contract requirements. The Fire Protection Specialist shall witness the preliminary and final tests, and shall sign the test results. The Fire Protection Specialist, after completion of the system inspections and a successful final test, shall certify in writing that the system has been installed in accordance with the contract requirements. Any discrepancy shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered.

3.4 ABOVEGROUND PIPING INSTALLATION

3.4.1 Piping in Exposed Areas

Exposed piping shall be installed so as not diminish exit access widths, corridors, or equipment access. Exposed horizontal piping, including drain piping, shall be installed to provide maximum headroom.

3.4.2 Piping in Finished Areas

In areas with suspended or dropped ceilings and in areas with concealed spaces above the ceiling, piping shall be concealed above ceilings. Piping shall be inspected, tested and approved before being concealed. Risers and similar vertical runs of piping in finished areas shall be concealed.

3.4.3 Pendent Sprinklers Locations

Sprinklers installed in the pendent position shall be of the listed dry pendent type, unless otherwise indicated. Dry pendent sprinklers shall be of the required length to permit the sprinkler to be threaded directly into a branch line tee. Hangers shall be provided on arm-overs exceeding 300 mm (12 inches) in length. Dry pendent sprinkler assemblies shall be such that sprinkler ceiling plates or escutcheons are of the uniform depth throughout the finished space. Pendent sprinklers in suspended ceilings shall be a minimum of 150 mm (6 inches) from ceiling grid. Recessed pendent sprinklers shall be installed such that the distance from the sprinkler deflector to the underside of the ceiling shall not exceed the manufacturer's listed range and shall be of uniform depth throughout the finished area.

3.4.4 Upright Sprinklers

Riser nipples or "sprigs" to upright sprinklers shall contain no fittings between the branch line tee and the reducing coupling at the sprinkler. Riser nipples exceeding 750 mm (30 inches) in length shall be individually supported.

3.4.5 Pendent Sprinklers Locations

Sprinklers installed in the pendent position shall be of the listed dry pendent type, unless otherwise indicated. Dry pendent sprinklers shall be of the required length to permit the sprinkler to be threaded directly into a branch line tee. Hangers shall be provided on arm-overs exceeding 300 mm (12 inches) in length. Dry pendent sprinkler assemblies shall be such that sprinkler ceiling plates or escutcheons are of the uniform depth throughout the finished space. Pendent sprinklers in suspended ceilings shall be a minimum of 150 mm (6 inches) from ceiling grid. Recessed pendent sprinklers shall be installed such that the distance from the sprinkler deflector to the underside of the ceiling shall not exceed the manufacturer's listed range and shall be of uniform depth throughout the finished area.

3.4.6 Pipe Joints

Pipe joints shall conform to NFPA 13, except as modified herein. Not more than four threads shall show after joint is made up. Welded joints will be permitted, only if welding operations are performed as required by NFPA 13 at the Contractor's fabrication shop, not at the project construction site. Flanged joints shall be provided where indicated or required by NFPA 13. Grooved pipe and fittings shall be prepared in accordance with the manufacturer's latest published specification according to pipe material, wall thickness and size. Grooved couplings and fittings shall be from the same manufacturer.

3.4.7 Reducers

Reductions in pipe sizes shall be made with one-piece tapered reducing fittings. The use of grooved-end or rubber-gasketed reducing couplings will not be permitted. When standard fittings of the required size are not manufactured, single bushings of the face type will be permitted. Where used, face bushings shall be installed with the outer face flush with the face of the fitting opening being reduced. Bushings shall not be used in elbow fittings, in more than one outlet of a tee, in more than two outlets of a cross, or where the reduction in size is less than 15 mm (1/2 inch).

3.4.8 Pipe Penetrations

Cutting structural members for passage of pipes or for pipe-hanger fastenings will not be permitted. Pipes that must penetrate concrete or masonry walls or concrete floors shall be core-drilled and provided with pipe sleeves. Each sleeve shall be Schedule 40 galvanized steel, ductile iron or cast iron pipe and shall extend through its respective wall or floor and be cut flush with each wall surface. Sleeves shall provide required clearance between the pipe and the sleeve per NFPA 13. The space between the sleeve and the pipe shall be firmly packed with mineral wool insulation. Where pipes penetrate fire walls, fire partitions, or floors, pipes shall be fire stopped in accordance with Section 07840 FIRESTOPPING. In penetrations that are not fire-rated or not a floor penetration, the space between the sleeve and the pipe shall be sealed at both ends with plastic waterproof cement that will dry to a firm but pliable mass or with a mechanically adjustable segmented elastomer seal.

3.4.9 Escutcheons

Escutcheons shall be provided for pipe penetration of ceilings and walls. Escutcheons shall be securely fastened to the pipe at surfaces through which piping passes.

3.4.10 Inspector's Test Connection

Unless otherwise indicated, test connection shall consist of 25 mm (1 inch) pipe connected to the remote branch line; a test valve located approximately 2 meters (7 feet) above the floor; a smooth bore brass outlet equivalent to the smallest orifice sprinkler used in the system; and a painted metal identification sign affixed to the valve with the words "Inspector's Test". The discharge orifice shall be located outside the building wall directed so as not to cause damage to adjacent construction or landscaping during full flow discharge.

3.4.11 Drains

Main drain piping shall be provided to discharge at a safe point outside the building. Auxiliary drains shall be provided as indicated and as required by NFPA 13. When the capacity of trapped sections of pipe is less than 11 liters (3 gallons), the auxiliary drain shall consist of a valve not smaller than 15 mm (1/2 inch) and a plug or nipple and cap. When the capacity of trapped sections of piping is more than 11 liters (3 gallons), the auxiliary drain shall consist of two 25 mm (1 inch) valves and one 50 x 300 mm (2 x 12 inch) condensate nipple or equivalent, located in an accessible location. Tie-in drains shall be provided for multiple adjacent trapped branch pipes and shall be a minimum of 25 mm (1 inch) in diameter. Tie-in drain lines shall be pitched a minimum of 15 mm per 3 mm (1/2 inch per 10 feet).

3.4.12 Installation of Fire Department Connection

Connection shall be mounted [on the exterior wall approximately 900 mm (3 feet) above finished grade. The piping between the connection and the check valve shall be provided with an automatic drip in accordance with NFPA 13 and arranged to drain to the outside.

3.4.13 Identification Signs

Signs shall be affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate or as required by NFPA 13. Hydraulic design data nameplates shall be permanently affixed to each sprinkler riser as specified in NFPA 13.

3.5 UNDERGROUND PIPING INSTALLATION

The fire protection water main shall be laid, and joints anchored, in accordance with NFPA 24. Minimum depth of cover shall be at least 300 mm (12 inches) plus the average local frost depth. The supply line shall terminate inside the building with a flanged piece, the bottom of which shall be set not less than 150 mm (6 inches) above the finished floor. A blind flange shall be installed temporarily on top of the flanged piece to prevent the entrance of foreign matter into the supply line. A concrete thrust block shall be provided at the elbow where the pipe turns up toward the floor. In addition, joints shall be anchored in accordance with NFPA 24 using pipe clamps and steel rods from the elbow to the flange above the floor and from the elbow to a pipe clamp in the horizontal run of pipe. Buried steel components shall be provided with a corrosion protective coating in accordance with AWWA C203. Piping more than 1500 mm (5 feet) outside the building walls shall meet the requirements of Section 02510 WATER DISTRIBUTION SYSTEM.

3.6 EARTHWORK

Earthwork shall be performed in accordance with applicable provisions of Section 02315 EXCAVATION, FILLING AND BACKFILLING FOR BUILDINGS.

3.7 ELECTRICAL WORK

Unless otherwise specified herein, power supply equipment and wiring shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR.

3.7.1 Overcurrent and Surge Protection

All equipment connected to alternating current circuits shall be protected from surges per IEEE C62.41 and NFPA 70. Cables and conductors that serve as communications links, except fiber optics, shall have surge protection circuits installed at each end. Fuses shall not be used for surge protection.

3.7.2 Grounding

Grounding shall be provided to building ground.

3.7.3 Wiring

System field wiring shall be installed in 20 mm (3/4 inch) minimum diameter electrical metallic tubing or metallic conduit. Wiring for the sprinkler system fire detection and control system shall be installed in tubing or conduits dedicated for that use only and not installed in conduit, outlet boxes or junction boxes which contain lighting and power wiring or equipment. Circuit conductors entering or leaving any mounting box, outlet box enclosure or cabinet shall be connected to screw terminals with each terminal marked and labeled in accordance with the wiring diagram. No more than one conductor shall be installed under any screw terminal. Connections and splices shall be made using screw terminal blocks. The use of wire nut type connectors is not permitted. Wiring within any control equipment shall be readily accessible without removing any component parts. Conductors shall be color-coded and shall be identified within each enclosure where a connection or termination is made. Conductor identification shall be by plastic-coated, self-sticking, printed markers or by heat-shrink type sleeves. Circuits shall be wired to maintain electrical supervision so that removal of any single wire from any device shall cause a "trouble" condition on the control panel.

3.7.4 Control Panel

The control panel and its assorted components shall be mounted so that no part of the enclosing cabinet is less than 600 mm (24 inches) and not more than 2000 mm (78 inches) above the finished floor.

3.7.5 Detectors

Detectors shall be ceiling-mounted per NFPA 72 and shall be at least 300 mm (12 inches) from any part of any lighting fixture. Detectors shall be located at least 900 mm (3 feet) from diffusers of air handling systems. Each detector shall be provided with appropriate mounting hardware as required by its mounting location.

3.7.6 Manual Actuation Stations

Manual actuation stations shall be mounted readily accessible and 1060 mm (42 inches) above the finished floor.

3.7.7 Notification Appliances

Notification appliances shall be mounted a minimum of 2400 mm (8 feet) above the finished floor unless limited by ceiling height.

3.8 DISINFECTION

If sprinkler piping is not isolated from the domestic water piping systems by means of a reduced pressure backflow prevention assembly or if sprinkler piping in connected to the domestic water piping, after all system components are installed and hydrostatic test(s) are successfully completed, each portion of the sprinkler system to be disinfected shall be thoroughly flushed with potable water until all entrained dirt and other foreign materials have been removed before introducing chlorinating material. Flushing shall be conducted by removing the flushing fitting of the cross mains and of the grid branch lines, and then back-flushing through the sprinkler main drains. The chlorinating material shall be hypochlorites or liquid chlorine. Water chlorination procedure shall be in accordance with AWWA M20. The chlorinating material shall be fed into the sprinkler piping at a constant rate of 50 parts per million (ppm). A properly adjusted hypochlorite solution injected into the system with a hypochlorinator, or liquid chlorine injected into the system through a solution-fed chlorinator and booster pump shall be used. Chlorination application shall continue until the entire system if filled. The water shall remain in the system for a minimum of 24 hours. Each valve in the system shall be opened and closed several times to ensure its proper disinfection. Following the 24-hour period, no less than 25 ppm chlorine residual shall remain in the system. The system shall then be flushed with clean water until the residual chlorine is reduced to less than one part per million. Samples of water in disinfected containers for bacterial examination will be taken from several system locations which are approved by the

Contracting Officer. Samples shall be tested for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA EWW. The testing method shall be either the multiple-tube fermentation technique or the membrane-filter technique. The disinfection shall be repeated until tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained. After the successful completion, all sprinklers or plugs and gravity flush all drops or trapped piping.

3.9 PIPE COLOR CODE MARKING

Color code marking of piping shall be as specified in Section 09900 PAINTING, GENERAL.

3.10 PRELIMINARY TESTS

The system including the underground water mains, the aboveground piping, detectors and control system and system components shall be tested to assure that equipment and components function as intended. The underground and aboveground interior piping systems and attached appurtenances subjected to system working pressure shall be tested in accordance with NFPA 13 and NFPA 24. Upon completion of specified tests, the Contractor shall complete certificates as specified in paragraph SUBMITTALS.

3.10.1 Underground Piping

3.10.1.1 Flushing

Underground piping shall be flushed in accordance with NFPA 24. This includes the requirement to flush the lead-in connection to the fire protection system at a flow rate not less that the calculated maximum water demand rate of the system.

3.10.2 Hydrostatic Testing

New underground piping shall be hydrostatically tested in accordance with NFPA 24. The allowable leakage shall be measured at the specified test pressure by pumping from a calibrated container. The amount of leakage at the joints shall not exceed 2 liters (2 quarts) per hour per 100 gaskets or joints, regardless of pipe diameter.

3.10.3 Aboveground Piping

3.10.3.1 Hydrostatic Testing

Aboveground piping shall be hydrostatically tested in accordance with NFPA 13 at not less than 1400 kPa (200 psi) or 350 kPa (50 psi) in excess of maximum system operating pressure and shall maintain that pressure without loss for 2 hours. There shall be no drop in gauge pressure or visible leakage when the system is subjected to the hydrostatic test. The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

3.10.3.2 Air Pressure Test

As specified in NFPA 13, an air pressure leakage test at 350 kPa (50 psi) shall be conducted for 24 hours. There shall be no drop in gauge pressure in excess of 10 kPa (1.5 psi) for the 24 hours. This air pressure test is in addition to the required hydrostatic test.

3.10.3.3 Backflow Prevention Assembly Forward Flow Test

Each backflow prevention assembly shall be tested at system flow demand, including all applicable hose streams, as specified in NFPA 13. The Contractor shall provide all equipment and instruments necessary to conduct a complete forward flow test, including 65 mm (2.5 inch) diameter hoses, playpipe nozzles, calibrated pressure gauges, and pitot tube gauge. The Contractor shall provide all necessary supports to safely secure hoses and nozzles during the test. At the system demand flow, the pressure readings and pressure drop (friction) across the assembly shall be recorded. A metal placard shall be provided on the backflow prevention assembly that lists the pressure readings both upstream and downstream of the assembly, total pressure drop, and the system test flow rate. The pressure drop shall be compared to the manufacturer's data.

3.10.4 Detection and Control System Tests

Upon completion of the installation, the detection and control system shall be subjected to functional and operational performance tests including tests of each installed initiating device, system actuation device and notification appliance. The control system tests specified in paragraph FINAL ACCEPTANCE TESTS shall be conducted to ensure that the system is completely functional and that wiring has been properly connected. If deficiencies are found, corrections shall be made and the system shall be retested to assure that the systems have no deficiencies.

3.10.5 Automatic Water Control Valve Test

Each water control valve shall be independently trip-tested in accordance with the manufacturer's published instructions. Each valve shall be electrically trip-tested by actuating a respective heat detector and a manual actuation station connected to the control panel and a manual actuation device that is part of the valve trim. A full-flow main drain test shall be made. For preaction systems with supervisory air, the air pressure shall be reduced to verify proper operation of the air supply system and associated supervisory alarm devices.

3.11 FINAL ACCEPTANCE TESTS

Final Acceptance Test shall begin only when the Preliminary Test Report has been approved. The Fire Protection Specialist shall conduct the Final Acceptance Test and shall provide a complete demonstration of the operation of the system. This shall include operation of control valves and flowing of inspector's test connections to verify operation of associated waterflow alarm switches. After operation of control valves has been completed, the main drain test shall be repeated to assure that control valves are in the open position. Each system shall be completely drained after each trip test. The system air supply system shall be tested to verify that system pressure is restored in the specified time. In addition, the Fire Protection Specialist shall have available copies of as-built drawings and certificates of tests previously conducted. The installation shall not be considered accepted until identified discrepancies have been corrected and test documentation is properly completed and received. After the system has been tested and drained, the system shall be drained periodically for at least 2 weeks until it can be assured that water from the system has been removed.

3.11.1 Control System Test

Testing shall be in accordance with NFPA 72. The test shall include the following:

a. Visual inspection of wiring connections.

b. Opening the circuit at each alarm initiating device, solenoid valve, and notification appliance to test the wiring and supervisory features.

c. Test of each function of the control panel.

d. Test of each circuit in the normal, open and ground fault modes.

e. Test of each initiating device in both normal and trouble conditions.

f. Test of each control circuit and device.

g. Test of each alarm notification appliance.

h. Test of the battery charger and batteries

i. Operational tests under emergency power supply, including activation of connected alarm notification appliances for the specified time period.

3.11.2 Trip-tests of Automatic Water Control Valves

Each water control valve shall be independently trip-tested in accordance with the manufacturer's published instructions. Each valve shall be electrically trip-tested by actuating a respective heat detector, a manual actuation station connected to the system control panel and the manual release which is part of the valve trim. Each valve shall be returned to normal condition after each test. Prior to trip testing sprinkler deluge system, precautionary steps shall be taken to prevent water damage to the building and equipment from sprinkler discharge. Control valves on deluge systems shall be shut off immediately after automatic water control valve trips. Control valves on preaction systems shall remain open until piping is filled with water.

3.11.3 Tests of Supervisory Air System

Preaction system supervisory air pressure shall be reduced from the normal system pressure to the point at which a low-pressure alarm is sounded. Air pressure shall be restored to verify trouble signal restoration. Automatic start/stop features of air compressor shall be tested.

3.12 ONSITE TRAINING

The Fire Protection Specialist and Manufacturer's Representative shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. . Training shall be provided for a period of 24 hours of normal working time and shall start after the system is functionally complete but prior to the Preliminary Tests and Final Acceptance Test. The Onsite Training shall cover all of the items contained in the approved Operating and Maintenance Instructions.

DIVISION 14 CONVEYING SYSTEMS

SECTION 14601

CRANES, BRIDGE, TOP RUNNING, 30-TON MAXIMUM CAPACITY
(for indoor usage in a non-hazardous atmosphere)

Page

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(1990; R 1999) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 390.03A	(1980; Errata 1983; R 1988) Gear Handbook Gear Classification, Materials and Measuring Methods for Bevel, Hypoid, Fine Pitch Wormgearing and Racks Only as Unassembled Gears (Partially replaced by AGMA 2000-A)
AGMA 2000	(1988; Errata Jan 89, Errata Jul 90) Gear Classification and Inspection Handbook, Tolerances & Measuring Methods for Unassembled Spur and Helical Gears (including Metric Equivalents)
AGMA 2001	(1995; Rev. C) Fundamental Rating Factors & Calculation Methods for Involute Spur and Helical Gear Teeth

AGMA 6010	(1997; Rev. F) Standard for Spur, Helical, Herringbone and Bevel Enclosed Drives
AGMA 6019	(1989; Rev. E) Gearmotors Using Spur, Helical, Herringbone, Straight Bevel, or Spiral Bevel Gears
AGMA 6021	(1989; Rev. G) Shaft Mounted and Screw Conveyer Drives Using Spur, Helical and Herringbone Gears

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 348	(1985; Appx A Jun 1994) Allowable Stress Design Specification for Structural Joints Using ASTM A 325 or A 490 Bolts

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C80.1	(1995) Rigid Steel Conduit - Zinc Coated

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 159	(1983; R 1993) Automotive Gray Iron Castings
ASTM A 325	(1997) Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A 325M	(1997) High-Strength Bolts for Structural Steel Joints (Metric)
ASTM A 490	(1997) Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength
ASTM A 490M	(1993) High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric)
ASTM A 668/ A 668M	(1996) Steel Forgings, Carbon and Alloy, for General Industrial Use
ASTM B 209	(1996) Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B 209M	(1995) Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B 438/ B 438M	(1995a) Sintered Bronze Bearings (Oil-Impregnated)
ASTM B 439	(1995) Iron-Base Sintered Bearings (Oil-Impregnated)
ASTM B 612	(1996) Iron Bronze Sintered Bearings (Oil-Impregnated)

ASME INTERNATIONAL (ASME)

ASME B30.2	(1996) Overhead and Gantry Cranes Top Running Bridge, Single or Multiple Girder Top Running Trolley Hoist

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(1998) Structural Welding Code – Steel

AWS D14.1	(1997) Welding Industrial and Mill Cranes and Other Material Handling Equipment

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-55810	(Apr 1996) Conduit, Metal, Flexible
FS RR-W-410	(Rev D; Am 1) Wire Rope and Strand

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 397	(1972; R 1979; 397-1 1980) Recommended Standard for) Thyristors

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std 597	(1983; R 1992) Practices and Requirements for General Purpose Thyristor for DC Drives

CRANE MANUFACTURERS ASSOCIATION OF AMERICA

CMAA 70	(1994) Electric Overhead Traveling Cranes

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA AB 1	(1993) Molded Case Circuit Breakers and Molded Case Switches
NEMA ICS 1	(1993) Industrial Controls and System
NEMA ICS 2	(1993) Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC
NEMA ICS 3	(1993) Industrial Control and Systems: Factory Built Assemblies
NEMA ICS 4	(1993 Rev Industrial Control and Systems: Terminal Blocks
NEMA ICS 6	(1993) Industrial Control and Systems: Enclosures
NEMA MG 1	(1993; Rev 1; Rev 2; Rev 3; Rev 4)) Motors and Generators
NEMA ST 1	(1988; R 1994) Specialty Transformers (Except General-Purpose Type)
NEMA WC 3	(1992; Rev 1) Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
NEMA WC 7	(1988; Rev 1; Rev 2) Crosslinked-Thermosetting-polyethylene-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
NEMA WC 8	(1988; Rev 1;Rev 2; Rev 3) Ethylene-Propylene-Rubber-

Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (1999) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 489 (1996) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

UL 943 (1993; Rev thru May 1998) Ground-Fault Circuit-Interrupters

UL 1004 (1994; Rev thru Dec 1997) Electric Motors

UL 1449 (1996; Rev thru Oct 1998) Transient Voltage Surge Suppressors

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Crane System; G

Detailed drawings containing complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout and anchorage of equipment and appurtenances and equipment relationship to other parts of the work including clearances for maintenance and operation.

SD-03 Product Data

Crane System; G

A complete list of equipment and materials, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions.

Spare Parts

Spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than 2 months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

Framed Instructions; G

Diagrams, instructions, and other sheets proposed for posting.

Hook Assembly; G

Record of hook material and any heat treatment performed shall be stamped on the hook shank or documented in certification papers furnished with the hooks.

SD-06 Test Reports

Acceptance Testing; G

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. The report shall include the information as required by paragraph ACCEPTANCE TESTING.

SD-10 Operation and Maintenance Data

Crane System; G

Six copies of operation manuals and six copies of maintenance manuals shall be supplied for the equipment furnished. One complete set shall be furnished prior to performance testing and the remainder upon acceptance. Operation manuals shall detail the step-by-step procedures required for system startup, operation, and shutdown. Operation manuals shall include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. Operation manuals shall include a copy of the acceptance test report for information and future reference. Operation manuals shall include an overall description of the system describing any unique features that may need special attention. Maintenance manuals shall provide step-by-step description of routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include piping layout diagrams, equipment layout diagrams, and detailed wiring and control diagrams of the system as installed. Maintenance manuals shall include a spare parts list of manufacturer's recommended spare parts that should be maintained on-site and any long lead time items should be clearly identified. Operation and maintenance manuals shall be approved prior to the field training course.

1.3 SYSTEM DESCRIPTION

1.3.1 General Requirements

1.3.1.1 Standard Products

Materials and equipment shall be standard products of manufacturers regularly engaged in the fabrication of cranes and shall essentially duplicate items which have been in satisfactory use for at least 2 years prior to bid opening. Any company licensed by a crane manufacturer to manufacture cranes bearing their name shall have the design and components approved by the licensor prior to submission to the Government for approval.

1.3.1.2 Nameplates

Each major component of equipment shall have the manufacturer's name, address, type or style, model or catalog number, and serial number on a metal plate secured to the equipment.

1.3.1.3 Verification of Dimensions

The Contractor shall verify all dimensions in the field and shall advise the Contracting Officer of any discrepancy before performing any work.

1.3.1.4 Welding

Welding shall be in accordance with qualified procedures using AWS D14.1 as modified. Written welding procedures shall specify the Contractor's standard dimensional tolerances for deviation from camber and sweep and such tolerances shall not exceed those specified in AWS D14.1. All welding shall be performed indoors. Welders and welding operators shall be qualified in accordance with AWS D1.1/D1.1M or AWS D14.1. Allowable stress values shall be in accordance with CMAA 70.

1.3.2 Crane Design Criteria

The cranes shall be designed to operate in the spaces and match the runway dimensions and rails indicated. The hook coverage and hook vertical travel shall not be less than that indicated.

1.3.2.1 Classification

The crane shall be designed and constructed to CMAA 70 Class D, Heavy Duty Service requirements for operation in indoor or outdoor, hazardous or nonhazardous environment as indicated or required.

1.3.2.2 Rated Capacity and Speeds

The rated capacity (metric tons) of the crane shall be as indicated. The lower load block and hook shall not be considered part of the rated capacity. Rated speeds in feet per minute for the hoist, bridge and trolley shall be as follows:

Floor Operated Industrial Cranes
(Feet Per Minute)

Rated Load (metric tons)	Main Hoist	auxiliary hoist	Trolley	Bridge
5	30	10	75	150
10	25	8	75	150
15	20	7	75	150
20	20	7	75	150
25	20	7	75	100
30	15	5	75	100

1.3.2.3 Capacity Plates

Two capacity plates shall be provided, one for each side of the bridge. Each plate shall be lettered to indicate the total rated hoisting capacity of the crane. All lettering shall be of sufficient size to be easily read from the floor. Each lower load block shall be marked with the hoist rated capacity.

1.4 DELIVERY AND STORAGE

Equipment delivered shall be placed in indoor storage, protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

PART 2 PRODUCTS

2.1 STRUCTURAL MATERIALS

2.1.1 Bolts, Nuts, and Washers

Bolts, nuts, and washers shall conform to ASTM A 325/325M bolts. High strength bolted connections shall conform to the requirements of AISC 348, except that ASTM A 490/490M bolts shall not be used. No galvanized bolts shall be used.

2.1.2 Bridge Girders

Bridge girders shall be wide flange beams, standard I-Beams, reinforced beams or sections fabricated from rolled plates and shapes. Bridge girders with a capacity greater than 18.1 tons (metric) 20 tons (2000 lb.) or a span greater than 12 meters (40 feet) shall be welded structural steel box sections.

2.1.3 Bridge Rails

The bridge rail shall be fastened to the top cover plate with welded clips. Bridge rail joints shall be bolted using standard joint bars. Rail joints shall be staggered.

2.1.4 End Ties and Bridge Girder End Connections

Horizontal gusset plates shall be provided at the elevation of the top and bottom end tie flanges for connection to girder ends. End connections shall be made using high-strength bolts. Body bound bolts fitted in drilled and reamed holes shall be used to maintain the crane square. With a capacity greater than 18.1 tons (metric) [20 tons (2000 lb)] or a span greater than 12 meters (40 feet), welded steel box sections shall be used for end ties, full-depth diaphragms shall be provided at girder connections and jacking points.

2.1.5 Bridge End Trucks

End trucks shall be fabricated from structural steel providing a rigid structure and shall be the rotating or fixed axle type. Jacking pads shall be provided for removal of wheel assemblies.

2.1.6 Trolley Frame

Trolley frame shall consist of two structural steel side frames or trucks welded together with one or more structural steel load girts to form a one-piece unit. Pads shall be provided for the use of jacks or wedges when changing truck wheels.

2.1.7 Stops and Bumpers

Structural stops or bumpers shall be provided on the bridge to engage bumpers or structural stops located at the ends of the runway rails. Structural stops or bumpers shall be provided on the trolley to engage bumpers or structural stops located at the ends of the bridge rails. Stops shall be located to permit maximum bridge and trolley travel. Structural stops and bumpers shall be designed and installed in accordance with CMAA 70.

2.1.8 Footwalks

The location and construction of footwalks shall be in accordance with ASME B30.2. A footwalk shall be provided on the drive side. To give access to the opposite side of the trolley, bridge conductors, or other equipment, a footwalk twice the length of the trolley, shall be mounted on the opposite side of the crane. A cross-over footwalk shall be provided over an end tie between the two girder footwalks. The drive side footwalk shall mate with the crane access platform. Footwalks and platforms shall be safety tread (raised pattern). The length of the drive side footwalk shall be along the entire length of the bridge. Safety handrails shall be provided for footwalks.

2.1.9 Runway Rails

The runway rails for the bridge travel shall be of the size recommended by the crane manufacturer and shall be in accordance with CMAA 70.

2.1.10 Additional Provisions for Outside Service

Welded structural members on outdoor cranes shall be seal welded. Cranes shall be provided with parking brakes sufficient to hold the crane against a wind pressure of 250 Pa (5 psf). Cranes shall be provided with manually operated rail clamps at each rail, designed to securely anchor the crane against a wind pressure of 1450 Pa (30 psf).

2.2 MECHANICAL EQUIPMENT

2.2.1 Drives

2.2.1.1 Bridge Drives

Bridge drives shall be either the A-1 or A-4 drive arrangement as specified in CMAA 70.

2.2.1.2 Trolley Drives

The trolley shall have a drive arrangement that has two wheels driven.

2.2.2 Load Blocks

2.2.2.1 Main and Auxiliary Hoist Load Blocks

Load blocks shall be of steel construction. The load block frame shall be completely enclosed except for rope openings. Load blocks shall be provided with a forged steel crosshead, separate from the sheave pin, with swivel mounting for the hook. Sheave bearing lubrication fittings shall be recessed within the sheave pin or adequately guarded to prevent damage.

2.2.2.2 Hook Assembly

Hooks shall be single barbed and shall be made of forged steel complying with ASTM A 668/A 668M. All hooks shall be fitted with safety latches designed to preclude inadvertent displacement of slings from the hook saddle. No painting or welding shall be performed on the hook. Hooks are required to be periodically disassembled, inspected, and nondestructively tested; therefore the hook nut shall be secured by a set screw or other similar, easily removable securing device, but shall not be welded. Hooks shall be commercially rated and shall have a minimum proof load of twice the safe working load and have a minimum straightening load of four times the safe working load.

2.2.3 Hoisting Ropes

Hoisting ropes shall be regular lay, preformed, uncoated, improved or extra improved plow steel, 6 by 37 construction, with independent wire rope core conforming to FS RR-W-410, Type I, Class 3. The hoisting ropes shall be selected such that the rated capacity load plus the load block weight divided by the number of parts of rope shall not exceed 20 percent of the certified breaking strength of the rope. Hoisting ropes shall be secured to the hoist drum so that no less than three wraps of rope remain at each anchorage of the hoist drum at the extreme low position (limit switch stop).

2.2.4 Sheaves

Sheaves shall be of cast steel, forged, rolled, or welded structural steel. Sheave grooves shall be accurately machined, smoothly finished, and free of surface defects.

2.2.5 Hoist Drums

Hoist drums shall be of welded rolled structural steel, cast steel, or seamless steel pipe. Drums shall be machined and provided with grooves, including two dead grooves at each of the two anchor points.

2.2.6 Gearing

Gearing shall be of the enclosed (gear reducers) or open type. The gears and pinions shall be spur, helical, or herringbone type only, and shall be forged, cast or rolled steel, except that drum gears may be of welded construction.

2.2.6.1 Gear Reducers

Gear reducers shall be the standard items of manufacturers regularly engaged in the design and manufacture of gear reducers, or they shall be integral components of standard hoists or hoist/trolley units of manufacturers regularly engaged in the design and manufacture of hoists or hoist/trolley units. Gear reducers shall be designed, manufactured, and rated in accordance with AGMA 6010, AGMA 6019, or AGMA 6021(for trolley drives only), as applicable.

2.2.6.2 Open Gearing

All gears and pinions shall have adequate strength and durability for the crane service class and manufactured to AGMA 2001 quality class 6 or better precision per AGMA 390.03A and AGMA 2000. Open gears shall be enclosed with safety guards provided with openings with covers for inspection and access for grease lubrication.

2.2.7 Brakes

Brakes shall be shoe or disc with thermal capacity suitable for Class D Service. Shoe and disc brakes shall be spring set and electrically released by a continuously rated direct acting magnet. All brakes shall be self-aligning and provide for easy adjustment for torque setting and lining wear. Brake wheels shall be cast iron conforming to ASTM A 159 or shall be the manufacturer's standard high-strength ductile cast iron, provided that the material exhibits wear characteristics in the form of powdered wear particles and is resistant to heat checking. Disc brakes shall be totally enclosed and have multiple discs with stationary releasing magnets. Brake torque shall be easily adjustable over a 2:1 torque range.

2.2.7.1 Hoist Holding Brakes

Each hoist shall be equipped with at least one holding brake. The holding brake shall be a friction brake of the shoe design and shall be applied to the motor shaft or to the gear reducer shaft.

2.2.7.2 Hoist Control Brake

Each hoist shall be equipped with an integral mechanical load brake-"Weston" or multiple-disc. The multiple-disc brake shall be provided with external adjustment for wear.

2.2.7.3 Trolley Brake

The trolley braking system shall have shoe or disc brakes that are spring applied and electrically released.

2.2.7.4 Bridge Brakes

The bridge braking system shall provide a single-shoe or disc brake for each bridge drive motor. The bridge brakes shall be spring applied and electrically released.

2.2.8 Wheels

The wheels shall be made of rolled or forged steel. The wheel treads and flanges shall be rim toughened to between 320 and 370 Brinell hardness number. Bridge and trolley wheels shall be double flanged. Trolley wheels shall have straight treads. Bridge wheels shall have tapered or straight treads.

2.2.9 Bearings

All bearings, except those subject only to small rocker motion, shall be of the antifriction type. Load ratings and fatigue life shall be in accordance with ABMA 9and ABMA 11. Equalizer sheaves shall be equipped with sintered oil impregnated type bushings in accordance with ASTM B 438/B 438M, ASTM B 439, or ASTM B 612.

2.2.10 Antidrip Provisions

The cranes shall be designed to preclude leakage of lubricants onto the lifted loads or the floor. Equipment and components which cannot be made leak-proof shall be fitted with suitable drip pans. The drip pans shall be made of steel and shall be designed to permit removal of the collected lubricant.

2.2.11 Lubrication System

A splash oil lubrication system shall be provided for the hoist, trolley and bridge gear cases, except that an oil pump shall be used on vertical mounted gear cases exceeding two reductions. Oil pumps shall be reversible and capable of maintaining the same oil flow direction and volume while being driven in either direction. Electric motor-driven pumps may be used when the input shaft speed is too low at any operating condition to ensure adequate oil flow. In such applications, the pump shall be energized whenever the drive mechanism brakes are released.

2.2.11.1 Electrically Driven Oil Pump Alarm

If an electric-driven lubricating pump is used, an audible alarm and red indicating light shall be provided and shall be energized in the event of pump malfunction.

2.3 ELECTRICAL COMPONENTS

2.3.1 Power Supply

2.3.1.1 General

Electric power for the normal operation of the crane will be supplied from the nominal volt as indicated, 3-phase, ungrounded, 60-Hz ac power distribution system.

2.3.1.2 Incoming Power Supply

a. General - Incoming power from the above power receptacles shall be brought into the crane by means of a Type G, three-conductor, 600-volt rubber or rubber-like insulated and extra-heavy-duty neoprene-jacketed portable power cable. The cable shall have a usable length as indicated or recommended by manufacturer, and shall be wound upon the cable reel to be furnished and mounted on the crane. The power plug shall be installed on the free end of the cable and an anchorage shall be provided to relieve the power plug and receptacle from the strain of reeling and unreeling the cable. The grounding conductors shall make electrical connection to the crane structure through the fourth collector ring and brush of the cable reel and shall be connected to the ground terminal of the power plug.

b. Cable Reel - The cable reel shall be rated for constant duty, amperes continuous as indicated or recommended by manufacturer, 600-volt AC, shall be provided with four collector rings and brushes, shall be of weather-proof construction, shall maintain approximately uniform tension in the cable, and shall automatically "pay out" and "take up" the cable as required by the crane travel. The cable reel shall be provided with a positive driven or actuated limit switch that will prevent excess "takeup". The reel shall be mounted on the crane in a location, as approved , that will allow ready maintenance and inspection as well as satisfactory operation.

2.3.1.3 Incoming Power Circuit Breaker

The crane's normal power supply shall be controlled by means of a volt as indicated, three-pole, manually operated air circuit breaker having a suitable ampere rating. Short circuit protection only shall be provided. The breaker shall be mounted on the protective panel.

2.3.2 TROLLEY CONDUCTORS AND COLLECTORS

2.3.2.1 Festoon Conductors

Power and control circuits may be brought to the crane trolley by means of a "festoon" system consisting of jacketed and color coded multiple conductor power and control cables which shall be bundled and supported by four-wheel trolleys running on "I" beam rails mounted on the inside of the main trolley girders. Trolley wheels shall be provided with antifriction bearings. The conductors of all cables shall be terminated at each end by terminal lugs connected to terminal blocks conforming to NEMA ICS 4 mounted in cast iron junction boxes of NEMA Type 4 construction conforming to Part ICS-1-110 of NEMA ICS 1. Power and control circuits shall be segregated and terminated in separate junction boxes. Two extra conductors shall be provided in each control cable. All cable of a given "festoon" group shall be bundled together using nylon lacing material. All cables shall be supported with sufficient trolleys to maintain a minimum of 900 mm (12 inches) from the top of the lifting beam.

2.3.3 Control Systems

A separate controller shall be provided for each motor; however, a duplex controller shall be used for two motor bridge drives. Overload protection shall be in conformance with the requirements of NEMA ICS 2. Contactors that are used for starting, stopping, and reversing shall be mechanically and electrically interlocked.

2.3.3.1 Hoist Control System

a. Motion Control - The main hoist and auxiliary hoist motion control system shall be two - speed, with AC magnetic control of AC squirrel cage motors.

b. Motor Control - The hoist motor control system shall provide two speeds in each direction by means of an electrically operated, full magnetic, across-the-line reversing starter. Electrical interlocks shall be used to prevent operation of all other speed contactors while the speed contactors for any one speed are energized.

2.3.3.2 Travel Control System

The bridge and trolley motion control system shall be two-speed with AC magnetic control of squirrel cage motors.

a. Bridge and Trolley Control - The bridge and trolley main control systems shall provide two speeds in each direction by means of an electrically operated, full magnetic, across-the-line reversing type starter. Centrifugal switches shall be provided and used in the control circuit to prevent the plugging of trolley or bridge drive motors; each switch shall be arranged to set the associated drive's brake while attempts are made to plug. The bridge and main control system shall be provided with primary resistor reduced voltage starting, acceleration, and deceleration for all speed points.

b. Drift Point - With the master switch in the "Off" position, operation of a thumb-operated auxiliary switch in the operating lever shall actuate the drift position. In the "Drift" position, the electric brakes shall be released and the crane travel motor or motors de-energized to allow full control of drifting travel.

2.3.3.3 Magnetic Control Equipment

The primary and accelerating contactors and/or static devices shall be mounted on one or more panels and shall be enclosed in a cabinet or cabinets. The control circuits shall be wired to terminal blocks or studs complete and ready for making all external connections. Insulated wire shall conform to the requirements of paragraph CONDUIT AND WIRING. Magnetic contactors for individual motor controls shall have a rating the equivalent of the motor controlled, but in no case shall a contactor less than NEMA size 1 be used. The protective panel main line contactor shall be rated in accordance with NEMA ICS 3 for Service Class I, except that in no case shall the rating be less than one NEMA size greater than the largest individual motor contactor used.

2.3.3.4 DC Conversion Equipment

a. General - Each crane motion which requires independent operation shall be provided with a separate control and solid-state conversion unit except that a single solid-state conversion unit and set of control equipment may be used in event more than one gantry travel motors is provided.

b. Solid-State Conversion Unit - The power conversion system for each motion shall be solid-state, silicon-controlled rectifier or thyristor with adequate capacity to drive its connected DC motor or motors at all specified speeds and loads. The conversion unit (including overload protection) shall be rated for continuous duty at the motor current necessary to lift 150 percent rated load at any speed point, and shall have a 1-minute rating equal to the necessary current to develop a motor torque corresponding to 200 percent of rated load. Rectifier elements shall be hermetically sealed and mounted on heat sinks cooled by natural convection, except that forced-air cooling may be used if over-temperature protection is provided for the rectifiers. Forced-air cooled units must be capable of delivering full-load without damage for not less than 5 minutes following loss of the cooling. The rectifier system shall be built, installed, and enclosed in accordance with EIA 397 or IEEE Std 597. Minimum protection shall consist of line isolating transformers, transient voltage and current surge suppressors conforming to UL 1449, and either current-limiting rectifier fuses or static instantaneous overcurrent circuits with sensing in each phase of the AC line. Individual Thyristors shall be with ultrafast current-limiting rectifier fuses and shall be provided with failure indication. The control circuit shall include an adjustable-operating current limit circuit capable of limiting maximum current to not more than the current necessary to obtain 200 percent motor torque. The repetitive peak inverse voltage rating of the rectifier shall be not less than 250 percent of the working peak inverse voltage. Thyristor case temperature shall not exceed 100 degrees C in a 30 degrees C ambient when delivering rate load. When parallel operation of thyristors is required, each unit's actual share of the load shall not differ from its calculated share by more than 10 percent. Purposely matched units shall not be used. Parallel operation of thyristors will not permitted for individual loads less than 235 amperes RMS. The firing pulse for paralleled thyristors shall have a rise time less than 0.5 microsecond and a peak gate current not less than 1.5 amperes. The firing pulse for nonparalleled thyristors shall have a rise time less than 1 microsecond and a peak gate current not less than 1 ampere for all devices rated above 35 amperes RMS. The maximum value of the DC average voltage output shall not exceed 500 volts.

2.3.3.5 Control Panels

Control panels shall be fabricated of solid sheet steel designed and constructed to conform to the requirements of NEMA ICS 6 Type as indicated or required. Control panel doors shall be hinged, equipped with gaskets, and shall be fitted with key-lock handles designed to latch the door at top, center, and bottom. A single key shall open all locks.

2.3.3.6 Protection

a. Main Line Disconnect - A main line disconnect consisting of a combination circuit breaker and nonreversing starter (main line contactor) in NEMA Type 1 enclosure shall be provided. The main line disconnect shall be controlled by a control circuit such that all crane motions shall be stopped upon main line undervoltage, overload, control circuit fuse failure, or operation of the POWER OFF pushbutton.

b. Circuit Breakers - Circuit breakers shall meet the requirements of UL 489 and NEMA AB 1.

c. Overloads - AC circuit overload relays shall be of the ambient compensated, automatic reset, inverse time type located in all phases of the main line and individual motor circuits and arranged to open the main line contactor.

2.3.3.8 Limit Switches

Limit switches shall be heavy duty quick-break double-pole double-throw type and shall conform to NEMA ICS 2. Geared limit switch interruption of a motion in one direction shall not prevent the opposite motion. Geared limit switches shall reset automatically. Limit switch housings shall be NEMA Type 1. Limit switches shall interrupt power to the control systems.

a. Hoist Upper Limit Switches - Two limit switches shall be provided for each hoist. A rotating adjustable geared control circuit interrupt limit switch shall provide hoist-up limiting. A secondary hoist upper limit shall be provided with a weight operated limit switch, to prevent raising beyond their safe limit. This secondary limit switch shall operate to interrupt power to all hoist motor conductors and set the hoist holding brakes.

b. Hoist Lower Limit Switches - Hoists shall be provided with a rotating adjustable geared control circuit interrupt limit switch for hoist-down travel limiting.

c. Bridge and Trolley Travel Limit Switches - Runway (track) limit switches shall be mounted to the crane bridge and trolley, respectively, adjacent to one runway rail to interrupt current to the bridge and trolley controls. Adjustable limit switch actuators shall be installed on both ends of those rails to actuate the limit switches and stop the crane bridge or trolley prior to contacting the runway bumpers.

d. Rail Clamp Limit Switches - Each rail clamp shall be furnished with a limit switch designed to interrupt the control circuits to the bridge drive when the rail clamps are set. A red pilot light shall be provided at the control station to indicate the rail clamps are set.

2.3.3.9 Warning Horn

A solid state electronic warning horn shall be provided on the crane. Any bridge or trolley motion shall be accompanied by a continuous series of alternating tones.

2.3.3.10 Load Limit System

A load limit system shall be provided for the main hoist. The primary purpose of the load limit system is to inform the operator by an alarm that the preset load has been exceeded. The system shall consist of a load cell, load sensing electronics, no-load and overload indicator lights, overload alarm bell, and alarm cut-out switch. The load cell shall be mounted to receive the load from the axle of the equalizing sheave. The alarm setpoint shall be adjustable.

2.3.4 Motors

2.3.4.1 General Requirements

Motors shall be designed specifically for cranes and hoist duty. Drain holes shall be provided at low points near each end. Inspection and service covers shall be provided with gaskets. All hardware shall be corrosion resistant. Motors shall conform to the requirements of NFPA 70, NEMA MG 1 and UL 1004.

2.3.4.2 Main and Auxiliary Hoist Motor

The hoist motor shall be industrial two-speed; two-winding, NEMA design D squirrel cage AC or wound rotor AC induction.

2.3.4.3 Bridge and Trolley Drive Motors

The bridge and trolley drive motors shall be industrial, two-speed; two-winding, NEMA design B squirrel cage AC rated or wound rotor AC induction.

2.3.4.4 Motor Enclosures

Motor enclosures shall be totally enclosed, fan cooled (TEFC).

2.3.4.5 Hoist Motor Insulation and Time Rating

The hoist motors shall be provided with Class F or H insulation with a 60-minute minimum motor time rating to satisfy NEMA permissible motor temperature rise above 40 degrees C ambient, permitted by Class B insulation.

2.3.4.6 Bridge and Trolley Motor Insulation and Tim e Rating

The bridge and trolley drive motors shall be provided with Class F or H insulation with a 60-minute minimum motor time rating to satisfy NEMA permissible motor temperature rise above 40 degrees C (100 degrees F) ambient, permitted by Class B insulation.

2.3.5 Electric Brakes

2.3.5.1 Hoist Brake Time Delay

One of the hoist holding brakes shall be provided with a time delay setting (from 1 to 3 seconds). Such time delay shall be initiated upon release of the control pushbutton or return of the master switch to OFF.

2.3.5.2 Automatic Stop System

All electrically controlled brakes shall be applied automatically when power is interrupted. Brakes shall be wired so that the brakes release upon operation of a pushbutton for the associated drive and shall set upon release of that pushbutton, return of the master switch to OFF, operation of POWER OFF pushbutton, de-energization of main line contactor, or power failure. Electric brakes shall be designed so that they can be mechanically released. Enclosures for brake electrical components shall be NEMA ICS 6. DC shunt magnetic shoe brakes shall be provided with an electrical forcing circuit for rapid release of the brake. Each shunt coil brake shall be circuited so that both conductors supplying the brake are opened simultaneously when the brake is de-energized.

2.3.6 Lighting Heating and Convenience Outlets

Three-phase 208Y/120-volt AC power, supplied via a circuit breaker conforming with NEMA ST 1 from the line side of the main line disconnect shall be used for lighting, heaters, and accessory circuits on the crane. The circuit breaker shall have a NEMA 1 enclosure in accordance with NEMA ICS 6. The enclosure shall have provisions to lock the breaker in the OFF position. Each pole of the circuit breaker shall have individual thermal and magnetic trip elements; a button shall be provided on the enclosure cover for mechanically tripping the circuit breaker. A three-phase 480-volt delta primary, and 208Y/120-volt wye secondary general lighting isolation transformer shall be fed from the accessory circuit breaker and shall feed a 208Y/120-volt UL listed circuit breaker panelboard and a heater circuit breaker/combination starter. The panelboard shall supply branch circuits for utilization of various accessories such as receptacles, lighting, and panel internal lighting.

2.3.6.1 Transformers

Transformers shall be dry type and shall carry full load continuously at rated voltage and frequency without exceeding an average temperature rise of 115 degrees C above an ambient temperature of 40 degrees C. The transformer shall have a totally enclosed case which shall be finished with manufacturer's standard coating system. Transformers shall be fully encapsulated, except for those specifically designed for use as an isolation transformer for static power conversion units.

2.3.6.2 Receptacles

Receptacles shall be, single-phase, 120-volt 15-amp, grounded, duplex with metal NEMA 1 enclosure with self-closing weather-proof receptacle cover. A receptacle shall be provided on each end of the bridge walkway, on the trolley, in the vicinity of bridge travel drive motors. Several receptacles shall be provided in the vicinity of the control equipment equally spaced every 1.5 m (5 feet).

2.3.6.3 Lighting

A circuit breaker, lighting transformer, and panelboard shall be provided for general lighting. Control panels shall be provided with a 120-volt lamp with an unbreakable lens and switch. Floodlights shall be provided to illuminate the work area under the crane, and the drum area on the crane and shall be controlled from the crane control station. Floodlight fixtures shall be attached to the underside of the crane and spaced for uniform lighting. Floodlights shall be metal halide, industrial luminaries. Each floodlight shall be totally enclosed, vapor tight design, gasketed, and have a heat- and impact-resistant glass lens.

2.3.7 Conduit and Wiring

2.3.7.1 General

All wiring between equipment units or components, except where flexible connections are specified, shall be installed in rigid, steel conduit with threaded condulet fittings and zinc-coated NEMA 1 outlet and pull boxes. Conduit connections to motors, brakes, limit switches, wheel trucks, and other items where flexible connections are required shall be made using short lengths of liquid-tight flexible conduit. The conduit shall be securely mounted and fastened to the crane framework and shall be installed in a neat and workmanlike manner. Change of direction of a conduit run shall be made by means of threaded condulet fittings and the conduit shall be installed to fit close to the crane framework. Conduit unions shall be used where standard couplings cannot be used to join conduits or as required to permit dismantling for shipment. No running threads will be permitted. Ends of conduits shall be carefully reamed. All threaded connections shall be made up with a compound composed of colloidal copy and rust inhibitors. Separate conduit systems shall be provided for power, control, and lighting circuits. The entire conduit system shall be grounded and shall be installed so that any moisture will be drained from terminal boxes and equipment. All conduit connections to equipment enclosures shall be watertight threaded. Suitable "drain-breather" devices shall be provided at all low points of the conduit system to allow water to escape continuously. The conduit system shall be installed in the shop, complete and ready for installing wire and after inspection shall be dismantled as necessary for shipment to the site.

2.3.7.2 Conduit

a. Rigid Conduit - Rigid steel conduit shall conform to ANSI C80.1 and shall, in addition, be zinc-coated (galvanized) both inside and outside by the hot-dip method.

b. Flexible Conduit - Flexible conduit shall conform to CID A-A-55810, shall have a hot-dipped galvanized steel core, copper ground wire, and a waterproof extruded PVC cover.

2.3.7.3 Insulated Wire and Cable

a. Materials, Construction and Tests - Materials, construction, and tests, unless otherwise specified, shall conform to the applicable requirements of NEMA WC 7 or NEMA WC 8, as applicable. Parts, tables, sections, appendices, grades, and classes specified will refer to the above NEMA standards, unless otherwise stated.

b. Conductors - Conductors shall be annealed copper wire. Copper conductors shall be tin or lead alloy coated, or bare, as required by the type of insulation used. All conductors shall have class B or C standing. Solid conductors will not be permitted.

c. Insulation

(1) Material

Insulation shall be a cross-linked polyethylene meeting the dimensional, electrical, and physical requirements of Part 3 of NEMA WC 7 or NEMA WC 8. Type I or Type II grade of EPR insulation shall be used for single-conductor cables with a jacket and for the individual conductors of a multiple-conductor cable with an overall jacket.

(2) Insulation Thickness

Insulation thickness shall be as required by Table 3-1, Part 3 of NEMA WC 7 or NEMA WC 8 as applicable, for rated circuit voltage of 0-600 volts. Single-conductor cross-linked polyethylene insulated cables with Column A thickness only will be permitted without a jacket. Single-conductor ethylene-propylene-rubber insulated conductors with Column A thickness will not be permitted.

d. Type - Unless otherwise specified or approved, all wire and cable for power, control, and lighting shall be single conductor.

e. Jackets - An outer jacket of a synthetic thermosetting material shall be applied over multiple-conductor cables. Single-conductor cables and individual conductors of a multiple-conductor cable may have a jacket. The jacket shall be tightly and concentrically formed around the core of the cable. Single-conductor cables shall have jackets when insulation thickness is in accordance with Column B, Table 3-1, Part 3 of NEMA WC 7 or NEMA WC 8. The jacket shall be a synthetic thermosetting compound and shall conform to one of the following:

(1) Heavy-duty black neoprene in accordance with paragraph 4.4.3 of NEMA WC 8.

(2) Heavy-duty black chlorosulfonated polyethylene in accordance with paragraph 4.4.9 of NEMA WC 8.

f. Dimensional Tolerance - The outside diameter of single-conductor wires and cables shall not vary more than 5 percent from the calculated outside diameter based on the thickness, including tolerance, of the component materials specified.

g. Wires - Near resistors, wiring exposed to heat shall have flame retardant, heat and moisture resistant insulation, and conform to the requirements of NFPA 70 and the following: Maximum operating temperature for conductors generally shall be 90 degrees C except that maximum operating temperature for internal wiring conductors in resistor cabinets shall be 125 degrees C.

h. Control Panel Wiring - Control panel wiring shall be stranded copper switchboard wire with 600-volt insulation and except for type SIS shall be coated. The wire shall be AVB or SIS. Hinge wire shall have

Class K stranding. Hinge wire shall be used between stationary and hinged equipment and shall be formed in wire loops or bundles at least 600 mm (2 feet) long which shall provide rotation around the longitudinal axis of the conductors.

i. Festoon System Cable - The connections to the trolley shall be made using type G cables with 75 degrees C, 600-volt insulation and heavy-duty "Neoprene" jacket for the power circuits and type SO cord with 60 degrees C, 600-volt insulation and "Neoprene" jacket for control and lighting circuits. Type G cables and SO cords shall conform to the applicable requirements of NEMA WC 3, Part 7, paragraphs 7.6 and 7.7, respectively. Conductors shall have not less than class H stranding.

j. Current Carrying Capacity - Wire for power and motor circuits shall have a current carrying capacity of not less than the full-load current of the motor or the circuit but in no case less than No. 10 AWG. Wire for control circuits shall not be smaller than No. 14 AWG. Wires exposed to heat or in resistor cabinets shall be sized as required but in no case less than No. 10 AWG.

k. Terminations and Continuity - All conductor connections, except for splices in lighting conductors which are made in junction boxes, shall be terminated at terminal studs or terminal blocks using approved indented terminal ring-tongue connectors. All screw terminals shall have lockwashers and all stud terminals shall have contact nuts and either locking nuts or lock washers. Splices will be permitted only in accordance with NFPA 70.

PART 3 EXECUTION

3.1 SHOP ASSEMBLY AND TESTS

The hoists, trolleys, trolley drives, and gantry drives shall be shop assembled and operated under their own power. Reeving of drums and sheaves will not be required. Permanent wiring except wire which would be disassembled or partly disassembled for shipment shall be installed. Permanent conduit except conduit attached to walkways, ladders, stairs, and machinery housing shall be installed. The bridge structural frame shall be assembled and checked for fit and alignment. The test shall demonstrate that the various parts and components are correctly fabricated, assembled, and fitted. The Contractor shall notify the Contracting Officer 14 days prior to testing operations.

3.2 PREPARATION FOR SHIPMENT

After completion of the shop tests, the crane shall be match-marked and prepared for shipment with electrical connections tagged. Four copies of a diagram of match-marks shall be furnished. All parts and equipment at the site shall be protected from weather, damage, abuse, and loss of identification.

3.3 ERECTION

Erection shall be in accordance with the manufacturer's instructions and as indicated.

3.3.1 Erection Procedures

Major components of the crane shall be shop assembled as completely as possible. The erection procedures shall ensure that the crane is erected without initial stresses, forced or improvised fits, misalignments, nicks of high-strength structural steel components, stress-raising welds, and rough burrs. After the crane is erected, any damaged painted surfaces shall be cleaned and repainted. After erection is complete, the equipment shall be serviced. All necessary grease and oil of approved quality and grade for the initial servicing and field test shall be provided by the Contractor.

3.3.2 Mechanical Alignment

All motors, couplings, brakes gear boxes, and drive components shall be aligned when reinstalled, in accordance with manufacturer's instructions.

3.3.3 Electrical Alignment

The control system shall be aligned in accordance with manufacturer's instructions. Alignment data shall include timer settings, resistor tap settings, potentiometer settings, test point voltages, supply voltages, motor voltages, motor currents, and test conditions such as ambient temperature, motor load, date performed, and person performing the alignment. A copy of the final alignment data shall be stored in control panel door.

3.3.4 Field Painting

Painting required for surfaces not otherwise specified and finish painting of items only primed at the facility shall be as specified in Section 09965 PAINTING: HYDRAULIC STRUCTURES.

3.4 ACCEPTANCE TESTING

3.4.1 Crane Test

The Contractor shall provide all personnel necessary to conduct the tests including but not limited to crane operators, riggers, rigging gear, and test weights. Testing shall be performed in the presence of Contracting Officer. The Contractor shall notify the Contracting Officer 14 days prior to testing operations.

3.4.1.1 Test Sequence

The crane shall be tested according to the applicable paragraphs of this procedure in the sequence provided.

3.4.1.2 Test Data

Operating and startup current measurements shall be recorded for electrical equipment (motors and coils) using appropriate instrumentation. Speed measurements shall be recorded as required by the facility evaluation tests (normally at 100 percent load). Recorded values shall be compared with design specifications or manufacturer's recommended values; abnormal differences shall be explained in the remarks and submitted for approval or appropriate adjustments performed. In addition, high temperatures or abnormal operation of any equipment or machinery shall be noted, investigated, and corrected. Hoist, trolley, and bridge speeds should be recorded during each test cycle.

3.4.1.3 Equipment Monitoring

During the load test, improper operation or poor condition of safety devices, electrical components, mechanical equipment, and structural assemblies shall be monitored. Observed defects critical to continued testing shall be reported immediately to the Contracting Officer, and testing shall be suspended until the deficiency is corrected. During and immediately following each load test, the following inspections shall be made:

a. Inspect for evidence of bending, warping, permanent deformation, cracking, or malfunction of structural components.

b. Inspect for evidence of slippage in wire rope sockets and fittings.

c. Check for overheating in brake operation; check for proper stopping. All safety devices, including emergency stop switches and POWER OFF pushbuttons, shall be tested and inspected separately to verify proper operation of the brakes.

d. Check for abnormal noise or vibration and overheating in machinery drive components.

e. Check wire rope sheaves and drum spooling for proper operation, freedom of movement, abnormal noise, or vibration.

f. Check electrical drive components for proper operation, freedom from chatter, noise, or overheating.

g. Inspect external gears for abnormal wear patterns, damage, or inadequate lubrication.

3.4.1.4 Hooks

Hooks shall be measured for hook throat spread before and after load test. A throat dimension base measurement shall be established by installing two tram points and measuring the distance between these tram points (to within 0.4 mm (1/64 inch)). This base dimension shall be recorded. The distance between tram points shall be measured before and after load test. An increase in the throat opening by more than 1 percent from the base measurement shall be cause for rejection.

3.4.2 No-Load Testing

3.4.2.1 Hoist Operating and Limit Switch Test

The load hook shall be raised and lowered through the full range of normal travel at rated speed and other speeds of the crane. The load hook shall be stopped below the geared limit switch upper setting. In slow speed only, proper operation of upper and lower limit switches shall be verified. The test shall be repeated a sufficient number of times (minimum of three) to demonstrate proper operation. Brake action shall be tested in each direction. The proper time delay shall be verified between the actuation of the dual brakes.

3.4.2.2 Trolley Travel

The trolley shall be operated the full distance of the bridge rails exercising all drive speed controls in each direction. Brake operation shall be verified in each direction. In slow speed the trolley bumpers shall contact the trolley stops located on the bridge girders.

3.4.2.3 Bridge Travel

The bridge shall be operated the full distance of the runway exercising all drive speed controls, in each direction. Brake operation shall be verified in each direction. In slow speed, the proper operation (interrupt power, automatic reset) of the bridge limit switches at both limits of bridge motion shall be tested. In slow speed, the crane bridge bumpers shall contact the runway rail stops.

3.4.2.4 Hoist Loss of Power No-Load Test

The hooks shall be raised to a height of approximately 3.5 m (12 feet) or less. While slowly lowering the hook, the main power source shall be disconnected verifying that the hook will not lower and that both brakes will set.

3.4.2.5 Travel Loss of Power No-Load Test

With the hook raised to clear obstructions and the trolley traveling in slow speed, the main power source shall be disconnected verifying that the trolley will stop and that the brake will set. The test shall be repeated for the bridge slow speed drive controls.

3.4.3 Load Test

3.4.3.1 Hoist

Unless otherwise indicated, the following tests shall be performed using a test load of 125 percent of rated load.

a. Hoist Static Load Test: Holding brakes and hoisting components shall be tested by raising the test load approximately 900 mm (1 foot) and manually releasing one of the holding brakes. The load shall be held for 10 minutes. The first holding brake shall be reapplied and the second holding brake released. The load shall be held for 10 minutes. Any lowering that may occur indicates a malfunction of the brakes or lowering components.

b. Dynamic Load Test: The test load shall be raised and lowered at each speed through the full operating range. The machinery shall be completely stopped at least once in each direction to ensure proper brake operation.

c. Hoist Load Brake: With test load raised approximately 1.5 m (5 feet) and with the hoist controller in the neutral position, the holding brake shall be released. The load brake shall be capable of holding the test load. With the holding brake in the released position, the test load shall be lowered (first point) and the controller shall be returned to OFF position as the test load lowers. The load brake shall prevent the test load from accelerating.

d. Hoist Loss of Power Test: After raising the test load to approximately 2.5 m (8 feet), begin slowly lowering the test load, the main power source and the control pushbutton shall be released verifying that the test load will not lower and that both brakes will set.

e. Trolley Dynamic Load Test: While operating the trolley the full distance of the bridge rails in each direction with test load on the hook (one cycle), the proper function of all speed control points and proper brake action shall be tested.

f. Bridge Dynamic Load Test: With test load on the hook, the bridge shall be operated for the full length of the runway in both directions with the trolley at each extreme end of the bridge. Proper function of all drive speed control points and brake action shall be verified. Binding of the bridge end trucks shall indicate malfunction.

3.4.3.2 Trolley and Bridge Loss of Power Test

Using a test load of 100 percent of rated load, the load shall be raised clear of any obstructions on the operating floor. Starting at a safe distance from walls or other obstructions, a slow speed shall be selected using the trolley and bridge drive. While maintaining a safe distance to obstructions, the main power source shall be disconnected and the brakes shall be verified to have set and that the equipment stops within the distance recommended by the manufacturer.

3.5 FRAMED INSTRUCTIONS

Framed instructions under acrylic plastic or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

3.6 MANUFACTURER'S SERVICES

Services of a manufacturer's representative who is experienced in the installation, adjustment, erection, and operation of the equipment specified shall be provided. The representative shall supervise the installation, adjustment, and testing of the equipment.

3.7 FIELD TRAINING

A field training course shall be provided for designated operating staff members. Training shall be provided for a total period of 24 hours of normal working time and shall start after the system is functionally complete but prior to final acceptance tests. Field training shall cover all of the items contained in the operating and maintenance instructions. The Contracting Officer shall be given at least 2 weeks advance notice of such training.

3.8 SPARE PARTS

One set of manufacturer's recommended spare parts shall be furnished and delivered to the site. The spare parts shall be suitably packaged for long-term protection and storage. The packaging shall be legibly labeled to identify the spare parts. A list of the furnished spare parts shall be included in the Maintenance manual.

DIVISION 15 MECHANICAL

SECTION 15080

THERMAL INSULATION FOR MECHANICAL SYSTEMS

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only. At the discretion of the Government, the manufacturer of any material supplied will be required to furnish test reports pertaining to any of the tests necessary to assure compliance with the standard or standards referenced in this specification.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 167 (1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A 580/A 580M (1998) Stainless Steel Wire

ASTM B 209/B 209M (1996) Aluminum and Aluminum-Alloy Sheet and Plate

ASTM C 195 (1995) Mineral Fiber Thermal Insulating Cement

ASTM C 449/C 449M	(1995) Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
ASTM C 518	(1998) Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
ASTM C 533	(1995) Calcium Silicate Block and Pipe Thermal Insulation
ASTM C 534	(1999) Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C 547	(1995) Mineral Fiber Pipe Insulation
ASTM C 552	(1991) Cellular Glass Thermal Insulation
ASTM C 553	(1992) Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C 591	(1994) Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C 610	(1995) Molded Expanded Perlite Block and Pipe thermal Insulation
ASTM C 612	(1993) Mineral Fiber Block and Board Thermal Insulation
ASTM C 647	(1995) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM C 665	(1998) Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing
ASTM C 795	(1998el) Thermal Insulation for Use in Contact With Austenitic Stainless Steel
ASTM C 916	(1985; R 1996e1) Adhesives for Duct Thermal Insulation
ASTM C 920	(1998) Elastomeric Joint Sealants
ASTM C 921	(1989; R 1996) Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM C 1126	(1998) Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
ASTM C 1136	(1995) Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C 1290	(1995) Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts
ASTM E 84	(1999) Surface Burning Characteristics of Building

Materials

ASTM E 96 (1995) Water Vapor Transmission of Materials

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-69 (1996) Pipe Hangers and Supports - Selection and Application

MIDWEST INSULATION CONTRACTORS ASSOCIATION (MICA)

MICA Insulation Standards (1993) National Commercial & Industrial Insulation Stds

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3698 (2002) Cold Rolled Stainless Steel Sheets, Plates and Strips

KS D 3703 (1997) Stainless Steel Wires

KS D 6701 (2002) Aluminum and Aluminum Alloy Sheets, Plates, Strips and Coiled Sheets

KS L 9101 (1999) Thermal Insulation Material Made of Calcium Silicate

KS L 9102 (1997) Artificial Mineral Fibre Thermal Insulation Materials

1.2 SYSTEM DESCRIPTION

Field-applied insulation and accessories on mechanical systems shall be as specified herein; factory-applied insulation is specified under the piping, duct or equipment to be insulated. Insulation of heat distribution systems and chilled water systems outside of buildings shall be as specified in the USACE Unified Facilities Guide Specifications (UFGS), Section 02552A PRE-ENGINEERED UNDERGROUND HEAT DISTRIBUTION SYSTEM, Section 02553A HEAT DISTRIBUTION SYSTEMS IN CONCRETE TRENCHES, Section 02554A ABOVEGROUND HEAT DISTRIBUTION SYSTEM, and Section 02555A PREFABRICATED UNDERGROUND HEATING/COOLING DISTRIBUTION SYSTEM. Field applied insulation materials required for use on Government-furnished items as listed in the SPECIAL CONTRACT REQUIREMENTS shall be furnished and installed by the Contractor.

1.3 GENERAL QUALITY CONTROL

1.3.1 Standard Products

Materials shall be the standard products of manufacturers regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.3.2 Installer's Qualifications

Qualified installers shall have successfully completed three or more similar type jobs within the last 5 years.

1.3.3 Surface Burning Characteristics

Unless otherwise specified, insulation not covered with a jacket shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Insulation systems which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Insulation materials located exterior to the building perimeter are not required to be fire-rated. Flame spread and smoke developed indexes shall be determined by ASTM E 84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E 84.

1.3.4 Identification of Materials

Packages or standard containers of insulation, jacket material, cements, adhesives, and coatings delivered for use, and samples required for approval shall have manufacturer's stamp or label attached giving the name of the manufacturer and brand, and a description of the material.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-04 Samples

Thermal Insulation Materials; G

A complete list of materials, including manufacturer's descriptive technical literature, performance data, catalog cuts, and installation instructions. The product number, k-value, thickness and furnished accessories for each mechanical system requiring insulation shall be included. Materials furnished under this section of the specification shall be submitted at one time. After approval of materials and prior to applying insulation a booklet shall be prepared and submitted for approval. The booklet shall contain marked-up MICA Insulation Stds plates (or detail drawings showing the insulation material and insulating system) for each pipe, duct, or piece of equipment required to be insulated per this specification. The MICA plates shall be marked up showing the materials to be installed in accordance with the requirements of this specification for the specific insulation application. The Contractor shall submit all MICA Plates required to show the entire insulating system, including Plates required to show insulation penetrations, vessel bottom and top heads, legs, and skirt insulation as applicable. If the Contractor elects to submit detailed drawings instead of marked-up MICA Plates, the detail drawings shall show cut-away, section views, and details indicating each component of the insulation system and showing provisions for insulating jacketing, and sealing portions of the equipment. For each type of insulation installation on the drawings, provide a label which identifies each component in the installation (i.e., the duct, insulation, adhesive, vapor retarder, jacketing, tape, mechanical fasteners, etc.). Indicate insulation by type and manufacturer. Three copies of the booklet shall be submitted at the jobsite to the Contracting Officer. One copy of the approved booklet shall remain with the insulation Contractor's display sample and two copies shall be provided for Government use. After approval of materials actual sections of installed systems properly insulated in accordance with the specification requirements shall be displayed. Such actual sections must remain accessible to inspection throughout the job and will be reviewed from time to time for controlling the quality of the work throughout the construction site. Each material used shall be identified, by indicating on an attached sheet the specification requirement for the material and the material by each manufacturer intended to meet the requirement. Display sample sections will be inspected at the jobsite by the Contracting Officer. Approved display sample sections shall remain on display at the jobsite during the construction period. Upon completion of construction, the display sample sections will be closed and sealed.

Pipe Insulation Display Sections: Display sample sections shall include as a minimum an elbow or tee, a valve, dielectric unions and flanges, a hanger with protection shield and insulation insert, or dowel as required, at support point, method of fastening and sealing insulation at longitudinal lap, circumferential lap, butt joints at fittings and on pipe runs, and terminating points for each type of pipe insulation used on the job, and for hot pipelines and cold pipelines, both interior and exterior, even when the same type of insulation is used for these services.

Duct Insulation Display Sections: Display sample sections for rigid and flexible duct insulation used on the job. A display section for duct insulation exposed to weather shall be protected by enclosing with a temporary covering.

1.5 STORAGE

Materials shall be delivered in the manufacturer's unopened containers. Materials delivered and placed in storage shall be provided with protection from weather, humidity, dirt, dust and other contaminants. Insulation material and supplies that become dirty, dusty, wet, or otherwise contaminated may be rejected by the Contracting Officer.

PART 2 PRODUCTS

2.1 GENERAL MATERIALS

Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either the wet or dry state. Materials to be used on stainless steel surfaces shall meet ASTM C 795 requirements. Materials shall be asbestos free and conform to the following:

2.1.1 Adhesives

2.1.1.1 Acoustical Lining Insulation Adhesive

Adhesive shall be a nonflammable, fire-resistant adhesive conforming to ASTM C 916, Type I.

2.1.1.2 Mineral Fiber Insulation Cement

Cement shall be in accordance with ASTM C 195.

2.1.1.3 Lagging Adhesive

Lagging is the material used for thermal insulation, especially around a cylindrical object. This may include the insulation as well as the cloth/material covering the insulation. Lagging adhesives shall be nonflammable and fire-resistant and shall have a flame spread rating no higher than 25 and a smoke developed rating no higher than 50 when tested in accordance with ASTM E 84. Adhesive shall be pigmented white or red and be suitable for bonding fibrous glass cloth to faced and unfaced fibrous glass insulation board; for bonding cotton brattice cloth to faced and unfaced fibrous glass insulation board; for sealing edges of and bounding fibrous glass tape to joints of fibrous glass board; for bonding lagging cloth to thermal insulation; or for attaching fibrous glass insulation to metal surfaces. Lagging adhesives shall be applied in strict accordance with the manufacturer's recommendations.

2.1.2 Contact Adhesive

Adhesive may be dispersed in a nonhalogenated organic solvent or, dispersed in a nonflammable organic solvent which shall not have a fire point below 94 degrees C (200 degrees F). The adhesive shall not adversely affect, initially or in service, the insulation to which it is applied, nor shall it cause any corrosive effect on metal to which it is applied. Any solvent dispersing medium or volatile component of the adhesive shall have no objectionable odor and shall not contain any benzene or carbon tetrachloride. The dried adhesive shall not emit nauseous, irritating, or toxic volatile matters or aerosols when the adhesive is heated to any temperature up to 100 degrees C (212 degrees F). The adhesive shall be nonflammable and fire resistant.

2.1.3 Caulking

ASTM C 920, Type S, Grade NS, Class 25, Use A.

2.1.4 Corner Angles

Nominal 0.4060 mm (0.016 inch) aluminum 25 x 25 mm (1 x 1 inch) with factory applied kraft backing. Aluminum shall be ASTM B 209/B 209M or KS D 6701, Alloy 3003, 3105, or 5005.

2.1.5 Finishing Cement

Mineral fiber hydraulic-setting thermal insulating cement ASTM C 449/C 449M. All cements that may come in contact with Austenitic stainless steel must include testing per ASTM C 795.

2.1.6 Fibrous Glass Cloth and Glass Tape

Fibrous glass cloth and glass tape shall have flame spread and smoke developed ratings of no greater than 25/50 when measured in accordance with ASTM E 84. Tape shall be 100 mm (4 inch) wide rolls.

2.1.7 Staples

Outward clinching type monel or ASTM A 167 or KS D 3698, Type 304 or 316 stainless steel. Monel is a nickel rich alloy which has high strength, high ductility, and excellent resistance to corrosion.

2.1.8 Jackets

ASTM C 921, Type I, maximum moisture vapor transmission 0.02 perms, (measured before factory application or installation), minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork, where a minimum puncture resistance of 25 Beach units is acceptable. Minimum tensile strength, 6.1 N/mm (35 pounds/inch) width. ASTM C 921, Type II, minimum puncture resistance 25 Beach units, tensile strength minimum 3.5 N/mm (20 pound/inch) width. Jackets used on insulation exposed in finished areas shall have white finish suitable for painting without sizing. Based on the application, insulation materials which require factory applied jackets are mineral fiber, cellular glass, and phenolic foam. All non-metallic jackets shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E 84.

2.1.8.1 White Vapor Retarder All Service Jacket (ASJ)

For use on hot/cold pipes, ducts, or equipment vapor retarder jackets used on insulation exposed in finished areas shall have white finish suitable for painting without sizing.

2.1.8.2 Aluminum Jackets

Aluminum jackets shall be corrugated, embossed or smooth sheet, 0.4060 mm (0.016 inch) nominal thickness; ASTM B 209/B 209M or KS D 6701, Temper H14, Temper H16, Alloy 3003, 5005, or 3105 with factory applied moisture retarder. Corrugated aluminum jacket shall not be used outdoors. Aluminum jacket securing bands shall be Type 304 stainless steel, 0.3960 mm (0.015 inch) thick, 12.7 mm (1/2 inch) wide for pipe under 300 mm 12 inch diameter and 19.1 mm (3/4 inch) wide for pipe over 300 mm (12 inch) and larger diameter. Aluminum jacket circumferential seam bands shall be 50.8 x 0.4060 mm (2 x 0.016 inch) aluminum matching jacket material. Bands for insulation below ground shall be 19.1 x 0.5080 mm (3/4 x 0.020 inch) thick stainless steel, or fiberglass reinforced tape. The jacket may, at the option of the Contractor, be provided with a factory fabricated Pittsburg or "Z" type longitudinal joint. When the "Z" joint is used, the bands at the circumferential joints shall be designed by the manufacturer to seal the joints and hold the jacket in place.

2.1.8.3 Polyvinyl Chloride (PVC) Jackets

Polyvinyl chloride (PVC) jacket and fitting covers shall have high impact strength, UV resistant rating or treatment and moderate chemical resistance with minimum thickness 0.7620 mm (0.030 inch).

2.1.9 Vapor Retarder Coating

The vapor retarder coating shall be fire and water resistant and appropriately selected for either outdoor or indoor service. Color shall be white. The water vapor permeance of the compound shall be determined according to procedure B of ASTM E 96 utilizing apparatus described in ASTM E 96. The coating shall be a nonflammable, fire resistant type. All other application and service properties shall be in accordance with ASTM C 647.

2.1.9.1 Vapor Retarder Required

ASTM C 1136, Type I, maximum moisture vapor transmission 0.02 perms, minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork, where Type II, maximum moisture vapor transmission 0.02 perms, a minimum puncture resistance of 25 Beach units is acceptable.

2.1.9.2 Vapor Retarder Not Required

ASTM C 1136, Type III, maximum moisture vapor transmission 0.10 perms, minimum puncture resistance 50 Beach units on all surfaces except ductwork, where Type IV, maximum moisture vapor transmission 0.10, a minimum puncture resistance of 25 Beach units is acceptable.

2.1.10 Wire

Soft annealed ASTM A 580/A 580M or KS D 3703, Type 302, 304 or 316 stainless steel, 16 or 18 gauge.

2.2 PIPE INSULATION MATERIALS

Pipe insulation materials shall be limited to those listed herein and shall meet the following requirements:

2.2.1 Aboveground Cold Pipeline

Insulation for minus 34 degrees to plus 16 degrees C (minus 30 degrees to plus 60 degrees F) for outdoor, indoor, exposed or concealed applications shall be as follows:

a. Cellular Glass: ASTM C 552, Type II, and Type III. Supply the insulation with manufacturer's recommended factory applied jacket.

b. Flexible Cellular Insulation: ASTM C 534, Type I or II. Type II shall have vapor retarder skin on both sides of the insulation.

c. Phenolic Insulation: ASTM C 1126, Type III. Phenolic insulations shall comply with ASTM C 795 and with the ASTM C 665 paragraph Corrosiveness. Supply the insulation with manufacturer's recommended factory applied jacket.

d. Polyisocyanurate Insulation: ASTM C 591, type I. Supply the insulation with manufacturer's recommended factory applied jacket.

2.2.2 Aboveground Hot Pipeline

Insulation for above 16 degrees C 60 degrees F, for outdoor, indoor, exposed or concealed applications shall meet the following requirements. Supply the insulation with manufacturers recommended factory applied jacket.

a. Mineral Fiber: ASTM C 547, Types I, II or III, or KS L 9102, supply the insulation with manufacturers recommended factory applied jacket.

b. Calcium Silicate: ASTM C 533, Type I indoor only, or outdoors above 121 degrees C 250 degrees F pipe temperature, or KS L 9101, Class 2-22.

c. Cellular Glass: ASTM C 552, Type II and Type III. Supply the insulation with manufacturers recommended factory applied jacket.

d. Flexible Cellular Insulation: ASTM C 534, Type I or II to 93 degrees C 200 degrees F service.

e. Phenolic Insulation: ASTM C 1126 Type III to 121 C 250 F service shall comply with ASTM C 795. Supply the insulation with manufacturers recommended factory applied jacket.

f. Perlite Insulation: ASTM C 610

g. Polyisocyanurate Insulation: ASTM C 591, Type 1, to 149 degrees C 300 degrees F service. Supply the insulation with manufacturer's recommended factory applied jacket.

2.2.3 Above Ground Dual Temperature Pipeline - Outdoor, Indoor - Exposed or Concealed Selection of insulation for use over a dual temperature pipeline system shall be in accordance with the most limiting/restrictive case. Find an allowable material from paragraph PIPE INSULATION MATERIALS and determine the required thickness from the most restrictive case. Use the thickness listed in paragraphs INSULATION THICKNESS for cold & hot pipe applications.

2.2.4 Below ground Pipeline Insulation

For below ground pipeline insulation the following requirements shall be met.

2.2.4.1 Cellular Glass

ASTM C 552, type II.

2.3 DUCT INSULATION MATERIALS

Duct insulation materials shall be limited to those listed herein and shall meet the following requirements:

2.3.1 Rigid Mineral Fiber

ASTM C 612, Type IA, IB, II, III, & IV., or KS L 9102.

2.3.2 Flexible Mineral Fiber

ASTM C 553, Type I,or Type II up to 121 C 250 F, ASTM C 1290 Type III, or KS L 9102.

2.3.3 Cellular Glass

ASTM C 552, Type I.

2.3.4 Phenolic Foam

ASTM C 1126 Type II, shall comply with ASTM C 795.

2.3.5 Flexible Cellular

ASTM C 534 Type II.

2.3.6 Polyisocyanurate

ASTM C 591, Type 1. Supply the insulation with manufacturer's recommended factory applied jacket.

2.4 EQUIPMENT INSULATION MATERIALS

Equipment insulation materials shall be limited to those listed herein and shall meet the following requirements:

2.4.1 Cold Equipment Insulation

For temperatures below 16 degrees C (60 degrees F).

2.4.1.1 Cellular Glass

ASTM C 552, Type I, Type III, or Type IV as required.

2.4.1.2 Flexible Cellular Insulation

ASTM C 534, Type II.

2.4.1.3 Phenolic Foam

ASTM C 1126 Type II shall comply with ASTM C 795.

2.4.1.4 Polyisocyanurate Foam

ASTM C 591, Type I. Supply the insulation with manufacturer's factory applied jacket.

2.4.2 Hot Equipment Insulation

For temperatures above 16 degrees C (60 degrees F).

2.4.2.1 Rigid Mineral Fiber

ASTM C 612, Type IA, IB, II, III, IV or V, or KS L 9102, as required for temperature encountered to 982 degrees C (1800 degrees F).

2.4.2.2 Flexible Mineral Fiber

ASTM C 553, Type I, II, III, IV, V, VI or VII, or KS L 9102, as required for temperature encountered to 649 degrees C (1200 degrees F).

2.4.2.3 Calcium Silicate

ASTM C 533, Type I or KS L 9101, indoors only, or outdoors above 121 degrees C (250 degrees F). Pipe shape may be used on diesel engine exhaust piping and mufflers to 649 degrees C (1200 degrees F).

2.4.2.4 Cellular Glass

ASTM C 552, Type I, Type III, or Type IV as required.

2.4.2.5 Flexible Cellular Insulation

ASTM C 534, Type II, to 93 degrees C (200 degrees F).

2.4.2.6 Phenolic Foam

ASTM C 1126 Type II to 121 degrees C (250 degrees F) shall comply with ASTM C 795.

2.4.2.7 Molded Expanded Perlite

ASTM C 610.

2.4.2.8 Polyisocyanurate Foam:

ASTM C 591, Type I. Supply the insulation with manufacturer's recommended factory applied jacket.

PART 3 EXECUTION

3.1 APPLICATION - GENERAL

3.1.1 Installation

Except as otherwise specified, material shall be installed in accordance with the manufacturer's written instructions. Insulation materials shall not be applied until tests and heat tracing specified in other sections of the contract specification are completed. Material such as rust, scale, dirt and moisture shall be removed from surfaces to receive insulation. Insulation shall be kept clean and dry. Insulation shall not be removed from its shipping containers until the day it is ready to use and shall be returned to like containers or equally protected from dirt and moisture at the end of each workday. Insulation that becomes dirty shall be thoroughly cleaned prior to use. If insulation becomes wet or if cleaning does not restore the surfaces to like new condition, the insulation will be rejected, and shall be immediately removed from the jobsite. Joints shall be staggered on multi layer insulation. Mineral fiber thermal insulating cement shall be mixed with demineralized water when used on stainless steel surfaces. Insulation, jacketing and accessories shall be installed in accordance with MICA

Insulation Stds standard plates except where modified herein or on the drawings.

3.1.2 Firestopping

Where pipes and ducts pass through fire walls, fire partitions, above grade floors, and fire rated chase walls, the penetration shall be sealed with fire stopping materials as specified in Section 07840 FIRESTOPPING.

3.1.3 Painting and Finishing

Painting shall be as specified in Section 09900 PAINTING, GENERAL.

3.1.4 Installation of Flexible Cellular Insulation

Flexible cellular insulation shall be installed with seams and joints sealed with a contact adhesive. Flexible cellular insulation shall not be used on surfaces greater than 93 degrees C (200 degrees F). Seams shall be staggered when applying multiple layers of insulation. Insulation exposed to weather and not shown to have jacketing shall be protected with two coats of UV resistant finish as recommended by the manufacturer after the adhesive is dry.

3.1.5 Welding

No welding shall be done on piping, duct or equipment without written approval of the Contracting Officer. The capacitor discharge welding process may be used for securing metal fasteners to duct.

3.1.6 Pipes/Ducts/Equipment which Require Insulation

Insulation is required on all pipes, ducts, or equipment, except for omitted items, as specified.

3.2 PIPE INSULATION INSTALLATION

3.2.1 Pipe Insulation

3.2.1.1 General

Pipe insulation shall be installed on aboveground hot and cold pipeline systems as specified below to form a continuous thermal retarder, including straight runs, fittings and appurtenances unless specified otherwise. Installation shall be with full length units of insulation and using a single cut piece to complete a run. Cut pieces or scraps abutting each other shall not be used. Pipe insulation shall be omitted on the following:

a. Pipe used solely for fire protection.

b. Chromium plated pipe to plumbing fixtures. However, fixtures for use by the physically handicapped shall have the hot water supply and drain, including the trap, insulated where exposed.

c. Sanitary drain lines.

d. Air chambers.

3.2.1.2 Pipes Passing Through Walls, Roofs, and Floors

a. Pipe insulation shall be continuous through the sleeve.

b. An aluminum jacket with factory applied moisture retarder shall be provided over the insulation wherever penetrations require sealing.

c. Where penetrating interior walls, the aluminum jacket shall extend 50 mm (2 inches) beyond either side of the wall and shall be secured on each end with a band.

d. Where penetrating floors, the aluminum jacket shall extend from a point below the backup material to a point 250 mm 10 inches above the floor with one band at the floor and one not more than 25 mm (1 inch) from the end of the aluminum jacket.

e. Where penetrating waterproofed floors, the aluminum jacket shall extend from below the backup material to a point 50 mm (2 inches) above the flashing with a band 25 mm (1 inch) from the end of the aluminum jacket.

f. Where penetrating exterior walls, the aluminum jacket required for pipe exposed to weather shall continue through the sleeve to a point 50 mm (2 inches) beyond the interior surface of the wall.

g. Where penetrating roofs, pipe shall be insulated as required for interior service to a point flush with the top of the flashing and sealed with vapor retarder coating. The insulation for exterior application shall butt tightly to the top of flashing and interior insulation. The exterior aluminum jacket shall extend 50 mm (2 inches) down beyond the end of the insulation to form a counter flashing. The flashing and counter flashing shall be sealed underneath with caulking.

h. For hot water pipes supplying lavatories or other similar heated service which requires insulation, the insulation shall be terminated on the backside of the finished wall. The insulation termination shall be protected with two coats of vapor barrier coating with a minimum total thickness of 2.0 mm (1/16 inch) applied with glass tape embedded between coats (if applicable). The coating shall extend out onto the insulation 50.0 mm (2 inches) and shall seal the end of the insulation. Glass tape seams shall overlap 25 mm (1 inch). Caulk the annular space between the pipe and wall penetration with approved fire stop material. Cover the pipe and wall penetration with a properly sized (well fitting) escutcheon plate. The escutcheon plate shall overlap the wall penetration at least 10 mm (3/8 inch).

i. For domestic cold water pipes supplying lavatories or other similar cooling service which requires insulation, the insulation shall be terminated on the finished side of the wall (i.e., insulation must cover the pipe throughout the wall penetration). The insulation shall be protected with two coats of vapor barrier coating with a minimum total thickness of 2.0 mm (1/16 inch). The coating shall extend out onto the insulation 50.0 (2 inches) and shall seal the end of the insulation. Caulk the annular space between the outer surface of the pipe insulation and the wall penetration with an approved fire stop material having vapor retarder properties. Cover the pipe and wall penetration with a properly sized (well fitting) escutcheon plate. The escutcheon plate shall overlap the wall penetration by at least 10 mm (3/8 inch).

3.2.1.3 Pipes Passing Through Hangers

a. Insulation, whether hot or cold application, shall be continuous through hangers. All horizontal pipes 50 mm (2 inches) and smaller shall be supported on hangers with the addition of a Type 40 protection shield to protect the insulation in accordance with MSS SP-69. Whenever insulation shows signs of being compressed, or when the insulation or jacket shows visible signs of distortion at or near the support shield, insulation inserts as specified below for piping larger than 50 mm (2 inches) shall be installed.

b. Horizontal pipes larger than 50 mm (2 inches) at 16 degrees C (60 degrees F) and above shall be supported on hangers in accordance with MSS SP-69, and Section 15400 PLUMBING, GENERAL PURPOSE.

c. Horizontal pipes larger than 50 mm (2 inches) and below 16 degrees C (60 degrees F) shall be supported on hangers with the addition of a Type 40 protection shield in accordance with MSS SP-69. An insulation insert of cellular glass or calcium silicate shall be installed above each shield. The insert shall cover not less than the bottom 180 degree arc of the pipe. Inserts shall be the same thickness as the insulation, and shall extend 50 mm (2 inches) on each end beyond the protection shield. When insulation inserts are required per the above, and the insulation thickness is less than 25 mm (1 inch), wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the weight of the pipe from crushing the insulation, as an option to installing insulation inserts. The insulation jacket shall be continuous over the wooden dowel, wooden block, or insulation insert.

d. Vertical pipes shall be supported with either Type 8 or Type 42 riser clamps with the addition of two Type 40 protection shields in accordance with MSS SP-69 covering the 360 degree arc of the insulation. An insulation insert of cellular glass or calcium silicate shall be installed between each shield and the pipe. The insert shall cover the 360 degree arc of the pipe. Inserts shall be the same thickness as the insulation, and shall extend 50 mm (2 inches) on each end beyond the protection shield. When insulation inserts are required per the above, and the insulation thickness is less than 25 mm (1 inch), wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the hanger from crushing the insulation, as an option instead of installing insulation inserts. The insulation jacket shall be continuous over the wooden dowel, wooden block, or insulation insert. The vertical weight of the pipe shall be supported with hangers located in a horizontal section of the pipe. When the pipe riser is longer than 9 m (30 feet), the weight of the pipe shall be additionally supported with hangers in the vertical run of the pipe which are directly clamped to the pipe, penetrating the pipe insulation. These hangers shall be insulated and the insulation jacket sealed as indicated herein for anchors in a similar service.

e. Inserts shall be covered with a jacket material of the same appearance and quality as the adjoining pipe insulation jacket, shall overlap the adjoining pipe jacket 38 mm (1-1/2 inches), and shall be sealed as required for the pipe jacket. The jacket material used to cover inserts in flexible cellular insulation shall conform to ASTM C 1136, Type 1, and is allowed to be of a different material than the adjoining insulation material.

3.2.1.4 Flexible Cellular Pipe Insulation

Flexible cellular pipe insulation shall be tubular form for pipe sizes 150 mm (6 inches) and less. Type II sheet insulation used on pipes larger than 150 mm (6 inches) shall not be stretched around the pipe. On pipes larger than 300 mm (12 inches), adhere insulation directly to the pipe on the lower 1/3 of the pipe. Seams shall be staggered when applying multiple layers of insulation. Sweat fittings shall be insulated with miter-cut pieces the same size as on adjacent piping. Screwed fittings shall be insulated with sleeved fitting covers fabricated from miter-cut pieces and shall be overlapped and sealed to the adjacent pipe insulation.

3.2.1.5 Pipes in high abuse areas.

In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, welded PVC or stainless steel or aluminum jackets shall be utilized. Pipe insulation to the 1.8 m (6 foot) level shall be protected.

3.2.2 Aboveground Cold Pipelines

The following cold pipelines shall be insulated per Table I minus 34 degrees C to plus 16 degrees C (minus 30 degrees to plus 60 degrees F):

a. Domestic cold and chilled drinking water.

b. Make-up water.

c. Horizontal and vertical portions of interior roof drains.

d. Refrigerant suction lines.

e. Chilled water.

f. Dual temperature water, i.e. HVAC hot/chilled water.

g. Air conditioner condensate drains.

h. Brine system cryogenics

i. Exposed lavatory drains, exposed domestic water piping and drains to areas for handicap personnel.

3.2.2.1 Insulation Thickness

Insulation thickness for cold pipelines shall be determined using Table I.

LEGEND:
PF - Phenolic Foam
CG - Cellular Glass
FC - Flexible Cellular
PC - Polyisocyanurate Foam

Table I - Cold Piping Insulation Thickness

Pipe Size (mm) Type of Service	Material	Runouts up to 50 mm*	25 mm & less	30 - 50 mm	65 - 100 mm	125 - 150 mm	205 mm & larger
Refrigerant Suction Piping	CG		40	40	40	40	40
	FC		25	25	25	25	25
	PF		25	25	25	25	25
	PC		25	25	25	25	25
Chilled water supply & return & dual temp piping	CG	40	40	40	50	50	50
	FC	15	25	25	25	25	25
	PF	25	25	25	25	25	25
	PC	25	25	25	25	25	25
Cold domestic water, above and below ceilings, & make up water	CG	40	40	40	40	40	40
	FC	10	10	10	10	10	10
	PF	25	25	25	25	25	25
	PC	25	25	25	25	25	25
Exposed lavatory Drains & domestic Water lines serving Plumbing fixtures for handicap personnel	FC	15	15	15	15	20	20
Horizontal & vertical roof drain leaders (including underside of roof drain fitting)	FC		15	15	15	15	15
	PF		25	25	25	25	25
	CG		40	40	40	40	40
	PC		25	25	25	25	25
Air conditioning condensate drain located inside building	FC		10	15	15	N/A	N/A
	PF		25	25	25	N/A	N/A
	PC		25	25	25	N/A	N/A

*When runouts to terminal units exceed 3.66 m the entire length of runout shall be insulated like the main feed pipe.

Table I - Cold Piping Insulation Thickness

Pipe Size (inches)

Type of Service	Material	Runouts up to 2 in*	1 in & less	1.25 - 2 in	2.5 - 4 in	5 - 6 in	8 in & larger
Refrigerant suction piping	CG		1.5	1.5	1.5	1.5	1.5
	FC		1.0	1.0	1.0	1.0	1.0
	PF		1.0	1.0	1.0	1.0	1.0
	PC		1.0	1.0	1.0	1.0	1.0
Chilled water supply & return & dual temp piping	CG	1.5	1.5	1.5	2.0	2.0	2.0
	FC	0.5	1.0	1.0	1.0	1.0	1.0
	PF	1.0	1.0	1.0	1.0	1.0	1.0
	PC	1.0	1.0	1.0	1.0	1.0	1.0
Cold domestic water, above and below ceilings & makeup water	CG	1.5	1.5	1.5	1.5	1.5	1.5
	FC	3/8	3/8	3/8	3/8	3/8	3/8
	PF	1.0	1.0	1.0	1.0	1.0	1.0
	PC	1.0	1.0	1.0	1.0	1.0	1.0
Exposed lavatory drains & domestic water lines serving plumbing Fixtures for handicap personnel	FC	0.5	0.5	0.5	0.5	3/4	3/4
Horizontal & vertical roof drain leaders (including underside of roof drain fitting)	FC		0.5	0.5	0.5	0.5	0.5
	PF		1.0	1.0	1.0	1.0	1.0
	CG		1.5	1.5	1.5	1.5	1.5
	PC		1.0	1.0	1.0	1.0	1.0
Air conditioning condensate drain located inside building	FC		3/8	0.5	0.5	N/A	N/A
	PF		1.0	1.0	1.0	N/A	N/A
	PC		1.0	1.0	1.0	N/A	N/A

*When runouts to terminal units exceed 12 feet, the entire length of runout shall be insulated like main feed pipe.

3.2.2.2 Jacket for Mineral Fiber, Cellular Glass, Phenolic Foam, and Polyisocyanurate Foam Insulated Pipe

Insulation shall be covered with a factory applied vapor retarder jacket or field applied seal welded PVC jacket. Insulation inside the building shown to be protected with an aluminum jacket shall have the insulation and vapor retarder jacket installed as specified herein. The aluminum jacket shall be installed as specified for piping exposed to weather, except sealing of the laps of the aluminum jacket is not required. In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, aluminum jackets shall be utilized. Pipe insulation to the 1.8 m (6 ft) level will be protected.

3.2.2.3 Insulation for Straight Runs (Mineral Fiber, Cellular Glass, Phenolic Foam and Polyisocyanurate Foam)

a. Insulation shall be applied to the pipe with joints tightly butted. All butted joints and ends shall be sealed with a vapor retarder coating.

b. Longitudinal laps of the jacket material shall overlap not less than 38 mm (1-1/2 inches). Butt strips 75 mm (3 inches) wide shall be provided for circumferential joints.

c. Laps and butt strips shall be secured with adhesive and stapled on 100 mm (4 inch) centers if not factory self-sealing. If staples are used, they shall be sealed per paragraph 3.2.2.3 e.

d. Factory self-sealing lap systems may be used when the ambient temperature is between 4 degrees and 50 degrees C (40 degrees and 120 degrees F) during installation. The lap system shall be installed in accordance with manufacturer's recommendations. Stapler shall be used only if specifically recommended by the manufacturer. Where gaps occur, the section shall be replaced or the gap repaired by applying adhesive under the lap and then stapling.

e. All Staples, including those used to repair factory self-seal lap systems, shall be coated with a vapor retarder coating. All seams, except those on factory self-seal systems shall be coated with vapor retarder coating.

f. Breaks and punctures in the jacket material shall be patched by wrapping a strip of jacket material around the pipe and securing it with adhesive, stapling, and coating with vapor retarder coating. The patch shall extend not less than 38 mm (1-1/2 inches) past the break.

g. At penetrations such as thermometers, the voids in the insulation shall be filled and sealed with vapor retarder coating.

3.2.2.4 Insulation for Fittings and Accessories

a. Pipe insulation shall be tightly butted to the insulation of the fittings and accessories. The butted joints and ends shall be coated with vapor retarder coating.

b. Precut or preformed insulation shall be placed around all fittings and accessories and shall conform to MICA plates except as modified herein: 5 for anchors; 10, 11, and 13 for fittings; 14 for valves; and 17 for flanges and unions. Insulation shall be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity. Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Insulation of the same thickness and conductivity as the adjoining pipe insulation shall be used. If nesting size insulation is used, the insulation shall be overlapped 50 mm (2 inches) or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow'.

c. Upon completion of insulation installation on flanges, unions, valves, anchors, fittings and accessories, terminations, seams, joints and insulation not protected by factory vapor retarder jackets or PVC fitting covers shall be protected with two coats of vapor retarder coating with a minimum total thickness of 2.0 mm (1/16 inch), applied with glass tape embedded between coats. Tape seams shall overlap 25 mm (1 inch). The coating shall extend out onto the adjoining pipe insulation 50 mm (2 inches). Fabricated insulation with a factory vapor retarder jacket shall be protected with two coats of vapor retarder coating with a minimum thickness of 2 mm (1/16 inch) and with a 50 mm 92 inch) wide glass tape embedded between coats. Where fitting insulation butts to pipe insulation, the joints shall be sealed with a vapor retarder coating and a 100 mm (4 inch) wide ASJ tape which matches the jacket of the pipe insulation.

d. Anchors attached directly to the pipe shall be insulated for a sufficient distance to prevent condensation but not less than 150 mm (6 inches) from the insulation surface.

e. Insulation shall be marked showing the location of unions, strainers, and check valves.

3.2.2.5 Optional PVC Fitting Covers

At the option of the Contractor, premolded, one or two piece PVC fitting covers may be used in lieu of the vapor retarder and embedded glass tape. Factory precut or premolded insulation segments shall be used under the fitting covers for elbows. Insulation segments shall be the same insulation as the pipe insulation including same density, thickness, and thermal conductivity. The covers shall be secured by PVC vapor retarder tape, adhesive, seal-welding or with tacks made for securing PVC covers. Seams in the cover, and tacks and laps to adjoining pipe insulation jacket, shall be sealed with vapor retarder tape to ensure that the assembly has a continuous vapor seal.

3.2.3 Aboveground Hot Pipelines

The following hot pipelines above 16 degrees C (60 degrees F) shall be insulated per Table II:

a. Domestic hot water supply & recirculating system.

b. Steam.

c. Condensate & compressed air discharge.

d. Hot water heating.

e. Heated oil.

f. Water defrost lines in refrigerated rooms.

3.2.3.1 Insulation Thickness

Insulation thickness for hot pipelines shall be determined using Table II.

LEGEND:
PF - Phenolic Foam
CG - Cellular Glass
CS - Calcium Silicate
MF - Mineral Fiber
FC - Flexible Cellular
PL - Perlite
PC - Polyisocyanurate Foam

Table II - Hot Piping Insulation Thickness

Pipe Size (mm) Type of Service (degrees C)	Material	Runouts up to 50 mm*	25 mm & less	32 - 50 mm	65 - 100 mm	125 - 150 mm	205 mm & larger
Hot domestic	CG	40	40	40	40	40	40
water supply	FC	15	25	25	40	40	40
& recirculating	PF	15	25	25	25	25	25
system & Water	MF	15	40	40	40	40	40
defrost lines	PC	25	25	25	25	25	25
(93C max)**							
Compressed Air	CG		40	50	50	50	65
discharge steam	PF		25	25	25	25	40
& condensate	MF		40	40	50	50	65
return	CS/PL		40	50	65	65	65
(94-121 C)	PC		25	25	25	25	25
Heating hot	CG	40	40	50	50	65	80
water, supply	PF	15	25	25	25	25	40
& return, &	MF	15	40	40	50	65	80
heated oil	CS/PL	25	40	50	65	65	80
(121 C Max)	PC	25	25	25	25	25	25
Medium temp hot	CG	40	65	80	90	90	100
water & steam,	MF	40	50	65	65	80	90
& heated oil	CS/PL	40	65	65	90	90	115
(122-177C)							
High Temp Hot	CG	50	90	100	115	125	140
water & steam,	MF	40	80	90	100	100	115
& heated oil	CS/PL	50	90	100	115	125	140
(177C-260C)							

* When runouts to terminal units exceed 3.66 m, the entire length of runout shall be insulated like the main feed pipe.

** Applied to recirculating sections of service or domestic hot water systems and first 2.4 meters from storage tank for non-recirculating systems.

Table II - Hot Piping Insulation Thickness

Pipe Size (inches) Type of Service (degrees F)	Material	Runouts up to 2 in *	1 in & less	1.25 - 2 in	2.5 - 4 in	5 - 6 in	8 in & larger
Hot domestic water supply & recirculating system, & water defrost lines (200 F max)**	CG	1.5	1.5	1.5	1.5	1.5	1.5
	FC	0.5	0.5	1.0	1.0	1.5	1.5
	PF	0.5	0.5	1.0	1.0	1.0	1.0
	MF	0.5	1.5	1.5	1.5	1.5	1.5
	PC	1.0	1.0	1.0	1.0	1.0	1.0
Compressed air discharge, steam & condensate return (201-250 F)	CG		1.5	2.0	2.0	2.0	3.5
	PF		1.0	1.0	1.0	1.0	1.5
	MF		1.5	1.5	2.0	2.0	2.5
	CS/PL		1.5	2.0	2.5	2.5	3.5
	PC		1.0	1.0	1.0	1.0	1.0
Heating hot water, supply & return, & Heating oil (250 F max)	CG	1.5	1.5	2.0	2.0	2.5	3.0
	PF	0.5	1.0	1.0	1.0	1.0	1.5
	MF	0.5	1.5	1.5	2.0	2.5	3.0
	CS	1.0	1.5	2.0	2.5	2.5	3.0
	PC	1.0	1.0	1.0	1.0	1.0	1.0
Medium temp hot water & steam, & heated oil (251 - 350F)	CG	1.5	2.5	3.0	3.5	3.5	4.0
	MF	1.5	2.0	2.5	2.5	3.0	3.5
	CS/PL	1.5	2.5	2.5	3.5	3.5	4.5
High Temp Hot water & steam (351 - 500 F)	CG	2.0	3.5	4.0	4.5	5.0	5.5
	MF	1.5	3.0	3.5	4.0	4.0	4.5
	CS/PL	2.0	3.5	4.0	4.5	5.0	5.5

* When runouts to terminal units exceed 12 feet, the entire length of runout shall be insulated like the main feed pipe.

** Applies to recirculating sections of service or domestic hot water systems and first 8 feet from storage tank for non-recirculating systems.

3.2.3.2 Jacket for Insulated Hot Pipe, Except Pipe Insulated with Flexible Cellular Insulation shall be covered, in accordance with manufacturer's recommendations, with a factory applied Type II jacket or field applied aluminum where required or seal welded PVC.

3.2.3.3 Insulation for Straight Runs

a. Insulation shall be applied to the pipe with joints tightly butted.

b. Longitudinal laps of the jacket material shall overlap not less than 38 mm (1-1/2 inches), and butt strips 75 mm 3 inches wide shall be provided for circumferential joints.

c. Laps and butt strips shall be secured with adhesive and stapled on 100 mm (4 inch) centers if not factory self-sealing. Adhesive may be omitted where pipe is concealed.

d. Factory self-sealing lap systems may be used when the ambient temperature is between 4 degrees and 49 degrees C (40 degrees and 120 degrees F) and shall be installed in accordance with manufacturer's instructions. Laps and butt strips shall be stapled whenever there is nonadhesion of the system. Where gaps occur, the section shall be replaced or the gap repaired by applying adhesive under the lap and then stapling.

e. Breaks and punctures in the jacket material shall be patched by either wrapping a strip of jacket material around the pipe and securing with adhesive and staple on 100 mm (4 inch) centers (if not factory self-sealing), or patching with tape and sealing with a brush coat of vapor retarder coating. Adhesive may be omitted where pipe is concealed. Patch shall extend not less than 38 mm (1-1/2 inches) past the break.

f. Flexible cellular pipe insulation shall be installed by slitting tubular sections and applying onto piping or tubing. Alternately, whenever possible, slide unslit sections over the open ends of piping or tubing. All seams and butt joints shall be secured and sealed with adhesive. When using self seal products only the butt joints shall be secured with adhesive. Insulation shall be pushed on the pipe, never pulled. Stretching of insulation may result in open seams and joints. All edges shall be clean cut. Rough or jagged edges of the insulation shall not be permitted. Proper tools such as sharp knives shall be used. Type II sheet insulation when used on pipe larger than 150 mm (6 inches) shall not be stretched around the pipe. On pipes larger than 300 mm (12 inches), adhere sheet insulation directly to the pipe on the lower 1/3 of the pipe.

3.2.3.4 Insulation for Fittings and Accessories

a. Pipe insulation shall be tightly butted to the insulation of the fittings and accessories.

b. Precut or preformed insulation shall be placed around all fittings and accessories and shall conform to MICA plates, except as modified herein: 5 for anchors; 10, 11, 12,and 13 for fittings; 14, 15 and 16 for valves; 17 for flanges and unions; and 18 for couplings. Insulation shall be the same as the pipe insulation, including same density, thickness, and thermal conductivity. Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Insulation of the same thickness and conductivity as the adjoining pipe insulation shall be used. If nesting size insulation is used, the insulation shall be overlapped 50 mm (2 inches) or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow".

c. Upon completion of installation of insulation on flanges, unions, valves, anchors, fittings and accessories, terminations and insulation not protected by factory vapor retarder jackets or PVC fitting covers shall be protected with two coats of adhesive applied with glass tape embedded between coats. Tape seams shall overlap 25 mm (1 inch). Adhesive shall extend onto the adjoining insulation not less than 50 mm (2 inches). The total dry film thickness shall be not less than 2.0 mm (1/16 inch).

d. Insulation terminations shall be tapered to unions at a 45-degree angle.

e. At the option of the Contractor, factory premolded one- or two-piece PVC fitting covers may be used in lieu of the adhesive and embedded glass tape. Factory premolded segments or factory or field cut blanket insert insulation segments shall be used under the cover and shall be the same thickness as adjoining pipe insulation. The covers shall be secured by PVC vapor retarder tape, adhesive, seal-welding or with tacks made for securing PVC covers.

3.2.4 Piping Exposed to Weather

Piping exposed to weather shall be insulated and jacketed as specified for the applicable service inside the building. After this procedure, an aluminum jacket or PVC jacket shall be applied. PVC jacketing requires no factory applied jacket beneath it, however an all service jacket shall be applied if factory applied jacketing is not furnished. Flexible cellular insulation exposed to weather shall be treated in accordance with paragraph INSTALLATION OF FLEXIBLE CELLULAR INSULATION.

3.2.4.1 Aluminum Jacket

The jacket for hot piping may be factory applied. The jacket shall overlap not less than 50 mm (2 inches) at longitudinal and circumferential joints and shall be secured with bands at not more than 300 mm (12 inch) centers. Longitudinal joints shall be overlapped down to shed water and located at 4 or 8 o'clock positions. Joints on piping 16 degrees C (60 degrees F) and below shall be sealed with caulking while overlapping to prevent moisture penetration. Where jacketing on piping 16 degrees C (60 degrees F) and below abuts an uninsulated surface, joints shall be caulked to prevent moisture penetration. Joints on piping above 16 degrees C (60 degrees F) shall be sealed with a moisture retarder.

3.2.4.2 Insulation for Fittings

Flanges, unions, valves, fittings, and accessories shall be insulated and finished as specified for the applicable service. Two coats of breather emulsion type weatherproof mastic (impermeable to water, permeable to air) recommended by the insulation manufacturer shall be applied with glass tape embedded between coats. Tape overlaps shall be not less than 25 mm (1 inch) and the adjoining aluminum jacket not less than 50 mm (2 inches). Factory preformed aluminum jackets may be used in lieu of the above. Molded PVC fitting covers shall be provided when PVC jackets are used for straight runs of pipe. PVC fitting covers shall have adhesive welded joints and shall be weatherproof.

3.2.4.3 PVC Jacket

PVC jacket shall be ultraviolet resistant and adhesive welded weather tight with manufacturer's recommended adhesive. Installation shall include provision for thermal expansion.

3.2.5 Below ground Pipe Insulation

The following shall be included:

a. Heated oil.

b. Domestic hot water.

c. Heating hot water.

d. Dual temperature water.

e. Steam.

f. Condensate.

3.2.5.1 Type of Insulation

Below ground pipe shall be insulated with 75 mm (3 inch) cellular glass insulation set in a coat of bedding compound as recommended by the manufacturer.

3.2.5.2 Installation of Below ground Pipe Insulation

a. Bore surfaces of the insulation shall be coated with a thin coat of gypsum cement of a type recommended by the insulation manufacturer. Coating thickness shall be sufficient to fill surface cells of insulation. Mastic type materials shall not be used for this coating.

b. Stainless steel bands, 19 mm (3/4 inch) wide by 0.5080 mm (0.020 inch) thick shall be used to secure insulation in place. A minimum of two bands per section of insulation shall be applied. As an alternate, fiberglass reinforced tape may be used to secure insulation on piping up to 300 mm (12 inches) in diameter. A minimum of two bands per section of insulation shall be applied.

c. Insulation shall terminate at anchor blocks but shall be continuous through sleeves and manholes.

d. At point of entry to buildings, underground insulation shall be terminated 50 mm 2 inches inside the wall or floor, shall butt tightly against the aboveground insulation and the butt joint shall be sealed with high temperature silicone sealant.

e. Provision for expansion and contraction shall be made in accordance with the insulation manufacturer's recommendations.

f. Flanges, couplings, valves, and fittings shall be insulated with factory premolded, prefabricated, or field-fabricated sections of insulation of the same material and thickness as the adjoining pipe insulation. Insulation sections shall be secured in place with wire, bore surfaces coated, and joints sealed as specified.

g. Insulation, including fittings, shall be finished with three coats of asphaltic mastic, with 6 by 5.5 mesh synthetic reinforcing fabric embedded between coats. Fabric shall be overlapped a minimum of 50 mm (2 inches) at joints. Total film thickness shall be a minimum of 4.7 mm (3/16 inch). As an alternate, a prefabricated bituminous laminated jacket, reinforced with internal reinforcement mesh, shall be applied to the insulation. Jacketing material and application procedures shall match manufacturer's written instructions.

h. At termination points, other than building entrances, the mastic and cloth or tape shall cover the ends of insulation and extend 50 mm (2 inches) along the bare pipe.

3.3 DUCT INSULATION INSTALLATION

Except for oven hood exhaust duct insulation, corner angles shall be installed on external corners of insulation on ductwork in exposed finished spaces before covering with jacket. Duct insulation shall be omitted on exposed supply and return ducts in air conditioned spaces where the difference between supply air temperature and room air temperature is less than 9 degrees C (15 degrees F) unless otherwise shown. Air conditioned spaces shall be defined as those spaces directly supplied with cooled conditioned air (or provided with a cooling device such as a fan-coil unit) and heated conditioned air (or provided with a heating device such as a unit heater, radiator or convector).

3.3.1 Duct Insulation Thickness

Duct insulation thickness shall be in accordance with Table III.

Table III - Minimum Duct Insulation

Cold Air Ducts	50 mm (2.0 inches)
Relief Ducts	40 mm (1.5 inches)
Fresh Air Intake Ducts	40 mm (1.5 inches)
Warm Air Ducts	50 mm (2.0 inches)
Relief Ducts	40 mm (1.5 inches)
Fresh Air Intake Ducts	40 mm (1.5 inches)

Maximum thickness for flexible cellular insulation shall not exceed 25 mm (I inch), and maximum thickness for polyisocyanurate foam insulation shall not exceed 40 mm (1.5 inch) to comply with ASTM E 84 flame spread/smoke developed ratings of 25/50.

3.3.2 Insulation and Vapor Retarder for Cold Air Duct

Insulation and vapor retarder shall be provided for the following cold air ducts and associated equipment.

a. Supply ducts.

b. Return air ducts.

c. Relief ducts.

d. Flexible runouts (field-insulated).

e. Plenums.

f. Duct-mounted coil casings.

g. Coil headers and return bends.

h. Coil casings.

i. Fresh air intake ducts.

j. Filter boxes.

k. Mixing boxes (field-insulated).

l. Supply fans (field-insulated).

m. Site-erected air conditioner casings.

n. Ducts exposed to weather.

o. Combustion air intake ducts.

Insulation for rectangular ducts shall be flexible type where concealed, minimum density 12 kg per cubic meter (3/4 pcf) and rigid type where exposed, minimum density 48 kg per cubic meter (3 pcf). Insulation for round/oval ducts shall be flexible type, minimum density 12 kg per cubic meter (3/4 pcf) with a factory Type I or II jacket; or, a semi rigid board, minimum density 48 kg per cubic meter (3 pcf), formed or fabricated to a tight fit, edges beveled and joints tightly butted and staggered, with a factory applied Type I or II all service jacket. Insulation for exposed ducts shall be provided with either a white, paintable, factory-applied Type I jacket or a vapor retarder jacket coating finish as specified. Insulation on concealed duct shall be provided with a factory-applied Type I or II vapor retarder jacket. The total dry film thickness shall be approximately 2.0 mm (1/16 inch). Duct insulation shall be continuous through sleeves and prepared openings except fire wall penetrations. Duct insulation terminating at fire dampers, shall be continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air and which may be prone to condensate formation. Duct insulation and vapor retarder shall cover the collar, neck, and any uninsulated surfaces of diffusers, registers and grills. Vapor retarder materials shall be applied to form a complete unbroken vapor seal over the insulation. Sheet Metal Duct shall be sealed in accordance with SECTION 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.3.2.1 Installation on Concealed Duct

a. For rectangular, oval or round ducts, insulation shall be attached by applying adhesive around the entire perimeter of the duct in 150 mm (6 inch) wide strips on 300 mm (12 inch) centers.

b. For rectangular and oval ducts, 600 mm (24 inches) and larger insulation shall be additionally secured to bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on 400 mm (16 inch) centers and not more than 400 mm (16 inches) from duct corners.

c. For rectangular, oval and round ducts, mechanical fasteners shall be provided on sides of duct risers for all duct sizes. Fasteners shall be spaced on 400 mm (16 inch) centers and not more than 400 mm (16 inches) from duct corners.

d. Insulation shall be impaled on the mechanical fasteners (self stick pins) where used and shall be pressed thoroughly into the adhesive. Care shall be taken to ensure vapor retarder jacket joints overlap 50 mm (2 inches). The insulation shall not be compressed to a thickness less than that specified. Insulation shall be carried over standing seams and trapeze-type duct hangers.

e. Self-locking washers shall be installed where mechanical fasteners are used. The pin shall be trimmed back and bent over.

f. Jacket overlaps shall be secured with staples and tape as necessary to ensure a secure seal. Staples, tape and seams shall be coated with a brush coat of vapor retarder coating.

g. Breaks in the jacket material shall be covered with patches of the same material as the vapor retarder jacket. The patches shall extend not less than 50 mm (2 inches) beyond the break or penetration in all directions and shall be secured with tape and staples. Staples and tape joints shall be sealed with a brush coat of vapor retarder coating.

h. At jacket penetrations such as hangers, thermometers, and damper operating rods, voids in the insulation shall be filled and the penetration sealed with a brush coat of vapor retarder coating.

i. Insulation terminations and pin punctures shall be sealed and flashed with a reinforced vapor retarder coating finish or tape with a brush coat of vapor retarder coating. The coating shall overlap the adjoining insulation and uninsulated surface 50 mm (2 inches). Pin puncture coatings shall extend 50 mm (2 inches) from the puncture in all directions.

j. Where insulation standoff brackets occur, insulation shall be extended under the bracket and the jacket terminated at the bracket.

3.3.2.2 Installation on Exposed Duct Work

a. For rectangular ducts, rigid insulation shall be secured to the duct by mechanical fasteners on all four sides of the duct, spaced not more than 300 mm (12 inches) apart and not more than 75 mm (3 inches) from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct 300 mm (12 inches) and larger. One row shall be provided for each side of duct less than 300 mm (12 inches).

b. Duct insulation shall be formed with minimum jacket seams. Each piece of rigid insulation shall be fastened to the duct using mechanical fasteners. When the height of projections is less than the insulation thickness, insulation shall be brought up to standing seams, reinforcing, and other vertical projections and shall not be carried over. Vapor retarder jacket shall be continuous across seams, reinforcing, and projections. When height of projections is greater than the insulation thickness, insulation and jacket shall be carried over.

c. Insulation shall be impaled on the fasteners; self-locking washers shall be installed and the pin trimmed or bent over.

d. Joints in the insulation jacket shall be sealed with a 100 mm (4 inch) wide strip of tape. Tape seams shall be sealed with a brush coat of vapor retarder coating.

e. Breaks and ribs or standing seam penetrations in the jacket material shall be covered with a patch of the same material as the jacket. Patches shall extend not less than 50 mm (2 inches) beyond the break or penetration and shall be secured with tape and stapled. Staples and joints shall be sealed with a brush coat of vapor retarder coating.

f. At jacket penetrations such as hangers, thermometers, and damper operating rods, the voids in the insulation shall be filled and the penetrations sealed with a brush coat of vapor retarder coating.

g. Insulation terminations and pin punctures shall be sealed and flashed with a reinforced vapor retarder coating finish. The coating shall overlap the adjoining insulation and uninsulated surface 50 mm (2 inches). Pin puncture coatings shall extend 50 mm (2 inches) from the puncture in all directions.

h. Oval and round ducts, flexible type, shall be insulated with factory Type I jacket insulation with minimum density of 12 kg per cubic meter (3/4 pcf), attached as per MICA standards.

3.3.3 Insulation for Warm Air Duct

Insulation and vapor barrier shall be provided for the following warm air ducts and associated equipment:.

a. Supply ducts.

b. Return air ducts

c. Relief air ducts

d. Flexible runouts (field insulated)

e. Plenums

f. Duct-mounted coil casings

g. Coil-headers and return bends

h. Coil casings.

i. Fresh air intake ducts

j. Filter boxes

k. Mixing boxes

l. Supply fans

m. Site-erected air conditioner casings

n. Ducts exposed to weather

Insulation for rectangular ducts shall be flexible type where concealed, minimum density 12 kg per cubic meter (3/4 pcf); and rigid type where exposed, minimum density 48 kg per cubic meter (3 pcf). Insulation on exposed ducts shall be provided with a white, paintable, factory-applied Type II jacket, or finished with adhesive finish. Flexible type insulation shall be used for round ducts, minimum density 12 kg per cubic meter (3/4 pcf) with a factory-applied Type II jacket. Insulation on concealed duct shall be provided with a factory-applied Type II jacket. Adhesive finish where indicated to be used shall be accomplished by applying two coats of adhesive with a layer of glass cloth embedded between the coats. The total dry film thickness shall be approximately 2.0 mm 1/16 inch. Duct insulation shall be continuous through sleeves and prepared openings. Duct insulation shall terminate at fire dampers and flexible connections.

3.3.3.1 Installation on Concealed Duct

a. For rectangular, oval and round ducts, insulation shall be attached by applying adhesive around the entire perimeter of the duct in 150 mm (6 inch) wide strips on 300 mm (12 inch) centers.

b. For rectangular and oval ducts 600 mm (24 inches) and larger, insulation shall be secured to the bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on 450 mm (18 inch) centers and not more than 450 mm (18 inches) from duct corner.

c. For rectangular, oval and round ducts, mechanical fasteners shall be provided on sides of duct risers for all duct sizes. Fasteners shall be spaced on 450 mm (18 inch) centers and not more than 450 mm (18 inches) from duct corners.

d. The insulation shall be impaled on the mechanical fasteners where used. The insulation shall not be compressed to a thickness less than that specified. Insulation shall be carried over standing seams and trapeze-type hangers.

e. Self-locking washers shall be installed where mechanical fasteners are used and the pin trimmed and bent over.

f. Insulation jacket shall overlap not less than 50 mm 2 inches at joints and the lap shall be secured and stapled on 100 mm 4 inch centers.

3.3.3.2 Installation on Exposed Duct

a. For rectangular ducts, the rigid insulation shall be secured to the duct by the use of mechanical fasteners on all four sides of the duct, spaced not more than 400 mm (16 inches) apart and not more than 150 mm (6 inches) from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct 300 mm (12 inches) and larger and a minimum of one row for each side of duct less than 300 mm (12 inches).

b. Duct insulation with factory-applied jacket shall be formed with minimum jacket seams, and each piece of rigid insulation shall be fastened to the duct using mechanical fasteners. When the height of projection is less than the insulation thickness, insulation shall be brought up to standing seams, reinforcing, and other vertical projections and shall not be carried over the projection. Jacket shall be continuous across seams, reinforcing, and projections. Where the height of projections is greater than the insulation thickness, insulation and jacket shall be carried over the projection.

c. Insulation shall be impaled on the fasteners; self-locking washers shall be installed and pin excess clipped and bent over.

d. Joints on jacketed insulation shall be sealed with a 100 mm (4 inch) wide strip of tape and brushed with vapor retarder coating.

e. Breaks and penetrations in the jacket material shall be covered with a patch of the same material as the jacket. Patches shall extend not less than 50 mm (2 inches) beyond the break or penetration and shall be secured with adhesive and stapled.

f. Insulation terminations and pin punctures shall be sealed with tape and brushed with vapor retarder coating.

g. Oval and round ducts, flexible type, shall be insulated with factory Type I jacket insulation, minimum density of 12 kg per cubic meter (3/4 pcf) attached by staples spaced not more than 400 mm (16 inches) and not more than 150 mm (6 inches) from the degrees of joints. Joints shall be sealed in accordance with paragraph 3.3.3.2 d.

3.3.4 Ducts Handling Air for Dual Purpose

For air handling ducts for dual purpose below and above 16 degrees C (60 degrees F), ducts shall be insulated as specified for cold air duct.

3.3.5 Insulation for Evaporative Cooling Duct

Evaporative cooling supply duct located in spaces not evaporatively cooled, shall be insulated. Material and installation requirements shall be as specified for duct insulation for warm air duct.

3.3.6 Duct Test Holes

After duct systems have been tested, adjusted, and balanced, breaks in the insulation and jacket shall be repaired in accordance with the applicable section of this specification for the type of duct insulation to be repaired.

3.3.7 Duct Exposed to Weather

3.3.7.1 Installation

Ducts exposed to weather shall be insulated and finished as specified for the applicable service for exposed duct inside the building. After the above is accomplished, the insulation shall then be further finished as detailed in the following subparagraphs.

3.3.7.2 Round Duct

Aluminum jacket with factory applied moisture retarder shall be applied with the joints lapped not less than 75 mm (3 inches) and secured with bands located at circumferential laps and at not more than 300 mm (12 inch) intervals throughout. Horizontal joints shall lap down to shed water and located at 4 or 8 o'clock position. Joints shall be sealed with caulking to prevent moisture penetration. Where jacketing abuts an uninsulated surface, joints shall be sealed with caulking.

3.3.7.3 Fittings

Fittings and other irregular shapes shall be finished as specified for rectangular ducts.

3.3.7.4 Rectangular Ducts

Two coats of weather barrier mastic reinforced with fabric or mesh for outdoor application shall be applied to the entire surface. Each coat of weatherproof mastic shall be 2.0 mm (1/16) inch minimum thickness. The exterior shall be a metal jacketing applied for mechanical abuse and weather protection, and secured with screws.

3.4 EQUIPMENT INSULATION INSTALLATION

3.4.1 General

Removable insulation sections shall be provided to cover parts of equipment which must be opened periodically for maintenance including vessel covers, fasteners, flanges and accessories. Equipment insulation shall be omitted on the following:

a. Handholes.

b. Boiler manholes.

c. Cleanouts.

d. ASME stamps.

e. Manufacturer's nameplates.

3.4.2 Insulation for Cold Equipment

Cold equipment below 16 degrees C:60 degrees F: Insulation shall be furnished on equipment handling media below 16 degrees C (60 degrees F) including the following:

a. Pumps.

b. Refrigeration equipment parts that are not factory insulated.

c. Drip pans under chilled equipment.

d. Cold water storage tanks.

e. Water softeners.

f. Duct mounted coils.

g. Cold and chilled water pumps.

h. Pneumatic water tanks.

i. Roof drain bodies.

j. Air handling equipment parts that are not factory insulated.

k. Expansion and air separation tanks.

3.4.2.1 Insulation Type

Insulation shall be suitable for the temperature encountered. Thicknesses shall be as follows:

a. Equipment handling media between 2 and 16 degrees C (35 and 60 degrees F): 40 mm (1.5 inch) thick cellular glass, 25 mm (1 inch) thick flexible cellular, 25 mm (1 inch) thick phenolic foam, or 25 mm (1 inch) thick polyisocyanurate foam.

b. Equipment handling media between minus 18 degrees C and plus 1 degrees C (0 degree F and 34 degrees F): 75 mm (3 inch) thick cellular glass, 40 mm (1 1/2 inch) flexible cellular, 40 mm (1 1/2 inch) thick phenolic foam, or 40 mm (1 1/2 inch) thick polyisocyanurate foam.

c. Equipment handling media between minus 34 degrees C and minus 18 degrees C (minus 30 degrees F and 1 degree F): 90mm (3 1/2 inch) thick cellular glass 45 mm (1 3/4 inch) thick flexible cellular, 40 mm (1 1/2 inch) thick phenolic foam, or 40 mm (1 1/2 inch) thick polyisocyanurate foam.

3.4.2.2 Pump Insulation

a. Pumps shall be insulated by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints which do not leave raw ends of insulation exposed. Joints between sides and between sides and bottom shall be joined by adhesive with lap strips for rigid mineral fiber and contact adhesive for flexible cellular insulation. The box shall conform to the requirements of MICA Insulation Stds plate No. 49 when using flexible cellular insulation. Joints between top cover and sides shall fit tightly forming a female shiplap joint on the side pieces and a male joint on the top cover, thus making the top cover removable.

b. Exposed insulation corners shall be protected with corner angles.

c. Upon completion of installation of the insulation, including removable sections, two coats of vapor retarder coating shall be applied with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 2.0 mm (1/16 inch). A parting line shall be provided between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. Caulking shall be applied to parting line, between equipment and removable section insulation, and at all penetrations.

3.4.2.3 Other Equipment

a. Insulation shall be formed or fabricated to fit the equipment. To ensure a tight fit on round equipment, edges shall be beveled and joints shall be tightly butted and staggered.

b. Insulation shall be secured in place with bands or wires at intervals as recommended by the manufacturer but not more than 300 mm (12 inch) centers except flexible cellular which shall be adhered. Insulation corners shall be protected under wires and bands with suitable corner angles.

c. Cellular glass and phenolic foam insulation shall be set in a coating of bedding compound, and joints shall be sealed with bedding compound as recommended by the manufacturer.

d. Insulation on heads of heat exchangers shall be removable. Removable section joints shall be fabricated using a male-female shiplap type joint. The entire surface of the removable section shall be finished by applying two coats of vapor retarder coating with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 2.0 mm (1/16 inch).

e. Exposed insulation corners shall be protected with corner angles.

f. Insulation on equipment with ribs shall be applied over 150 x 150 mm (6 x 6 inches) by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot welded to the equipment over the ribs. Insulation shall be secured to the fabric with J-hooks and 50 x 50 mm (2 x 2 inches) washers or shall be securely banded or wired in place on 300 mm (12 inch) centers.

3.4.2.4 Vapor Retarder

Upon completion of installation of insulation, penetrations shall be caulked. Two coats of vapor retarder coating shall be applied over insulation, including removable sections, with a layer of open mesh synthetic fabric embedded between the coats. The total dry thickness of the finish shall be 2.0 mm (1/16 inch). Caulking shall be applied to parting line between equipment and removable section insulation.

3.4.3 Insulation for Hot Equipment

Insulation shall be furnished on equipment handling media above 16 degrees C (60 degrees F) including the following:

a. Converters.

b. Heat exchangers.

c. Hot water generators.

d. Water heaters.

e. Pumps handling media above 54 degrees C. 130 degrees F.

f. Fuel oil heaters.

g. Hot water storage tanks.

h. Air separation tanks.

i. Surge tanks.

j. Flash tanks.

k. Feedwater heaters.

l. Unjacketed boilers or parts of boilers.

m. Boiler flue gas connection from boiler to stack (if inside).

n. Induced draft fans.

o. Fly ash and soot collectors.

p. Condensate receivers.

3.4.3.1 Insulation

Insulation shall be suitable for the temperature encountered. Shell and tube-type heat exchangers shall be insulated for the temperature of the shell medium. Insulation thickness for hot equipment shall be determined using Table IV:

Legend
RMF: Rigid Mineral Fiber
FMF: Flexible Mineral Fiber
CS: Calcium Silicate
PL: Perlite
CG: Cellular Glass
FC: Flexible Cellular
PF: Phenolic Foam
PC: Polyisocyanurate Foam

TABLE IV

Insulation Thickness for Hot Equipment

Equipment handling steam or other media to indicated pressure or temperature limit:	Material	Thickness
103.4 kPa (15 psig) or 121 C (250 F)	RMF	50 mm (2.0 inches)
	FMF	50 mm (2.0 inches)
	CS/PL	100 mm (4.0 inches)
	CG	75 mm (3.0 inches)
	PF	40 mm (1.5 inches)
	FC (<93 C/200 F)	25 mm (1.0 inches)
	PC	25 mm (1.0 inches)
1379.0kPa (200 psig) or 204 C (400 F)	RMF	75 mm (3.0 inches)
	FMF	75 mm (3.0 inches)
	CS/PL	100 mm (4.0 inches)
	CG	100 mm (4.0 inches)
316 C (600 F)	RMF	125 mm (5.0 inches)
	FMF	150 mm (6.0 inches)
	CS/PL	150 mm (6.0 inches)
	CG	150 mm (6.0 inches)

316 C (600 F): Thickness necessary to limit the external temperature of the insulation to 50 C (120 F), except that diesel engine exhaust piping and mufflers shall be covered with 150 mm (6 inch) thick material suitable for 650 degrees C (1200 degrees F) service. Heat transfer calculations shall be submitted to substantiate insulation and thickness selection.

3.4.3.2 Insulation of Pumps

Pumps shall be insulated by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints which do not leave raw ends of insulation exposed. Bottom and sides shall be banded to form a rigid housing which does not rest on the pump. Joints between top cover and sides shall fit tightly. The top cover shall have a joint forming a female shiplap joint on the side pieces and a male joint on the top cover, making the top cover removable. Two coats of Class I adhesive shall be applied over insulation, including removable sections, with a layer of glass cloth embedded between the coats. A parting line shall be provided between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. The total dry thickness of the finish shall be 2.0 mm. 1/16 inch. Caulking shall be applied to parting line of the removable sections and penetrations.

3.4.3.3 Other Equipment

a. Insulation shall be formed or fabricated to fit the equipment. To ensure a tight fit on round equipment, edges shall be beveled and joints shall be tightly butted and staggered.

b. Insulation shall be secured in place with bands or wires at intervals as recommended by the manufacturer but not greater than 300 mm (12 inch) centers except flexible cellular which shall be adhered. Insulation corners shall be protected under wires and bands with suitable corner angles.

c. On high vibration equipment, cellular glass insulation shall be set in a coating of bedding compound as recommended by the manufacturer, and joints shall be sealed with bedding compound. Mineral fiber joints shall be filled with finishing cement.

d. Insulation on heads of heat exchangers shall be removable. The removable section joint shall be fabricated using a male-female shiplap type joint. Entire surface of the removable section shall be finished as specified.

e. Exposed insulation corners shall be protected with corner angles.

f. On equipment with ribs, such as boiler flue gas connection, draft fans, and fly ash or soot collectors, insulation shall be applied over 150 x 150 mm (6 x 6 inch by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot welded to the equipment over the ribs. Insulation shall be secured to the fabric with J-hooks and 50 x 50 mm (2 x 2 inch) washers or shall be securely banded or wired in place on 300 mm (12 inch) (maximum) centers.

g. On equipment handling media above 316 degrees C (600 degrees F), insulation shall be applied in two or more layers with joints staggered.

h. Upon completion of installation of insulation, penetrations shall be caulked. Two coats of adhesive shall be applied over insulation, including removable sections, with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 2.0 mm (1/16 inch). Caulking shall be applied to parting line between equipment and removable section insulation.

3.4.4 Equipment Handling Dual Temperature Media

Below and above 16 degrees C (60 degrees F): equipment handling dual temperature media shall be insulated as specified for cold equipment.

3.4.5 Equipment Exposed to Weather

3.4.5.1 Installation

Equipment exposed to weather shall be insulated and finished in accordance with the requirements for ducts exposed to weather in paragraph DUCT INSULATION INSTALLATION.

3.4.5.2 Optional Panels

At the option of the Contractor, prefabricated metal insulation panels may be used in lieu of the insulation and finish previously specified. Thermal performance shall be equal to or better than that specified for field applied insulation. Panels shall be the standard catalog product of a manufacturer of metal insulation panels. Fastenings, flashing, and support system shall conform to published recommendations of the manufacturer for weatherproof installation and shall prevent moisture from entering the insulation. Panels shall be designed to accommodate thermal expansion and to support a 1112 N (250 pound) walking load without permanent deformation or permanent damage to the insulation. Exterior metal cover sheet shall be aluminum and exposed fastenings shall be stainless steel or aluminum.

SECTION 15181

CHILLED, CONDENSER, OR DUAL SERVICE WATER PIPING

TABLE OF CONTENTS

PAGE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.22	(1999) Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM B 32	(1996) Solder Metal
ASTM D 3308	(1997) PTFE Resin Skived Tape
ASTM D 520	(2000) Zinc Dust Pigment
ASTM E 84	(2000a) Surface Burning Characteristics of Building Materials
ASTM F 1199	(1988; R 1998) Cast (All Temperature and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003	(1995) Water Pressure Reducing Valves for Domestic Water Supply Systems
ASSE 1017	(1986) Temperature Actuated Mixing Valves for Primary Domestic use

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8	(1992) Filler Metals for Brazing and Braze Welding
AWS Brazing Hdbk	(1991) Brazing Handbook
AWS D1.1	(2000) Structural Welding Code – Steel
AWS Z49.1	(1999) Safety in Welding and Cutting

ASME INTERNATIONAL (ASME)

ASME B31.1	(1998) Power Piping
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type – Elastic Element
ASME BPVC SEC IX	(1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.5	(1994) Centrifugal Pumps

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1993) Pipe Hangers and Supports - Materials, Design and Manufacture

MSS SP-69	(1996) Pipe Hangers and Supports - Selection and Application

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1997) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(1998) Motors and Generators
NEMA MG 2	(1989) Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(1999) Installation of Air Conditioning and Ventilating Systems

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 0222	(1987) Taper Pipe Threads
KS B 1004	(1990) Square Head Bolts
KS B 1006	(1975) Hole Sizes Before Threading
KS B 1503	(1999) Steel welding pipe flanges
KS B 1527	(2001) Pipe Supports
KS B 1531	(1997) Screwed Type Malleable Cast Iron Pipe Fittings
KS B 1536	(1986) Bellows Type Expansion Pipe Joints
KS B 1541	(1992) Steel But-Welding Pipe Fittings
KS B 1542	(1990) Steel Socket-Welding Pipe Fittings
KS B 1543	(1986) Steel Plate But-Welding Pipe Fittings
KS B 1544	(2001) Copper Alloy Solder-Joint Fittings
KS B 2301	(1999) Bronze Gate, Globe, Angle, and Check Valves
KS B 2308	(2002) Ball Valve
KS B 2330	(1985) Floating Valves for Waterworks
KS B 2335	(2000) Plug Valve
KS B 2350	(2002) Gray Cast-Iron Valves

KS B 2813 (1998) Wafer Type Rubber - Seated Butterfly Valves

KS D 3503 (1998) Rolled Steels for General Structure

KS D 3506 (2001) Hot-Dip Zinc-Coated Steel Sheets and Coils

KS D 3562 (1989) Carbon Steel Pipes for Pressure Service

KS D 5301 (2001) Copper And Copper Alloy Seamless Pipes and Tubes

KS D 5578 (2000) Pipe Fittings of Copper and Copper Alloys

KS D 6704 (2001) Soft Solder

KS D 8319 (1989) Silver Brazing Filler Metals

KS M 3520 (2001) Unsintered Polytetrafluoroethylene Tapes for Thread Sealing

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Piping System; G

Drawings, at least 5 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

a. Piping layouts which identify all valves and fittings.

b. Plans and elevations which identify clearances required for maintenance and operation.

SD-03 Product Data

Piping System; G

Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. Data shall be provided for the following components as a minimum:

a. Piping and Fittings

b. Valves and Accessories

c. Expansion Joints

d. Pumps

e. Expansion Tanks

f. Air Separator Tanks

g. Pipe Hangers, Inserts, and Supports

Spare Parts

Spare parts data for each different item of equipment specified, after approval of detail drawings and not later than 1 month prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Qualifications

Six copies of qualified procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations.

Field Tests

A schedule, at least 2 weeks prior to the start of related testing, for each test. The schedules shall identify the proposed date, time, and location for each test.

Demonstrations

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

Verification of Dimensions

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

SD-06 Test Reports

Field Tests; G

Six copies of the report shall be provided in bound 216 x 279 mm (8 1/2 x 11 inch) booklets. Reports shall document all phases of the tests performed. The report shall include initial test summaries, all repairs/adjustments made, and the final test results.

SD-07 Certificates

Service Organization; G

A certified list of qualified permanent service organizations, which includes their addresses and qualifications, for support of the equipment. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

SD-10 Operation and Maintenance Data

Operation Manuals; G

Six complete copies of an operation manual in bound 216 x 279 mm (8-1/2 x 11 inch) booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Maintenance Manuals; G

Six complete copies of maintenance manual in bound 216 x 279 (8-1/2 x 11 inch) booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping layouts and simplified wiring and control diagrams of the system as installed.

1.3 QUALIFICATIONS

Piping shall be welded in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made, as a permanent record. Structural members shall be welded in accordance with Section 05090 WELDING, STRUCTURAL.

1.4 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

1.5 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the

Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.6.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including pumps, pump motors, expansion tanks, and air separator tanks shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of anodized aluminum or stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics shall be as shown, and unless otherwise indicated, all motors of 746 kW (1 hp) and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.4 PIPING SYSTEM

System design, component selection, and system installation, including pressure containing parts and material, shall be based upon a minimum service pressure of 862 kPa (125 psi) at 66 degrees C (150 degrees F); minimum Class 125/Class 10K. Chilled, condenser, and dual service (hot and cold) water piping shall be steel pipe with the exception that piping 100 mm (4 inches) and smaller may be copper tubing.

2.5 STEEL PIPE

Steel pipe shall conform to KS D 3562, Schedule 40.

2.5.1 Fittings and End Connections (Joints)

Fittings and end connections shall be as defined herein, except as identified elsewhere. Piping and fittings 25 mm (1 inch) and smaller shall have threaded connections. Piping and fittings larger than 25 mm (1 inch) and smaller than 80 mm (3 inches) shall have either threaded or welded connections. Piping and fittings 80 mm (3 inches) and larger shall have welded or flanged connections.

2.5.1.1 Threaded Connections

Threaded valves and pipe connections shall conform to KS B 0222. Threaded fitting shall conform to KS B 1531.

2.5.1.2 Flanged Connections

Flanges shall conform to KS B 1503, Class 10K. Gaskets shall be nonasbestos compressed material, 1.59 mm (1/16 inch) thickness, full face or self-centering flat ring type. These gaskets shall contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). Bolts, nuts, and bolt patterns shall conform to KS B 1004 or KS B 1006. Bolts shall be high or intermediate strength material conforming to KS D 3503.

2.5.1.3 Welded Connections

Butt-welded fittings shall conform to KS B 1541 or KS B 1543. Socket-welded fittings shall conform to KS B 1542. Welded fittings shall be identified with the appropriate grade and marking symbol.

2.5.1.4 Dielectric Waterways and Flanges

Dielectric waterways shall have a water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint. When dry, insulation barrier shall be able to withstand a 600-volt breakdown test. Dielectric waterways shall be constructed of galvanized steel and have threaded end connections to match connecting piping. Dielectric waterways shall be suitable for the required operating pressures and temperatures. Dielectric flanges shall provide the same pressure ratings as standard flanges and provide complete electrical isolation between connecting pipe and/or equipment as described herein for dielectric waterways.

2.6 COPPER PIPE

Copper pipe shall conform to KS D 5301, Type K or L.

2.6.1 Fittings and End Connections (Joints)

Wrought copper and bronze solder-joint pressure fittings shall conform to KS D 5578. Cast copper alloy solder-joint pressure fittings shall conform to KS B 1544. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

2.6.2 Solder

Solder shall conform to ASTM B 32 or KS D 6704, grade Sb5, tin-antimony alloy for service pressures up to 1034 kPa (150 psig). Solder flux shall be liquid form, non-corrosive, and shall be formulated to ensure the soldering of the joints is simple to carry out and that defective joints are prevented. The flux shall not contain more than 0.2 % lead.

2.6.3 Brazing Filler Metal

Filler metal shall conform to AWS A5.8 or KS D 8319, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.7 VALVES

Valves shall meet the material, fabrication and operating requirements of Korean Industrial Standards (KS). Chain operators shall be provided for valves located 3 m (10 feet) or higher above the floor.

2.7.1 Gate Valve

Gate valves 65 mm (2-1/2 inches) and smaller shall conform to KS B 2301 and shall be bronze with rising stem and threaded, soldered, or flanged ends. Gate valves 80 mm (3 inches) and larger shall conform to KS B 2350, Class 10K and shall be gray cast iron with bronze trim, outside screw and yoke, and flanged ends.

2.7.2 Globe and Angle Valve

Globe and angle valves 65 mm (2-1/2 inches) and smaller shall conform to KS B 2301 and shall be bronze with threaded, soldered, or flanged ends. Globe and angle valves 80 mm (3 inches) and larger shall conform to KS B 2350, Class 10K and shall be gray cast iron with bronze trim and flanged ends.

2.7.3 Check Valve

Check valves 65 mm (2-1/2 inches) and smaller shall conform to KS B 2301 and shall be bronze with threaded, soldered, or flanged ends. Check valves 80 mm (3 inches) and larger shall conform to KS B 2350, Class 10K and shall be gray cast iron with bronze trim and flanged ends.

2.7.4 Butterfly Valve

Butterfly valves shall be in accordance with KS B 2813, Class 10K and shall be the wafer type. Valves shall be bubble tight at 1,000 kPa (150 psig). Valve bodies shall be cast iron, malleable iron, or steel. Valves smaller than 200 mm (8 inches) shall have throttling handles with a minimum of seven locking positions. Valves 200 mm (8 inches) and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Valves in insulated lines shall have extended neck to accommodate insulation thickness.

2.7.5 Plug Valve

Plug valves 50 mm (2 inches) and larger shall conform to KS B 2335, have flanged or threaded ends, and have cast iron bodies with bronze trim. Valves 50 mm (2 inches) and smaller shall be bronze with NPT connections for black steel pipe and brazed connections for copper tubing. Valve shall be lubricated, non-lubricated, or tetrafluoroethylene resin-coated type. Valve shall be resilient, double seated, trunnion mounted with tapered lift plug capable of 2-way shutoff. Valve shall operate from fully open to fully closed by rotation of the handwheel to lift and turn the plug. Valve shall a weatherproof operators with mechanical position indicators. Valves 200 mm (8 inches) or larger shall be provided with manual gear operators with position indicators.

2.7.6 Ball Valve

Ball valves 15 mm (1/2 inch) and larger shall conform to KS B 2308, Class 10K and shall be ductile iron or bronze with threaded, soldered, or flanged ends. Valves 200 mm (8 inches) or larger shall be provided with manual gear operators with position indicators.

2.7.7 Calibrated Balancing Valve

Valve shall be calibrated so that flow can be determined when the temperature and pressure differential across valve is known. Valve shall have an integral pointer which registers the degree of valve opening. Valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation. Valve's Cv rating shall be as indicated. Valve bodies shall be provided with tapped openings and pipe extensions with positive shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential. One portable differential meter, suitable for the operating pressure specified, shall be provided. The meter shall be complete with hoses, vent, integral metering connections, and carrying case as recommended by the valve manufacturer.

2.7.8 Automatic Flow Control Valve

Valve shall automatically maintain a constant flow as indicated. Valve shall modulate by sensing the pressure differential across the valve body. Valve shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Valve shall control the flow within 5 percent of the tag rating. Valve materials shall be the same as specified for the ball or plug valves. Valve Cv rating shall be as indicated. Valve operators shall be the electric or pneumatic type as indicated. Valve shall be capable of positive shutoff against the system pump head, valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings and differential meter, suitable for the operating pressure specified. The meter shall be complete with hoses, vent, integral metering connections, and carrying case as recommended by the valve manufacturer.

2.7.9 Pump Discharge Valve

Valve shall shall perform the functions of a nonslam check valve, a manual balancing valve, and a shutoff. Valve shall be of cast iron or ductile iron construction with bronze and/or stainless steel accessories. Valve shall have an integral pointer which registers the degree of valve opening. Flow through the valve shall be manually adjustable from bubble tight shutoff to full flow. Valves smaller than 50 mm (2 inches) shall have NPT connections. Valves 50 mm (2 inches) and larger shall have flanged end connections. Valve design shall allow the back seat for the stem to be replaced in the field under full line pressure. Valve's Cv rating shall be as indicated.

2.7.10 Temperature-Mixing Valve

Valve shall be in accordance with ASSE 1017 for water service.

2.7.11 Pressure-Reducing Valve

Valve shall be in accordance with ASSE 1003 for water service.

2.7.12 Pressure Relief Valve

Valve shall prevent excessive pressure in the piping system when the piping system reaches its maximum heat buildup. Valve shall be in accordance with ANSI Z21.22 and shall have cast iron bodies with corrosion resistant internal working parts. The discharge pipe from the relief valve shall be the size of the valve outlet unless otherwise indicated.

2.7.13 Float Valve

Valve shall be in accordance with KS B 2330. Where float rods are extended for tank applications, extension shall be properly supported and guided to avoid bending of float rod or stressing of valve pilot linkage.

2.7.14 Drain Valves

Valves shall be the gate valve type which are in accordance with KS B 2301. Valve shall be manually-operated, 20 mm (3/4 inch) pipe size and above with a threaded end connection. Valve shall be provided with a water hose nipple adapter. Frost-free type valves shall be provided in installations exposed to freezing temperatures.

2.7.15 Air Vents

Manually-operated general service type air vents shall be brass or bronze valves which are furnished with threaded plugs or caps. Automatic type air vents shall be the ball-float type with brass/bronze or brass bodies, 300 series corrosion-resistant steel float, linkage and removable seat. Air vents on water coils shall have not less than 3 mm (1/8 inch) threaded end connections. Air vents on water mains shall have not less than 20 mm (3/4 inch) threaded end connections. Air vents on all other applications shall have not less than 15 mm (1/2 inch) threaded end connections.

2.8 PIPING ACCESSORIES

2.8.1 Strainer

Strainer shall be the cleanable, basket or "Y" type, Class 10K, the same size as the pipeline. Strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. The bodies shall have arrows clearly cast on the sides indicating the direction of flow. Strainer shall be equipped with removable cover and sediment screen. The screen shall be made of minimum 0.8 mm (22 gauge) brass sheet, monel, or corrosion-resistant steel, with small perforations numbering not less than 60 per square centimeter (400 per square inch) to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.8.2 Combination Strainer and Suction Diffuser

Unit shall consist of an angle type body with removable strainer basket and straightening vanes, a suction pipe support, and a blowdown outlet. Strainer shall be in accordance with ASTM F 1199, except as modified herein. Unit body shall have arrows clearly cast on the sides indicating the direction of flow. Strainer screen shall be made of minimum 0.8 mm (22 gauge) brass sheet, monel, or corrosion-resistant steel, with small perforations numbering not less than

60 per square centimeter (400 per square inch) to provide a net free area through the basket of at least 3.30 times that of the entering pipe. Flow shall be into the screen and out through the perforations.

2.8.3 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 862 kPa (125 psig) service as appropriate for the static head plus the system head. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. The flexible section shall be suitable for intended service with end connections to match adjacent piping. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Covers to protect the bellows shall be provided where indicated.

2.8.4 Pressure and Vacuum Gauges

Gauges shall conform to ASME B40.1 and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 85 mm (3-1/2 inches) in diameter with a range from 0 kPa (0 psig) to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.8.5 Temperature Gauges

Temperature gauges shall be the industrial duty type and be provided for the required temperature range. Gauges shall have Fahrenheit scale in 2 degree graduations scale (black numbers) on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 1.5 m (5 feet) of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 1.5 to 2.1 m (5 to 7 feet) above the finished floor. Remote element type temperature gauges shall be provided in thermal wells located 2.1 m (7 feet) above the finished floor.

2.8.5.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 229 mm (9 inches) long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.8.5.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 89 mm (3-1/2 inches), stainless steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment. Accuracy shall be one percent of dial range.

2.8.5.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 89 mm (3-1/2 inches), stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.8.5.4 Thermal Well

Thermal well shall be identical size, 15 or 20 mm (1/2 or 3/4 inch) NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 15 mm (1/2 inch) NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury shall not be used in thermometers. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 25 mm (1 inch).

2.8.6 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, guides, and supports shall conform to MSS SP-58, MSS SP-69 and KS B 1527.

2.8.7 Escutcheons

Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.8.8 Expansion Joints

Expansion joints shall be flexible, guided bellows type. Bellows expansion type joints shall be in accordance with KS B 1536, Class 10K with Type 304 stainless steel corrugated bellows, reinforced with equalizing rings, internal sleeves, and external protective covers. Joint end connections shall be flanged or beveled for welding. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint.

2.9 PUMPS

Pumps shall be the electrically driven, non-overloading, centrifugal type which conform to HI 1.1-1.5. Pump capacity, efficiency, motor size, and impeller type shall be as indicated on the drawings. Pumps shall be selected at or within 5 percent of peak efficiency. Pump curve shall rise continuously from maximum capacity to shutoff. Pump motor shall conform to NEMA MG 1, be open, splash-proof or totally enclosed, and have sufficient wattage (horsepower) for the service required. Pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in the cover.

2.9.1 Construction

Shaft seal shall be mechanical-seal or stuffing-box type. Impeller shall be statically and dynamically balanced. Each pump casing shall be designed to withstand the discharge head specified plus the static head on system plus 50 percent of the total, but not less than 862 kPa (125 psig). Pump casing and bearing housing shall be close grained cast iron. High points in the casing shall be provided with manual air vents; low points shall be provided with drain plugs. Impeller, impeller wearing rings, glands, casing wear rings, and shaft sleeve shall be bronze. Shaft shall be carbon or alloy steel, turned and ground. Bearings shall be ball-bearings, roller-bearings, or oil-lubricated bronze-sleeve type bearings, and be efficiently sealed or isolated to prevent loss of oil or entrance of dirt or water. Pump and motor shall be mounted on a common cast iron base having lipped edges and tapped drainage openings or structural steel base with lipped edges or drain pan and tapped drainage openings. Pump shall be provided with shaft coupling guard. Close coupled pumps shall be provided with drip pockets and tapped openings. Pump motor shall have the required capacity to prevent overloading with pump operating at any point on its characteristic curve. Pump speed shall not exceed 3,600 rpm, except where the pump head is less than 180 kPa (60 feet) of water, the pump speed shall not exceed 1,750 rpm. Pump shall be accessible for servicing without disturbing piping connections.

2.9.2 Mechanical Shaft Seals

Seals shall be single, inside mounted, end-face-elastomer bellows type with stainless steel spring, brass or stainless steel seal head, carbon rotating face, and tungsten carbide or ceramic sealing face. Glands shall be bronze and of the water-flush design to provide lubrication flush across the face of the seal. Bypass line from pump discharge to flush connection in gland shall be provided, with filter or cyclone separator in line.

2.9.3 Stuffing-Box Type Seals

Stuffing box shall include minimum 4 rows of square, impregnated TFE (Teflon) or graphite cord packing and a bronze split-lantern ring. Packing gland shall be bronze interlocking split type.

2.10 EXPANSION TANKS

Tank shall be welded steel, constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 862 kPa 125 psig and precharged to the minimum operating pressure. Tank shall have a replaceable diaphragm and be the captive air type. Tanks shall accommodate expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. Each tank air chamber shall be fitted with a drain, fill, an air charging valve, and system connections. Tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The only air in the system shall be the permanent sealed-in air cushion contained within the expansion tank.

2.11 AIR SEPARATOR TANKS

External air separation tank shall have an internal design suitable for creating the required vortex and subsequent air separation. Tank shall be steel, constructed, tested, and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 862 kPa (125 psig). Tank shall have tangential inlets and outlets connections, threaded for 50 mm (2 inches) and smaller and flanged for sizes 65 mm (2 1/2 inches) and larger. Air released from a tank shall be to the atmosphere or vented as indicated. Tank shall be provided with a blow-down connection.

2.12 CHEMICAL SHOT FEEDER

A shot feeder shall be provided as indicated. Size and capacity of feeder shall be based on local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.13 FABRICATION

2.13.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B 117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm (1/8 inch) on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

2.13.2 Factory Applied Insulation

Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E 84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E 84.

2.14 SUPPLEMENTAL COMPONENTS/SERVICES

2.14.1 Drain and Make-Up Water Piping

Piping and backflow preventers shall comply with the requirements of Section 15400 PLUMBING, GENERAL PURPOSE. Drains which connect to sanitary sewer system shall be connected by means of an indirect waste.

2.14.2 Field Applied Insulation

Field applied insulation shall be provided and installed in accordance with Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

PART 3 EXECUTION

3.1 INSTALLATION

Pipe and fitting installation shall conform to the requirements of ASME B31.1. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

3.1.1 Directional Changes

Changes in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) and smaller will be permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees will not be permitted. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted.

3.1.2 Functional Requirements

Horizontal supply mains shall pitch down in the direction of flow as indicated. The grade shall not be less than 2 mm in 1 m (1 inch in 40 feet). Reducing fittings shall be used for changes in pipe sizes. Open ends of pipelines and equipment shall be capped or plugged during installation to keep dirt or other foreign materials out of the system. Pipe not otherwise specified shall be uncoated. Connections to appliances shall be made with malleable iron unions for steel pipe 65 mm (2-1/2 inches) or less in diameter, and with flanges for pipe 80 mm (3 inches) and above in diameter. Connections between ferrous and copper piping shall be electrically isolated from each other with dielectric waterways or flanges. Piping located in air plenums shall conform to NFPA 90A requirements. Pipe and fittings installed in inaccessible conduits or trenches under concrete floor slabs shall be welded. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance. Electric isolation fittings shall be provided between dissimilar metals.

3.1.3 Fittings and End Connections

3.1.3.1 Threaded Connections

Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with ASTM D 3308, KS M 3520, or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.3.2 Brazed Connections

Brazing shall be performed in accordance with AWS Brazing Hdbk, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Piping shall be supported prior to brazing and not be sprung or forced.

3.1.3.3 Welded Connections

Branch connections shall be made with welding tees or forged welding branch outlets. Pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding, the pipe and fittings shall be filled with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1 or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.3.4 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.1.3.5 Flanges and Unions

Except where copper tubing is used, union or flanged joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for the intended application.

3.1.4 Valves

Isolation gate or ball valves shall be installed on each side of each piece of equipment, at the midpoint of all looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purpose. Isolation valves may be omitted where balancing cocks are installed to provide both balancing and isolation functions. Each valve except check valves shall be identified. Valves in horizontal lines shall be installed with stems horizontal or above.

3.1.5 Air Vents

Air vents shall be provided at all high points, on all water coils, and where indicated to ensure adequate venting of the piping system.

3.1.6 Drains

Drains shall be provided at all low points and where indicated to ensure complete drainage of the piping. Drains shall be accessible, and shall consist of nipples and caps or plugged tees unless otherwise indicated.

3.1.7 Flexible Pipe Connectors

Connectors shall be attached to components in strict accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the flexible pipe connector manufacturer and shall be provided at the intervals recommended.

3.1.8 Temperature Gauges

Temperature gauges shall be located on coolant supply and return piping at each heat exchanger, on condenser water piping entering and leaving a condenser, at each automatic temperature control device without an integral thermometer, and where indicated or required for proper operation of equipment. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 25 mm (1 inch).

3.1.9 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58, MSS SP-69 and KS B 1527, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.1.9.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.1.9.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.1.9.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.1.9.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.1.9.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 100 mm (4 inches) and larger when the temperature of the medium is 16 degrees C (60 degrees F) or higher. Type 40 shields shall be used on all piping less than 100 mm (4 inches) and all piping 100 mm (4 inches) and larger carrying medium less than 16 degrees C (60 degrees F). A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 50 mm (2 inches) and larger.

3.1.9.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm (1 foot) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1.5 m (5 feet) apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 23 kg (50 pounds) shall have the excess hanger loads suspended from panel points.

3.1.9.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4.5 m (15 feet), not more than 2.4 m (8 feet) from end of risers, and at vent terminations.

3.1.9.8 Pipe Guides

Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.1.9.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) and larger, a Type 39 saddle shall be used. On piping under 100 mm (4 inches) a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.1.9.10 High Temperature Guides with Cradles

Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm (4 inches), or by an amount adequate for the insulation, whichever is greater.

3.1.9.11 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.1.9.12 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material used for support shall be as specified under Section 05120 STRUCTURAL STEEL.

3.1.10 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 1.5 m (5 feet) on each side of each expansion joint, and in lines 100 mm (4 inches) or smaller not more than 600 mm (2 feet) on each side of the joint.

3.1.11 Pipe Anchors

Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Detailed drawings of pipe anchors shall be submitted for approval before installation.

3.1.12 Building Surface Penetrations

Sleeves shall not be installed in structural members except where indicated or approved. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to KS D 3506, Coating Class Z-27, 1.0 mm (20 gauge). Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to KS D 3562, Schedule 40. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 13 mm (1/2 inch) depth. Sleeves shall not be installed in structural members.

3.1.12.1 Refrigerated Space

Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Integral cast-in collar type sleeve shall be flashed as indicated. Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than 100 mm (4 inches) of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.1.12.2 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of 6.35 mm (1/4 inch) all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07900 JOINT SEALING.

3.1.12.3 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a 5.17 kg/sq. m. (17 ounce) copper sleeve, or a 0.81 mm (0.032 inch) thick aluminum sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 200 mm (8 inches) from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 50 mm (2 inches) above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproofing Clamping Flange: Pipes up to and including 250 mm (10 inches) in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal rubber sealing elements to expand and provide a watertight seal between the pipe/conduit seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.1.12.4 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07840 FIRESTOPPING.

3.1.12.5 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.1.13 Pumps

Support, anchor, and guide so that no strains are imposed on pump by weight or thermal movement of piping. Air vents on pump casings shall be provided. Drain outlets on pump bases shall be piped to the nearest floor or other acceptable drains, with necessary clean-out tees.

3.1.14 Access Panels

Access panels shall be provided for all concealed valves, vents, controls, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05500A MISCELLANEOUS METAL.

3.1.15 Field Applied Insulation

Field installed insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.16 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09900 PAINTING, GENERAL.

3.1.16.1 Color Coding

Color coding for piping identification is specified in Section 09900 PAINTING, GENERAL.

3.1.16.2 Color Coding Scheme

A color coding scheme for locating hidden piping shall be in accordance with Section 15400 PLUMBING, GENERAL PURPOSE.

3.2 CLEANING AND ADJUSTING

Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. A temporary bypass shall be provided for all water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from all water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed.

3.3 FIELD TESTS

Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. The services of a qualified technician shall be provided as required to perform all tests and procedures indicated herein. Field tests shall be coordinated with Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.3.1 Hydrostatic Tests

Following the cleaning procedures defined above, all chilled and condenser water piping systems shall be hydrostatically tested as defined herein. Unless otherwise agreed by the Contracting Officer, water (or glycol solution) shall be the test medium.

3.3.1.1 Equipment and Component Isolation

Prior to testing, equipment and components that cannot withstand the test pressure shall be properly isolated.

3.3.1.2 Tests

Piping shall be hydrostatically tested at a pressure equal to 150 percent of the total system operating pressure for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Test pressure shall be monitored by a calibrated, test pressure gauge. Leaks shall be repaired and piping retested until test is successful. No loss of pressure shall be allowed. Leaks shall be repaired by rewelding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before concealing.

3.3.2 Backflow Prevention Assemblies Tests

Backflow prevention assemblies shall be tested in accordance with Section 15400 PLUMBING, GENERAL PURPOSE.

3.4 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 24 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

SECTION 15182

REFRIGERANT PIPING

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 710 (1995) Liquid-Line Driers

ARI 720 (1997) Refrigerant Access Valves and Hose Connectors

ARI 750 (1994) Thermostatic Refrigerant Expansion Valves

ARI 760 (1994) Solenoid Valves for Use With Volatile Refrigerants

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM B 280	(1999) Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B 32	(1996) Solder Metal
ASTM B 813	(2000) Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube
ASTM D 3308	(1997) PTFE Resin Skived Tape
ASTM D 520	(2000) Zinc Dust Pigment
ASTM E 84	(2000a) Surface Burning Characteristics of Building Materials

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(1994) Safety Code for Mechanical Refrigeration
ASHRAE 17	(1998) Method of Testing for Capacity Rating of Thermostatic Refrigerant Expansion Valves

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8	(1992) Filler Metals for Brazing and Braze Welding
AWS Brazing Hdbk	(1991) Brazing Handbook
AWS D1.1	(2000) Structural Welding Code – Steel
AWS Z49.1	(1999) Safety in Welding and Cutting

ASME INTERNATIONAL (ASME)

ASME B31.1	(1998) Power Piping
ASME B31.5	(1992; B31.5a1994) Refrigeration Piping
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type – Elastic Element
ASME BPVC SEC IX	(1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1993) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(1996) Pipe Hangers and Supports - Selection and Application

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 0222	(1987) Taper Pipe Threads
KS B 1004	(1990) Square Head Bolts
KS B 1006	(1975) Hole Sizes Before Threading
KS B 1503	(1999) Steel welding pipe flanges
KS B 1527	(2001) Pipe Supports
KS B 1531	(1997) Screwed Type Malleable Cast Iron Pipe Fittings
KS B 1537	(1997) Flare Type and Brazing Type Fittings for Refrigerants
KS B 1541	(1992) Steel But-Welding Pipe Fittings
KS B 1542	(1990) Steel Socket-Welding Pipe Fittings
KS B 1543	(1986) Steel Plate But-Welding Pipe Fittings
KS D 3506	(2001) Hot-Dip Zinc-Coated Steel Sheets and Coils
KS D 3562	(1989) Carbon Steel Pipes for Pressure Service
KS D 3571	(1990) Steel Heat Exchanger Tubes for Low Temperature Service
KS D 5578	(2000) Pipe Fittings of Copper and Copper Alloys
KS D 6704	(2001) Soft Solder
KS D 8319	(1989) Silver Brazing Filler Metals
KS M 3520	(2001) Unsintered Polytetrafluoroethylene Tapes for Thread Sealing

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Refrigerant Piping System; G

Drawings, at least 5 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

a. Piping layouts which identify all valves and fittings.

b. Plans and elevations which identify clearances required for maintenance and operation.

SD-03 Product Data

Refrigerant Piping System; G

Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. Data shall be provided for the following components as a minimum:

a. Piping and Fittings

b. Valves

c. Piping Accessories

d Pipe Hangers, Inserts, and Supports

Spare Parts

Spare parts data for each different item of equipment specified, after approval of detail drawings and not later than 1 month prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Qualifications

Four copies of qualified procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations.

Refrigerant Piping Tests

A schedule, at least 2 weeks prior to the start of related testing, for each test. The schedules shall identify the proposed date, time, and location for each test.

Demonstrations

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

Verification of Dimensions

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

SD-06 Test Reports

Refrigerant Piping Tests; G

Six copies of the report shall be provided in bound 216 x 279 mm (8 1/2 x 11 inch) booklets. Reports shall document all phases of the tests performed. The report shall include initial test summaries, all repairs/adjustments made, and the final test results.

SD-07 Certificates

Service Organization; G

A certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

SD-10 Operation and Maintenance Data

Operation Manuals; G

Six complete copies of an operation manual in bound 216 x 279 (81/2 x 11 inch) booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Maintenance Manuals; G

Six complete copies of maintenance manual in bound 216 x 279 (81/2 x 11 inch) booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping layouts and simplified wiring and control diagrams of the system as installed.

1.3 QUALIFICATIONS

Piping shall be welded in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made, as a permanent record. Structural members shall be welded in accordance with Section 05090 WELDING, STRUCTURAL.

1.4 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

1.5 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.6.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 ELECTRICAL WORK

Electrical equipment and wiring shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Field wiring shall be in accordance with manufacturer's instructions. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.3 REFRIGERANT PIPING SYSTEM

Refrigerant piping, valves, fittings, and accessories shall be in accordance with ASHRAE 15 and ASME B31.5, except as specified herein. Refrigerant piping, valves, fittings, and accessories shall be compatible with the fluids used and capable of withstanding the pressures and temperatures of the service. Refrigerant piping, valves, and accessories used for refrigerant service shall be cleaned, dehydrated, and sealed (capped or plugged) prior to shipment from the manufacturer's plant.

2.4 PIPE, FITTINGS AND END CONNECTIONS (JOINTS)

2.4.1 Steel Pipe

Steel pipe for refrigerant service shall conform to KS D 3562, Schedule 40.

2.4.1.1 Welded Fittings and Connections

Butt-welded fittings shall conform to KS B 1541 or KS B 1543. Socket-welded fittings shall conform to KS B 1542. Welded fittings shall be identified with the appropriate grade and marking symbol.

2.4.1.2 Threaded Fittings and Connections

Threaded fitting shall conform to KS B 1531. Threaded valves and pipe connections shall conform to KS B 0222.

2.4.1.3 Flanged Fittings and Connections

Flanges shall conform to KS B 1503, Class 10K. Gaskets shall be nonasbestos compressed material, 1.59 mm (1/16 inch) thickness, full face or self-centering flat ring type. These gaskets shall contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). Bolts, nuts, and bolt patterns shall conform to KS B 1004 or KS B 1006. Bolts shall be high or intermediate strength material conforming to KS D 3503.

2.4.2 Steel Tubing

Tubing shall be cold-rolled, electric-forged, welded-steel in accordance with KS D 3571. Joints and fittings shall be socket type provided by the steel tubing manufacturer.

2.4.3 Copper Tubing

Copper tubing shall conform to ASTM B 280 annealed or hard drawn as required. Copper tubing shall be soft annealed where bending is required and hard drawn where no bending is required. Soft annealed copper tubing shall not be used in sizes larger than 35 mm (1-3/8 inches). Joints shall be brazed except that joints on lines 22 mm (7/8 inch) and smaller may be flared. Cast copper alloy fittings for flared copper tube shall conform to KS B 1537. Wrought copper and bronze solder-joint pressure fittings shall conform to KS D 5578. Joints and fittings for brazed joint shall be wrought-copper or forged-brass sweat fittings. Cast sweat-type joints and fittings shall not be allowed for brazed joints. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

2.4.4 Solder

Solder shall conform to ASTM B 32 or KS D 6704, grade Sb5, tin-antimony alloy for service pressures up to 1034 kPa (150 psig). Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B 813.

2.4.5 Brazing Filler Metal

Filler metal shall conform to AWS A5.8 or KS D 8319, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.5 VALVES

Valves shall be designed, manufactured, and tested specifically for refrigerant service. Valve bodies shall be of brass, bronze, steel, or ductile iron construction. Valves 25 mm (1 inch) and smaller shall have brazed or socket welded connections. Valves larger than 25 mm (1 inch) shall have tongue-and-groove flanged or butt welded end connections. Threaded end connections shall not be used, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Internal parts shall be removable for inspection or replacement without applying heat or breaking pipe connections. Valve stems exposed to the atmosphere shall be stainless steel or corrosion resistant metal plated carbon steel. Direction of flow shall be legibly and permanently indicated on the valve body. Control valve inlets shall be fitted with integral or adapted strainer or filter where recommended or required by the manufacturer. Purge, charge and receiver valves shall be of manufacturer's standard configuration.

2.5.1 Refrigerant Stop Valves

Valve shall be the globe or full-port ball type with a back-seating stem especially packed for refrigerant service. Valve packing shall be replaceable under line pressure. Valve shall be provided with a handwheel or wrench operator and a seal cap. Valve shall be the straight or angle pattern design as indicated.

2.5.2 Check Valves

Valve shall be the swing or lift type as required to provide positive shutoff at the differential pressure indicated. Valve shall be provide with resilient seat.

2.5.3 Liquid Solenoid Valves

Valves shall comply with ARI 760 and be suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions. Valves shall be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions shall be furnished. Solenoid coils shall be moisture-proof, UL approved, totally encapsulated or encapsulated and metal jacketed as required. Valves shall have safe working pressure of 2760 kPa (400 psi) and a maximum operating pressure differential of at least 1375 kPa (200 psi) at 85 percent rated voltage. Valves shall have an operating pressure differential suitable for the refrigerant used.

2.5.4 Expansion Valves

Valve shall conform to ARI 750 and ASHRAE 17. Valve shall be the diaphragm and spring-loaded type with internal or external equalizers, and bulb and capillary tubing. Valve shall be provided with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 1 degrees C (2 degrees F) of saturated suction temperature at evaporator conditions. Bulb charge shall be determined by the manufacturer for the application and such that liquid will remain in the bulb at all operating conditions. Gas limited liquid charged valves and other valve devices for limiting evaporator pressure shall not be used without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body. Pilot-operated valves shall have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. An isolatable pressure gauge shall be provided in the pilot line, at the main valve. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicted or for constant evaporator loads.

2.5.5 Safety Relief Valves

Valve shall be the two-way type, unless indicated otherwise. Valve shall bear the ASME code symbol. Valve capacity shall be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve shall be of an automatically reseating design after activation.

2.5.6 Evaporator Pressure Regulators, Direct-Acting

Valve shall include a diaphragm/spring assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 1 degrees C (2 degrees F) change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.

2.5.7 Refrigerant Access Valves

Refrigerant access valves and hose connections shall be in accordance with ARI 720.

2.6 PIPING ACCESSORIES

2.6.1 Filter Driers

Driers shall conform to ARI 710. Sizes 15 mm (5/8 inch) and larger shall be the full flow, replaceable core type. Sizes 15 mm (1/2 inch) and smaller shall be the sealed type. Cores shall be of suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant. Filter driers shall be constructed so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 10.3 Mpa (1.500 psi).

2.6.2 Sight Glass and Liquid Level Indicator

2.6.2.1 Assembly and Components

Assembly shall be pressure- and temperature-rated and constructed of materials suitable for the service. Glass shall be borosilicate type. Ferrous components subject to condensation shall be electro-galvanized.

2.6.2.2 Gauge Glass

Gauge glass shall include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

2.6.2.3 Bull's-Eye and Inline Sight Glass Reflex Lens

Bull's-eye and inline sight glass reflex lens shall be provided for dead-end liquid service. For pipe line mounting, two plain lenses in one body suitable for backlighted viewing shall be provided.

2.6.2.4 Moisture Indicator

Indicator shall be a self-reversible action, moisture reactive, color changing media. Indicator shall be furnished with full-color-printing tag containing color, moisture and temperature criteria. Unless otherwise indicated, the moisture indicator shall be an integral part of each corresponding sight glass.

2.6.3 Vibration Dampeners

Dampeners shall be of the all-metallic bellows and woven-wire type.

2.6.4 Flexible Pipe Connectors

Connector shall be a composite of interior corrugated phosphor bronze or Type 300 Series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly shall be constructed with a safety factor of not less than 4 at 150 degrees C (300 degrees F). Unless otherwise indicated, the length of a flexible connector shall be as recommended by the manufacturer for the service intended.

2.6.5 Strainers

Strainers used in refrigerant service shall have brass or cast iron body, Y-or angle-pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than ten times the pipe diameter with pressure rating compatible with the refrigerant service. Screens shall be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

2.6.6 Pressure and Vacuum Gauges

Gauges shall conform to ASME B40.1 and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 85 mm (3-1/2 inches) in diameter with a range from 0 kPa (0 psig) to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.6.7 Temperature Gauges

Temperature gauges shall be the industrial duty type and be provided for the required temperature range. Gauges shall have Fahrenheit scale in 2 degree graduations scale (black numbers) on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 1.5 m (5 feet) of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 1.5 to 2.1 m (5 to 7 feet) above the finished floor. Remote element type temperature gauges shall be provided in thermal wells located 2.1 m (7 feet) above the finished floor.

2.6.7.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 229 mm (9 inches) long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.6.7.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 89 mm (3-1/2 inches), stainless steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment. Accuracy shall be one percent of dial range.

2.6.7.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 89 mm (3-1/2 inches), stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.6.7.4 Thermal Well

Thermal well shall be identical size, 15 or 20 mm (1/2 or 3/4 inch) NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 15 mm (1/2 inch) NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury shall not be used in thermometers. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 25 mm (1 inch).

2.6.8 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, guides, and supports shall conform to MSS SP-58, MSS SP-69 and KS B 1527.

2.6.9 Escutcheons

Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.7 FABRICATION

2.7.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B 117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm (1/8 inch) on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

2.7.2 Factory Applied Insulation

Refrigerant suction lines between the cooler and each compressor shall be insulated with not less than 19 mm (3/4 inch) thick unicellular plastic foam. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E 84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E 84.

2.8 SUPPLEMENTAL COMPONENTS/SERVICES

2.8.1 Field Applied Insulation

Field applied insulation shall be provided and installed in accordance with Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

PART 3 EXECUTION

3.1 INSTALLATION

Pipe and fitting installation shall conform to the requirements of ASME B31.1. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

3.1.1 Directional Changes

Changes in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) and smaller will be permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees will not be permitted. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted.

3.1.2 Functional Requirements

Piping shall be installed 4 mm per m (1/2 inch per 10 feet) of pipe in the direction of flow to ensure adequate oil drainage. Open ends of refrigerant lines or equipment shall be properly capped or plugged during installation to keep moisture, dirt, or other foreign material out of the system. Piping shall remain capped until installation. Equipment piping shall be in accordance with the equipment manufacturer's recommendations and the contract drawings. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance.

3.1.3 Fittings and End Connections

3.1.3.1 Threaded Connections

Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with ASTM D 3308, KS M 3520, or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.3.2 Brazed Connections

Brazing shall be performed in accordance with AWS Brazing Hdbk, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Joints in steel tubing shall be painted with the same material as the baked-on coating within 8 hours after joints are made. Tubing shall be protected against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Piping shall be supported prior to brazing and not be sprung or forced.

3.1.3.3 Welded Connections

Welded joints in steel refrigerant piping shall be fusion-welded. Branch connections shall be made with welding tees or forged welding branch outlets. Pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding the pipe and fittings shall be filled with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1 or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.3.4 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.1.3.5 Flanged Connections

When steel refrigerant piping is used, union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment requiring maintenance, such as compressors, coils, chillers, control valves, and other similar items. Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for use with the refrigerants to be handled.

3.1.4 Valves

3.1.4.1 General

Refrigerant stop valves shall be installed on each side of each piece of equipment such as compressors condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Stop valves shall be installed with stems horizontal unless otherwise indicated. Ball valves shall be installed with stems positioned to facilitate operation and maintenance. Isolating valves for pressure gauges and switches shall be external to thermal insulation. Safety switches shall not be fitted with isolation valves. Filter dryers having access ports may be considered a point of isolation. Purge valves shall be provided at all points of systems where accumulated noncondensible gases would prevent proper system operation. Valves shall be furnished to match line size, unless otherwise indicated or approved.

3.1.4.2 Expansion Valves

Expansion valves shall be installed with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 54 mm (2-1/8 inches) in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 54 mm (2-1/8 inches). The bulb shall be securely fastened with two clamps. The bulb shall be insulated. The bulb shall installed in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb must be installed in a vertical line, the bulb tubing shall be facing up.

3.1.4.3 Valve Identification

Each system valve, including those which are part of a factory assembly, shall be tagged. Tags shall be in alphanumeric sequence, progressing in direction of fluid flow. Tags shall be embossed, engraved, or stamped plastic or nonferrous metal of various shapes, sized approximately 34 mm (1-3/8 inch) diameter, or equivalent dimension, substantially attached to a component or immediately adjacent thereto. Tags shall be attached with nonferrous, heavy duty, bead or link chain, 14 gauge annealed wire, nylon cable bands or as approved. Tag numbers shall be referenced in Operation and Maintenance Manuals and system diagrams.

3.1.5 Vibration Dampers

Vibration damper shall be provided in the suction and discharge lines on spring mounted compressors. Vibration dampers shall be installed parallel with the shaft of the compressor and shall be anchored firmly at the upstream end on the suction line and the downstream end in the discharge line.

3.1.6 Strainers

Strainers shall be provided immediately ahead of solenoid valves and expansion devices. Strainers may be an integral part of an expansion valve.

3.1.7 Filter Dryer

A liquid line filter dryer shall be provided on each refrigerant circuit located such that all liquid refrigerant passes through a filter dryer. Dryers shall be sized in accordance with the manufacturer's recommendations for the system in which it is installed. Dryers shall be installed such that it can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Dryers shall be installed in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

3.1.8 Sight Glass

A moisture indicating sight glass shall be installed in all refrigerant circuits down stream of all filter dryers and where indicated. Site glasses shall be full line size.

3.1.9 Discharge Line Oil Separator

Discharge line oil separator shall be provided in the discharge line from each compressor. Oil return line shall be connected to the compressor as recommended by the compressor manufacturer.

3.1.10 Accumulator

Accumulators shall be provided in the suction line to each compressor, having extended refrigerant lines, 15 m (50 feet) or longer.

3.1.11 Flexible Pipe Connectors

Connectors shall be installed perpendicular to line of motion being isolated. Piping for equipment with bidirectional motion shall be fitted with two flexible connectors, in perpendicular planes. Reinforced elastomer flexible connectors shall be installed in accordance with manufacturer's instructions. Piping guides and restraints related to flexible connectors shall be provided as required.

3.1.12 Temperature Gauges

Temperature gauges shall be located specifically on, but not limited to the following: the sensing element of each automatic temperature control device where a thermometer is not an integral part thereof, the liquid line leaving a receiver and the suction line at each evaporator or liquid cooler. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 25 mm (1 inch).

3.1.13 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58, MSS SP-69 and KS B 1527, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.1.13.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.1.13.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.1.13.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.1.13.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.1.13.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 100 mm (4 inches) and larger when the temperature of the medium is 16 degrees C (60 degrees F) or higher. Type 40 shields shall be used on all piping less than 100 mm (4 inches) and all piping 100 mm (4 inches) and larger carrying medium less than 16 degrees C (60 degrees F). A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 50 mm (2 inches) and larger.

3.1.13.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm (1 foot) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1.5 m (5 feet) apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 23 kg (50 pounds) shall have the excess hanger loads suspended from panel points.

3.1.13.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4.5 m (15 feet), not more than 2.4 m (8 feet) from end of risers, and at vent terminations.

3.1.13.8 Pipe Guides

Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.1.13.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) and larger, a Type 39 saddle shall be used. On piping under 100 mm (4 inches) a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.1.13.10 High Temperature Guides with Cradles

Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm (4 inches), or by an amount adequate for the insulation, whichever is greater.

3.1.13.11 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.1.13.12 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material used for support shall be as specified under Section 05120 STRUCTURAL STEEL.

3.1.13 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 1.5 m (5 feet) on each side of each expansion joint, and in lines 100 mm (4 inches) or smaller not more than 600 mm (2 feet) on each side of the joint.

3.1.14 Pipe Anchors

Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Detailed drawings of pipe anchors shall be submitted for approval before installation.

3.1.15 Building Surface Penetrations

Sleeves shall not be installed in structural members except where indicated or approved. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to KS D 3506, Coating Class Z-27, 1.0 mm (20 gauge). Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to KS D 3562, Schedule 40. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 13 mm (1/2 inch) depth. Sleeves shall not be installed in structural members.

3.1.16.1 Refrigerated Space

Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Integral cast-in collar type sleeve shall be flashed with not less than 100 mm (4 inches) of cold side vapor barrier overlap of sleeve surface. Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than 100 mm (4 inches) of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.1.16.2 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of 6.35 mm (1/4 inch) all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07900 JOINT SEALING.

3.1.16.3 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a 5.17 kg/sq. m. (17 ounce) copper sleeve, or a 0.81 mm (0.032 inch) thick aluminum sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 200 mm 8 inches from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 50 mm (2 inches) above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproofing Clamping Flange: Pipes up to and including 250 mm (10 inches) in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal rubber sealing elements to expand and provide a watertight seal between the pipe/conduit seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.1.16.4 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07840 FIRESTOPPING.

3.1.16.5 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.1.17 Access Panels

Access panels shall be provided for all concealed valves, vents, controls, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05500 MISCELLANEOUS METAL.

3.1.18 Field Applied Insulation

Field installed insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.19 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09900 PAINTING, GENERAL.

3.1.19.1 Color Coding

Color coding for piping identification is specified in Section 09900 PAINTING, GENERAL.

3.1.19.2 Color Coding Scheme

A color coding scheme for locating hidden piping shall be in accordance with Section 15400 PLUMBING, GENERAL PURPOSE.

3.2 CLEANING AND ADJUSTING

Clean uncontaminated system(s) by evacuation and purging procedures currently recommended by refrigerant and refrigerant equipment manufacturers, and as specified herein, to remove small amounts of air and moisture. Systems containing moderate amounts of air, moisture, contaminated refrigerant, or any foreign matter shall be considered contaminated systems. Restoring contaminated systems to clean condition including disassembly, component replacement, evacuation, flushing, purging, and re-charging, shall be performed using currently approved refrigerant and refrigeration manufacturer's procedures. Restoring contaminated systems shall be at no additional cost to the Government as determined by the Contracting Officer. Water shall not be used in any procedure or test.

3.3 REFRIGERANT PIPING TESTS

After all components of the refrigerant system have been installed and connected, the entire refrigeration system (except packaged, unitary equipment which is charged at the factory) shall be subjected to pneumatic, evacuation, and startup tests as described herein. Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. The services of a qualified technician shall be provided as required to perform all tests and procedures indicated herein. Field tests shall be coordinated with Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.3.1 Preliminary Procedures

Prior to pneumatic testing, equipment which has been factory tested and refrigerant charged as well as equipment which could be damaged or cause personnel injury by imposed test pressure, positive or negative, shall be isolated from the test pressure or removed from the system. Safety relief valves and rupture discs, where not part of factory sealed systems, shall be removed and openings capped or plugged.

3.3.2 Pneumatic Test

Pressure control and excess pressure protection shall be provided at the source of test pressure. Valves shall be wide open, except those leading to the atmosphere. Test gas shall be dry nitrogen, with minus 55 degrees C (minus 70 degree F) dewpoint and less than 5 ppm oil. Test pressure shall be applied in two stages before any refrigerant pipe is insulated or covered. First stage test shall be at 69 kPa (10 psi) with every joint being tested with a thick soap or color indicating solution. Second stage tests shall raise the system to the minimum refrigerant leakage test pressure specified in ASHRAE 15 with a maximum test pressure 25 percent greater. Pressure above 690 KPa (100 psig) shall be raised in 10 percent increments with a pressure acclimatizing period between increments. The initial test pressure shall be recorded along with the ambient temperature to which the system is exposed. Final test pressures of the second stage shall be maintained on the system for a minimum of 24 hours. At the end of the 24 hour period, the system pressure will be recorded along with the ambient temperature to which the system is exposed. A correction factor of 2 kPa (0.3 psi) will be allowed for each degree C (F) change between test space initial and final ambient temperature, plus for increase and minus for a decrease. If the corrected system pressure is not exactly equal to the initial system test pressure, then the system shall be investigated for leaking joints. To repair leaks, the joint shall be taken apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, remelting, or back-welding/brazing shall not be acceptable. Following repair, the entire system shall be retested using the pneumatic tests described above. The entire system shall be reassembled once the pneumatic tests are satisfactorily completed.

3.3.3 Evacuation Test

Following satisfactory completion of the pneumatic tests, the pressure shall be relieved and the entire system shall be evacuated to an absolute pressure of 300 micrometers. During evacuation of the system, the ambient temperature shall be higher than 2 degrees C (35 degrees F). No more than one system shall be evacuated at one time by one vacuum pump. Once the desired vacuum has been reached, the vacuum line shall be closed and the system shall stand for 1 hour. If the pressure rises over 500 micrometers after the 1 hour period, then the system shall be evacuated again down to 300 micrometers and let set for another 1 hour period. The system shall not be charged until a vacuum of at least 500 micrometers is maintained for a period of 1 hour without the assistance of a vacuum line. If during the testing the pressure continues to rise, check the system for leaks, repair as required, and repeat the evacuation procedure. During evacuation, pressures shall be recorded by a thermocouple-type, electronic-type, or a calibrated-micrometer type gauge.

3.3.4 System Charging and Startup Test

Following satisfactory completion of the evacuation tests, the system shall be charged with the required amount of refrigerant by raising pressure to normal operating pressure and in accordance with manufacturer's procedures. Following charging, the system shall operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. The entire system shall be tested for leaks. Fluorocarbon systems shall be tested with halide torch or electronic leak detectors.

3.3.5 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. Under no circumstances shall the refrigerant be discharged into the atmosphere.

3.3.6 Contractor's Responsibility

The Contractor shall, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 85 g (3 ounces) of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year shall be repaired in accordance with the requirements herein at no cost to the Government including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.4 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 24 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

SECTION 15400

PLUMBING, GENERAL PURPOSE

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 700	(1999) Specifications for Fluorocarbon and Other Refrigerants
ARI 1010	(1994) Self-Contained, Mechanically Refrigerated Drinking-Water Coolers

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.10.1	(1998; Z21.10.1a; Z21.10.1b; Z21.10.1c) Gas Water Heaters Vol. I, Storage Water Heaters with Input Ratings of 75,000 Btu Per Hour or Less
ANSI Z21.10.3	(1998) Gas Water Heaters Vol.III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous Water Heaters
ANSI Z21.22	(1999) Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems
ANSI Z21.56	(1994; Z21.56a) Gas-Fired Pool Heaters
ANSI A117.1	(1998) ICC/ANSI A117.1 (Guidelines for Access Usable Buildings and Facilities)
ANSI Z124.5	(1997) Plastic Toilet (Water Closets) Seats
ANSI Z358.1	(1998) Emergency Eyewash and Shower Equipment

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 111/111M	(1998e1) Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM B 32	(2000) Solder Metal
ASTM B 75/75M	(1999) Seamless Copper Tube
ASTM B 813	(2000) Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube
ASTM C 920	(2002) Elastomeric Joint Sealants
ASTM D 3308	(2001) PTFE Resin Skived Tape

ASTM E 1	(2001) ASTM Thermometers

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 34	(2001; Errata 2002) Number Designation and Safety Classification of Refrigerants
ASHRAE 90.1	(2001; Errata 2002) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1001	(2002) Pipe Applied Atmospheric Type Vacuum Breakers
ASSE 1002	(1999) Anti-siphon Fill Valves (Ballcocks) for Water Closet Flush Tanks
ASSE 1003	(2001) Water Pressure Reducing Valves
ASSE 1005	(1999) Water Heater Drain Valves
ASSE 1006	(1986) Residential Use Dishwashers
ASSE 1011	(1993) Hose Connection Vacuum Breakers
ASSE 1012	(1993) Backflow Preventers with Intermediate Atmospheric Vent
ASSE 1013	(1999) Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers
ASSE 1018	(2001) Trap Seal Primer Valves, Water Supply Fed
ASSE 1020	(1998) Pressure Vacuum Breaker Assembly
ASSE 1037	(1990; Rev thru Mar 1990) Pressurized Flushing Devices (Flushometers) for Plumbing Fixtures

AMERICAN WATER WORKS ASSOCIATION(AWWA)

AWWA B300	(1999) Hypochlorites
AWWA B301	(1999) Liquid Chlorine
AWWA C700	(1995) Cold-Water Meters - Displacement Type, Bronze Main Case
AWWA C701	(1988) Cold-Water Meters - Turbine Type, for Customer Service
AWWA D100	(1996) Welded Steel Tanks for Water Storage

AWWA EWW	(1998) Standard Methods for the Examination of Water and Wastewater
AWWA M20	(1973) Manual: Water Chlorination Principles and Practices

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8	(1992) Filler Metals for Brazing and Braze Welding
AWS B2.2	(1991) Brazing Procedure and Performance Qualification

ASME INTERNATIONAL (ASME)

ASME A112.1.2	(1991; R 1998) Air Gaps in Plumbing Systems
ASME A112.14.1	(1975; R 1998)Backwater Valves
ASME A112.18.1M	(2000) Plumbing Fixture Fittings
ASME A112.19.2M	(1998) Vitreous China Plumbing Fixtures
ASME A112.19.3M	(2001) Stainless Steel Fixtures (Designed for Residential Use)
ASME A112.19.4M	(1994; R 1999) Porcelain Enameled Formed Steel Plumbing Fixtures
ASME A112.6.1M	(1997) Floor Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use
ASME B31.1	(2001) Power Piping
ASME B31.5	(2001) Refrigeration Piping and Heat Transfer Components
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element
ASME BPVC SEC VIII D1	(2001) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage
ASME BPVC SEC IX	(2001) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME CSD-1	(2002) Control and Safety Devices for Automatically Fired Boilers

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(1994; R 1995) Copper Tube Handbook

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR-CCC Manual-9	(9th Edition) Manual of Cross-Connection Control

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.5 (1994) Centrifugal Nomenclature

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1 (1998) Accessible and Usable Buildings and Facilities

ICC International Plumbing Code (2000)International Plumbing Code

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58 (1993) Pipe Hangers and Supports - Materials, Design and Manufacture

MSS SP-69 (1996) Pipe Hangers and Supports - Selection and Application

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (1997)Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31 (2001) Installation of Oil Burning Equipment

NFPA 54 (1999) National Fuel Gas Code

NFPA 90A (1999) Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF 14 (2002) Plastics Piping Components and Related Materials

NSF 3 (2001) Commercial Warewashing Equipment

NSF 5 (2002e) Water Heaters, Hot Water Supply Boilers, and Heat Recovery Equipment

NSF 61 (1999;2001 Addendum 1 - Sep 2001) Drinking Water System Components - Health Effects

PLASTIC PIPE AND FITTINGS ASSOCIATION (PPFA)

PPFA-01 (1998) Plastic Pipe in Fire Resistive Construction

PLUMBING AND DRAINAGE INSTITUTE (PDI)

PDI G 101 (1996) Testing and Rating Procedure for Grease Interceptors with Appendix of Sizing and Installation Data

PDI WH 201 (1992) Water Hammer Arresters

PLUMBING-HEATING-COOLING CONTRACTORS NATIONAL ASSOCIATION (PHCC)

NAPHCC Plumbing Code (2000) National Standard Plumbing Code

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-240	(Rev A; Canc. Notice 1) Shower Head, Ball Joint
CID A-A-50012	(Basic) Garbage Disposal Machine,Commercial

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 430 Energy Conservation Program for Consumer Products

UNDERWRITERS LABORATORIES (UL)

UL 174	(1996; Rev thru Oct 1999) Household Electric Storage Tank Water Heaters
UL 430	(1994; Rev thru Mar 2001) Waste Disposers
UL 732	(1995; Rev thru Jan 1999) Oil-Fired Storage Tank Water Heaters
UL 749	(1997; Rev thru Feb 1999) Household Dishwashers
UL 921	(1996; Rev thru Mar 2000) Commercial Electric Dishwashers

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 0222	(1987) Taper Pipe Threads
KS B 1503	(1999) Steel Welding Pipe Flanges
KS B 1527	(2001) Pipe Supports
KS B 1531	(1997) Screwed Type Malleable Cast Iron Pipe Fitting
KS B 1544	(2001) Copper Alloy Solder-Joint Fittings
KS B 1565	(1992) Floor Drain
KS B 2301	(1999) Bronze Gate, Globe, Angle, and Check Valves
KS B 2308	(2002) Ball Valve
KS B 2333	(1995) Butterfly Valves for Water Works
KS B 2350	(2002) Gray Cast-Iron Valves
KS B 2371	(1997) Screwed Bronze Plug Cocks and Gland Cocks
KS D 3503	(1998) Rolled Steel for General Structural Purpose

KS D 3521	(1991) Steel Plates for Pressure Vessels for Intermediate Temperature Service
KS D 3562	(1989) Carbon Steel Pipes for Pressure Service
KS D 3710	(2001) Carbon Steel Forging
KS D 4307	(1999) Cast-Iron Soil Pipe and Fittings
KS D 5201	(2001) Copper and Copper Alloy-Sheets, Plates, Strip and Coiled Sheets
KS D 5301	(2001) Copper and Copper Alloy Seamless Pipes and Tubes
KS D 5578	(2000) Pipe Fittings of Copper and Copper Alloys
KS D 6704	(2001) Soft Solder
KS D 8050	(1988) Copper Phosphorus Brazing Filler Metal
KS D 9201	(1992) Coupling for Hubless Cast-Iron Soil Pipe
KS F 4522	(1997) Roof Drains
KS F 4806	(1997) Bathtubs
KS L 1551	(1994) Sanitary Wares
KS M 2201	(2002) Asphalt Cement for Use in Pavement Construction
KS M 3006	(1993) Determination of Tensile Properties of Plastics
KS M 3088	(1994) Testing Methods for Water Vapor Transmission Rate of Plastic Film and Sheeting (Instrument Method)
KS M 3404	(2001) Unplasticized Polyvinyl Chloride Pipes for General Service
KS M 3409	(1976) Adhesives of Rigid Polyvinyl Chloride Pipe
KS M 3410	(1997) Unplasticized Polyvinyl Chloride Pipe Fittings for Drain
KS M 3501	(1997) Rigid Polyvinyl Chloride plates
KS M 3520	(2001) Unsintered Polytetrafluoroethylene Tapes for Thread Sealing

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Plumbing System; G

Detail drawings consisting of illustrations, schedules, performance charts, instructions, brochures, diagrams, and other information to illustrate the requirements and operations of each system. Detail drawings for the complete plumbing system including piping layouts and locations of connections; dimensions for roughing-in, foundation, and support points; schematic diagrams and wiring diagrams or connection and interconnection diagrams. Detail drawings shall indicate clearances required for maintenance and operation. Where piping and equipment are to be supported other than as indicated, details shall include loadings and proposed support methods. Mechanical drawing plans, elevations, views, and details, shall be drawn to scale.

Electrical Work; G

Complete electrical schematic lineless or full line interconnection and connection diagram for each piece of mechanical equipment having more than one automatic or manual electrical control device.

SD-03 Product Data

Welding

A copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators.

Plumbing Fixture Schedule; G

Catalog cuts of specified plumbing fixtures, valves, related piping system and system location where installed.

Vibration-Absorbing Features; G

Details of vibration-absorbing features, including arrangement, foundation plan, dimensions and specifications.

Plumbing System; G

Diagrams, instructions, and other sheets proposed for posting. Manufacturer's recommendations for the installation of bell and spigot and hubless joints for cast iron soil pipe.

SD-06 Test Reports

Tests, Flushing and Disinfection; G

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, completion and testing of the installed system. Each test report shall indicate the final position of controls.

Test of Backflow Prevention Assemblies; G

Certification of proper operation shall be as accomplished in accordance with state regulations by an individual certified by the state to perform such tests. If no state requirement exists, the Contractor shall have the manufacturer's representative test the device, to ensure the unit is properly installed and performing as intended. The Contractor shall provide written documentation of the tests performed and signed by the individual performing the tests.

SD-07 Certificates

Materials and Equipment

Where materials or equipment are specified to comply with requirements of AGA, ASME, NSF, or KS, proof of such compliance shall be included. The label or listing of the specified agency will be acceptable evidence. In lieu of the label or listing, a written certificate may be submitted from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency. Where equipment is specified to conform to requirements of the ASME Boiler and Pressure Vessel Code, the design, fabrication, and installation shall conform to the code.

Bolts

Written certification by the bolt manufacturer that the bolts furnished comply with the specified requirements. The certification shall include illustrations of product-required markings, the date of manufacture, and the number of each type of bolt to be furnished based on this certification.

SD-10 Operation and Maintenance Data

Plumbing System; G

Six copies of the operation manual outlining the step-by-step procedures required for system startup, operation and shutdown. The manual shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Six copies of the maintenance manual listing routine maintenance procedures, possible breakdowns and repairs. The manual shall include piping and equipment layout and simplified wiring and control diagrams of the system as installed.

1.3 STANDARD PRODUCTS

Specified materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products. Specified equipment shall essentially duplicate equipment that has performed satisfactorily at least two years prior to bid opening.

1.4 ELECTRICAL WORK

Motors, motor controllers and motor efficiencies shall conform to the requirements of Section 16415 ELECTRICAL WORK, INTERIOR. Electrical motor-driven equipment specified herein shall be provided complete with motors. Equipment shall be rated at 60 Hz, single phase, ac unless otherwise indicated. Where a motor controller is not provided in a motor-control center on the electrical drawings, a motor controller shall be as indicated. Motor controllers shall be provided complete with properly sized thermal-overload protection in each ungrounded conductor, auxiliary contact, and other equipment, at the specified capacity, and including an allowable service factor.

1.5 PERFORMANCE REQUIREMENTS

1.5.1 Welding

Piping shall be welded in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX or KS (Korean Industrial Standards). Welding procedures qualified by others, and welders and welding operators qualified by another employer, may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests, and the tests shall be performed at the work site if practicable. Welders or welding operators shall apply their assigned symbols near each weld they make as a permanent record. Structural members shall be welded in accordance with Section 05090 WELDING, STRUCTURAL.

1.5.2 Cathodic Protection and Pipe Joint Bonding Cathodic protection and pipe joint bonding systems shall be in accordance with USACE Unified Facilities Guide Specifications (UFGS), Section 13110A CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE) and Section 13112A CATHODIC PROTECTION SYSTEM (IMPRESSED CURRENT).

1.6 REGULATORY REQUIREMENTS

Plumbing work shall be in accordance with ICC International Plumbing Code.

1.7 PROJECT/SITE CONDITIONS

The Contractor shall become familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

PART 2 PRODUCTS

2.1 MATERIALS

Materials for various services shall be in accordance with TABLES I and II. Pipe schedules shall be selected based on service requirements. Pipe fittings shall be compatible with the applicable pipe materials. Pipe threads (except dry seal) shall conform to KS B 0222. Material or equipment containing lead shall not be used in any potable water system. In line devices such as water meters, building valves, check valves, meter stops, valves, fittings and back flow preventers shall comply with PL 93-523 and NSF 61, Section 8. End point devices such as drinking water fountains, lavatory faucets, kitchen and bar faucets, residential ice makers, supply stops and end point control valves used to dispense water for drinking must meet the requirements of NSF 61, Section 9. Hubless cast-iron soil pipe shall not be installed underground, under concrete floor slabs, or in crawl spaces below kitchen floors. Plastic pipe shall not be installed in air plenums.

2.1.1 Pipe Joint Materials

Hubless cast-iron soil pipe shall not be used under ground. Joints and gasket materials shall conform to the following:

a. Coupling for Hubless Cast-Iron Pipe: KS D 9201.

b. Flange Gaskets: Gaskets shall be made of non-asbestos material. Gaskets shall be flat, 1.6 mm (1/16 inch) thick, and contain Aramid fibers bonded with Styrene Butadiene Rubber (SBR) or Nitro Butadiene Rubber (NBR). Gaskets shall be the full face or self centering flat ring type. Gaskets used for hydrocarbon service shall be bonded with NBR.

c. Brazing Material: Brazing material shall conform to AWS A5.8 or KS D 8050, BCuP-5.

d. Brazing Flux: Flux shall be in paste or liquid form appropriate for use with brazing material. Flux shall be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides; and contain fluorides.

e. Solder Material: Solder metal shall conform to ASTM B 32 or KS D 6704.

f. Solder Flux: Flux shall be liquid form, non-corrosive, and conform to ASTM B 813, Standard Test 1.

g. PTFE Tape: PTFE Tape, for use with Threaded Metal or Plastic Pipe, ASTM D 3308 or KS M 3520.

h. Plastic Solvent Cement for PVC Plastic Pipe: KS M 3409.

i. Flanged fittings including flanges, bolts, nuts, bolt patterns etc., shall be in accordance with KS B 1503, Class 10K and shall have the manufacturer's trademark affixed in accordance with KS D 3710. Flange material shall conform to KS D 3710. Blind flange material shall conform to KS D 3521. Bolts shall be high strength or intermediate strength with material conforming to KS D 3503.

2.1.2 Miscellaneous Materials

Miscellaneous materials shall conform to the following:

a. Water Hammer Arrester: PDI WH 201.

b. Copper, Sheet and Strip for Building Construction: KS D 5201.

c. Asphalt Roof Cement: KS M 2201.

d. Supports for Off-The-Floor Plumbing Fixtures: ASME A112.6.1M.

e. Metallic Cleanouts: KS B 1565.

f. Plumbing Fixture Setting Compound: A preformed flexible ring seal molded from hydrocarbon wax material. The seal material shall be nonvolatile nonasphaltic and contain germicide and provide watertight, gastight, odorproof and verminproof properties.

g. Hypochlorites: AWWA B300.

h. Liquid Chlorine: AWWA B301.

i. Gauges - Pressure and Vacuum Indicating Dial Type - Elastic Element: ASME B40.1.

j. Thermometers: ASTM E 1. Mercury shall not be used in thermometers.

2.1.3 Pipe Insulation Material

Insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.2 PIPE HANGERS, INSERTS, AND SUPPORTS

Pipe hangers, inserts, and supports shall conform to MSS SP-58 or KS B 1527, and MSS SP-69.

2.3 VALVES

Valves shall be provided on each supply to equipment and fixtures, each branch serving a group of fixtures, and each riser serving a group of fixtures. Valves 65 mm (2-1/2 inches) and smaller shall be bronze with threaded bodies for pipe and solder-type connections for tubing. Valves 80 mm (3 inches) and larger shall have flanged iron bodies and bronze trim. Pressure ratings shall be based upon the application. Valves shall conform to the following standards:

Description	Standard
Butterfly Valves	KS B 2333, Class 1, Type B
Cast-Iron Gate, Angle, Globe, and Swing Check Valves, Flanged Ends	KS B 2350, Class 10K
Ball Valves, Flanged and Threaded Ends	KS B 2308 Class 10K
Cast-Iron Plug Valves, Flanged and Threaded Ends	KS B 2371
Bronze Gate, Globe, Angle, and Check Valves	KS B 2301, Class 10K
Backwater Valves	ASME A112.14.1
Vacuum Relief Valves	ANSI Z21.22
Water Pressure Reducing Valves	ASSE 1003
Water Heater Drain Valves	ASSE 1005
Trap Seal Primer Valves	ASSE 1018
Temperature and Pressure Relief Valves for Hot Water Supply Systems	ANSI Z21.22
Temperature and Pressure Relief Valves for Automatically Fired Hot Water Boilers	ASME CSD-1 Safety Code No., Part CW, Article 5

2.3.1 Backwater Valves

Backwater valves shall be either separate from the floor drain or a combination floor drain, P-trap, and backwater valve, as shown. Valves shall have cast-iron bodies with cleanouts large enough to permit removal of interior parts. Valves shall be of the flap type, hinged or pivoted, with revolving disks. Hinge pivots, disks, and seats shall be nonferrous metal. Disks shall be slightly open in a no-flow no-backwater condition. Cleanouts shall extend to finished floor and be fitted with threaded countersunk plugs.

2.3.2 Wall Faucets

Wall faucets with vacuum-breaker backflow preventer shall be brass with 20 mm (3/4 inch) male inlet threads, hexagon shoulder, and 20 mm (3/4 inch) hose connection. Faucet handle shall be securely attached to stem.

2.3.3 Wall Hydrants

Wall hydrants with vacuum-breaker backflow preventer shall have a nickel-brass or nickel-bronze wall plate or flange with nozzle and detachable key handle. A brass or bronze operating rod shall be provided within a galvanized iron casing of sufficient length to extend through the wall so that the valve is inside the building, and the portion of the hydrant between the outlet and valve is self-draining. A brass or bronze valve with coupling and union elbow having metal-to-metal seat shall be provided. Valve rod and seat washer shall be removable through the face of the hydrant. The hydrant shall have 20 mm (3/4 inch) exposed hose thread on spout and 20 mm (3/4 inch) male pipe thread on inlet.

2.3.4 Lawn Faucets

Lawn faucets shall be brass, with either straight or angle bodies, and shall be of the compression type. Body flange shall be provided with internal pipe thread to suit 20 mm (3/4 inch) pipe. Body shall be suitable for wrench grip. Faucet spout shall have 20 mm (3/4 inch) exposed hose threads. Faucet handle shall be securely attached to stem.

2.3.5 Yard Hydrants

Yard box or post hydrants shall have valve housings located below frost lines. Water from the casing shall be drained after valve is shut off. Hydrant shall be bronze with cast-iron box or casing guard. "T" handle key shall be provided.

2.3.6 Relief Valves

Water heaters and hot water storage tanks shall have a combination pressure and temperature (P&T) relief valve. The pressure relief element of a P&T relief valve shall have adequate capacity to prevent excessive pressure buildup in the system when the system is operating at the maximum rate of heat input. The temperature element of a P&T relief valve shall have a relieving capacity which is at least equal to the total input of the heaters when operating at their maximum capacity. Relief valves shall be rated according to ANSI Z21.22. Relief valves for systems where the maximum rate of heat input is less than 59 kW (200,000 Btuh) shall have 20 mm (3/4 inch) minimum inlets, and 20 mm (3/4 inch) outlets. Relief valves for systems where the maximum rate of heat input is greater than 59 kW (200,000 Btuh) shall have 25 mm (1 inch) minimum inlets, and 25 mm (1 inch) outlets. The discharge pipe from the relief valve shall be the size of the valve outlet.

2.3.7 Thermostatic Mixing Valves

Mixing valves, thermostatic type, pressure-balanced or combination thermostatic and pressure-balanced shall be line size and shall be constructed with rough or finish bodies either with or without plating. Each valve shall be constructed to control the mixing of hot and cold water and to deliver water at a desired temperature regardless of pressure or input temperature changes. The control element shall be of an approved type. The body shall be of heavy cast bronze, and interior parts shall be brass, bronze, corrosion-resisting steel or copper. The valve shall be equipped with necessary stops, check valves, unions, and sediment strainers on the inlets. Mixing valves shall maintain water temperature within 2 degrees C (5 degrees F) of any setting.

2.4 FIXTURES

Fixtures shall be water conservation type, in accordance with ICC International Plumbing Code. Fixtures for use by the physically handicapped shall be in accordance with ICC A117.1. Vitreous china, nonabsorbent, hard-burned, and vitrified throughout the body shall be provided. Porcelain enameled ware shall have specially selected, clear white, acid-resisting enamel coating evenly applied on surfaces. No fixture will be accepted that shows cracks, crazes, blisters, thin spots, or other flaws. Fixtures shall be equipped with appurtenances such as traps, faucets, stop valves, and drain fittings. Each fixture and piece of equipment requiring connections to the drainage system, except grease interceptors, shall be equipped with a trap. Brass expansion or toggle bolts capped with acorn nuts shall be provided for supports, and polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Fixtures with the supply discharge below the rim shall be equipped with backflow preventers. Internal parts of flush and/or flushometer valves, shower mixing valves, shower head face plates, pop-up stoppers of lavatory waste drains, and pop-up stoppers and overflow tees and shoes of bathtub waste drains may contain acetal resin, fluorocarbon, nylon, acrylonitrile-butadiene-styrene (ABS) or other plastic material, if the material has provided satisfactory service under actual commercial or industrial operating conditions for not less than 2 years. Plastic in contact with hot water shall be suitable for 82 degrees C (180 degrees F) water temperature. Plumbing fixtures shall be as indicated in paragraph PLUMBING FIXTURE SCHEDULE.

2.4.1 Lavatories

Vitreous china lavatories shall be provided with two integral molded lugs on the back-underside of the fixture and drilled for bolting to the wall in a manner similar to the hanger plate.

2.4.2 Automatic Flushing System

Flushing system shall consist of solenoid-activated flush valve with electrical-operated light beam sensor or pushbutton to energize solenoid as indicated. Flushing devices shall be provided as described in paragraph FIXTURES AND FIXTURE TRIMMINGS.

2.5 BACKFLOW PREVENTERS

Backflow preventers shall be approved and listed by the Foundation For Cross-Connection Control & Hydraulic Research. Reduced pressure principle assemblies, double check valve assemblies, atmospheric (nonpressure) type vacuum breakers, and pressure type vacuum breakers shall be tested, approved, and listed in accordance with FCCCHR-CCC Manual-9. Backflow preventers with intermediate atmospheric vent shall conform to ASSE 1012. Reduced pressure principle backflow preventers shall conform to ASSE 1013. Hose connection vacuum breakers shall conform to ASSE 1011. Pipe applied atmospheric type vacuum breakers shall conform to ASSE 1001. Pressure vacuum breaker assembly shall conform to ASSE 1020. Air gaps in plumbing systems shall conform to ASME A112.1.2.

2.6 DRAINS

2.6.1 Floor and Shower Drains

Floor and shower drains shall consist of a galvanized body, integral seepage pan, and adjustable perforated or slotted chromium-plated bronze, nickel-bronze, or nickel-brass strainer, consisting of grate and threaded collar. Floor drains shall be cast iron except where metallic waterproofing membrane is installed. Drains shall be of double drainage pattern for embedding in the floor construction. The seepage pan shall have weep holes or channels for drainage to the drainpipe. The strainer shall be adjustable to floor thickness. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or waterproofing membrane shall be provided when required. Drains shall be provided with threaded connection. Between the drain outlet and waste pipe, a neoprene rubber gasket made of a properly vulcanized virgin compound containing virgin rubber as the sole elastomer with no scrap or reclaim may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Floor and shower drains shall conform to KS B 1565.

2.6.1.1 Metallic Shower Pan Drains

Where metallic shower pan membrane is installed, polyethylene drain with corrosion-resistant screws securing the clamping device shall be provided. Polyethylene drains shall have fittings to adapt drain to waste piping. Drains shall have separate cast-iron "P" trap, circular body, seepage pan, and strainer, unless otherwise indicated.

2.6.1.2 Drains and Backwater Valves

Drains and backwater valves installed in connection with waterproofed floors or shower pans shall be equipped with bolted-type device to securely clamp flashing.

2.6.2 Area Drains

Area drains shall be plain pattern with polished stainless steel perforated or slotted grate and bottom outlet. The drain shall be circular or square with a 300 mm (12 inch) nominal overall width or diameter and 250 mm (10 inch) nominal overall depth. Drains shall be cast iron with manufacturer's standard coating. Grate shall be easily lifted out for cleaning. Outlet shall be suitable for inside caulked connection to drain pipe.

2.6.3 Floor Sinks

Floor sinks shall be circular or square, with 300 mm (12 inch) nominal overall width or diameter and 250 mm (10 inch) nominal overall depth. Floor sink shall have an acid-resistant enamel interior finish with cast-iron body, aluminum sediment bucket, and perforated grate of cast iron in industrial areas and stainless steel in finished areas. The outlet pipe size shall be as indicated or of the same size as the connecting pipe.

2.6.4 Boiler Room Drains

Boiler room drains shall have combined drain and trap, hinged grate, removable bucket, and threaded brass cleanout with brass backwater valve. The removable galvanized cast-iron sediment bucket shall have rounded corners to eliminate fouling and shall be equipped with hand grips. Drain shall have a minimum water seal of 100 mm (4 inches). The grate area shall be not less than 0.065 square meters (100 square inches).

2.6.5 Pit Drains

Pit drains shall consist of a body, integral seepage pan, and nontilting perforated or slotted grate. Drains shall be of double drainage pattern suitable for embedding in the floor construction. The seepage pan shall have weep holes or channels for drainage to the drain pipe. Membrane or flashing clamping device shall be provided when required. Drains shall be cast iron with manufacturer's standard coating. Drains shall be circular and provided with bottom outlet suitable for inside caulked connection, unless otherwise indicated. Drains shall be provided with separate cast-iron "P" traps, unless otherwise indicated.

2.6.6 Sight Drains

Sight drains shall consist of body, integral seepage pan, and adjustable strainer with perforated or slotted grate and funnel extension. The strainer shall have a threaded collar to permit adjustment to floor thickness. Drains shall be of double drainage pattern suitable for embedding in the floor construction. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or membrane shall be provided for other than concrete construction. Drains shall have a galvanized heavy cast-iron body and seepage pan and chromium-plated bronze, nickel-bronze, or nickel-brass strainer and funnel combination. Drains shall be provided with threaded connection and with a separate cast-iron "P" trap, unless otherwise indicated. Drains shall be circular, unless otherwise indicated. The funnel shall be securely mounted over an opening in the center of the strainer. Minimum dimensions shall be as follows:

Area of strainer and collar; 0.023 square meters (36 square inches)

Height of funnel; 95 mm (3-3/4 inches)

Diameter of lower portion; 50 mm (2 inches) of funnel

Diameter of upper portion; 100 mm (4 inches) of funnel

2.6.7 Roof Drains and Expansion Joints

Roof drains shall conform to KS F 4522, with dome and integral flange, and shall have a device for making a watertight connection between roofing and flashing. The whole assembly shall be galvanized heavy pattern cast iron. For aggregate surface roofing, the drain shall be provided with a gravel stop. On roofs other than concrete construction, roof drains shall be complete with underdeck clamp, sump receiver, and an extension for the insulation thickness where applicable. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or membrane shall be provided when required to suit the building construction. Strainer openings shall have a combined area equal to twice that of the drain outlet. The outlet shall be equipped to make a proper connection to threaded pipe of the same size as the downspout. An expansion joint of proper size to receive the conductor pipe shall be provided. The expansion joint shall consist of a heavy cast-iron housing, brass or bronze sleeve, brass or bronze fastening bolts and nuts, and gaskets or packing. The sleeve shall have a nominal thickness of not less than 3.416 mm (0.134 inch). Gaskets and packing shall be close-cell neoprene, O-ring packing shall be close-cell neoprene of 70 durometer. Packing shall be held in place by a packing gland secured with bolts.

2.7 SHOWER PAN

Shower pan may be copper, or nonmetallic material.

2.7.1 Sheet Copper

Sheet copper shall be 4.9 kg per square meter (16 ounce) weight.

2.7.2 Plasticized Polyvinyl Chloride Shower Pan Material

Material shall be sheet form. The material shall be 1.016 mm (0.040 inch) minimum thickness of plasticized polyvinyl chloride or chlorinated polyethylene and shall be in accordance with KS M 3501.

2.7.3 Nonplasticized Polyvinyl Chloride (PVC) Shower Pan Material

Material shall consist of a plastic waterproofing membrane in sheet form. The material shall be 1.016 mm (0.040 inch) minimum thickness of nonplasticized PVC and shall have the following minimum properties:

a. KS M 3006:

Ultimate Tensile Strength: 1.79 MPa (2600 psi)
Ultimate Elongation: 398 percent
100 Percent Modulus: 3.07 MPa (445 psi)
Tear Strength: 53 kilonewtons per meter (300 pounds per inch)

b. KS M 3088:

Permeance: 0.46 ng per Pa per second per square meter (0.008 perms)

c. Other Properties:

Specific Gravity: 1.29
PVC Solvent: Weldable
Cold Crack: -47 degrees C (-53 degrees F)
Dimensional stability, 100 degrees C (212 degrees F): -2.5 percent
Hardness, Shore A: 89

2.8 TRAPS

Unless otherwise specified, traps shall be copper-alloy adjustable tube type with slip joint inlet and swivel. Traps shall be without a cleanout. Tubes shall be copper alloy with walls not less than 0.813 mm (0.032 inch) thick within commercial tolerances, except on the outside of bends where the thickness may be reduced slightly in manufacture by usual commercial methods. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level. Swivel joints shall be below the discharge level and shall be of metal-to-metal or metal-to-plastic type as required for the application. Nuts shall have flats for wrench grip. Outlets shall have internal pipe thread, except that when required for the application, the outlets shall have sockets for solder-joint connections. The depth of the water seal shall be not less than 50 mm (2 inches). The interior diameter shall be not more than 3.2 mm (1/8 inch) over or under the nominal size, and interior surfaces shall be reasonably smooth throughout. A copper alloy "P" trap assembly consisting of an adjustable "P" trap and threaded trap wall nipple with cast brass wall flange shall be provided for lavatories. The assembly shall be a standard manufactured unit and may have a rubber-gasketed swivel joint.

2.9 GREASE INTERCEPTOR

Grease interceptor of the size indicated shall be of reinforced concrete, precast concrete construction, or equivalent capacity commercially available steel grease interceptor with removable three-section, 9.5 mm (3/8 inch) checker-plate cover, and shall be installed outside the building. Steel grease interceptor shall be installed in a concrete pit and shall be epoxy-coated to resist corrosion as recommended by the manufacturer. Interceptors shall be tested and rated in accordance with PDI G 101. Concrete shall have 21 MPa (3,000 psi) minimum compressive strength at 28 days.

2.10 WATER HEATERS

Water heater types and capacities shall be as indicated. Each water heater shall have replaceable anodes. Each primary water heater shall have controls with an adjustable range that includes 32 to 71 degrees C (90 to 160 degrees F). Each gas-fired water heater and booster water heater shall have controls with an adjustable range that includes 49 to 82 degrees C (120 to 180 degrees F). Hot water systems utilizing recirculation systems shall be tied into building off-hour controls. The thermal efficiencies and standby heat losses shall conform to TABLE III for each type of water heater specified. The only exception is that storage water heaters and hot water storage tanks having more than 2000 liters (500 gallons) storage capacity need not meet the standard loss requirement if the tank surface area is insulated to R-12.5 and if a standing light is not used. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. A factory pre-charged expansion tank shall be installed on the cold water supply to each water heater. Expansion tanks shall be specifically designed for use on potable water systems and shall be rated for 93 degrees C (200 degrees F) water temperature and 1034 kPa (150 psi) working pressure. The expansion tank size and acceptance volume shall be as indicated. Water heaters shall be glass lined.

2.10.1 Automatic Storage Type

Heaters shall be complete with control system, temperature gauge, and pressure gauge, and shall have ASME rated combination pressure and temperature relief valve.

2.10.1.1 Oil-Fired Type

Oil-fired type water heaters shall conform to UL 732.

2.10.1.2 Gas-Fired Type

Gas-fired water heaters shall conform to ANSI Z21.10.1 when input is 22 KW (75,000 BTU per hour) or less or ANSI Z21.10.3 for heaters with input greater than 22 KW (75,000 BTU per hour).

2.10.1.3 Electric Type

Electric type water heaters shall conform to UL 174 with dual heating elements. Each element shall be 4.5 KW. The elements shall be wired so that only one element can operate at a time.

2.10.1.4 Indirect Heater Type

Steam and high temperature hot water (HTHW) heaters with storage system shall be the assembled product of one manufacturer, and be ASME tested and "U" stamped to code requirements under ASME BPVC SEC VIII D1. The storage tank shall be as specified in paragraph HOT-WATER STORAGE TANKS. The heat exchanger shall be single wall type that separates the potable water from the heat transfer medium with a space vented to the atmosphere in accordance with ICC International Plumbing Code.

a. HTHW Energy Source: The heater element shall have a working pressure of 2758 kPa (400 psig) with water at a temperature of 204 degrees C (400 degrees F). The heating surface shall be based on 0.093 square meter (1 square foot) of heating surface to heat 76 L (20 gallons) or more of water in 1 hour from 4 to 82 degrees C (40 to 180 degrees F) using hot water at a temperature of 178 degrees C (350 degrees F). Carbon steel heads shall be used. Tubing shall conform to ASTM B 111M/ASTM B 111, Copper Alloy No. 706 (90-10 copper-nickel). Heating elements shall withstand an internal hydrostatic pressure of 4137 kPa (600 psig) for not less than 15 seconds without leaking or any evidence of damage.

b. Steam Energy Source: The heater element shall have a working pressure of 1034 kPa per square meter (150 psig) with steam at a temperature of 185 degrees C (365 degrees F0. The heating surface shall be based on 0.093 square meter (1 square foot) of heating surface to heat 76 L (20 gallons) or more of water in 1 hour from 4 to 82 degrees C (40 to 180 degrees F) using steam at atmospheric pressure. Cast iron or bronze heads shall be used. Tubing shall be light-drawn copper tubing conforming to ASTM B 75M/ASTM B 75. Heating elements shall withstand an internal hydrostatic pressure of 1551 kPa (225 psig) for not less than 15 seconds without leaking or any evidence of damage.

2.10.2 Instantaneous Water Heater

Heater shall be crossflow design with service water in the coil and steam or hot water in the shell. An integral internal controller shall be provided, anticipating a change in demand so that the final temperature can be maintained under all normal load conditions when used in conjunction with pilot-operated temperature control system. Normal load conditions shall be as specified by the manufacturer for the heater. Unit shall be manufactured in accordance with ASME BPVC SEC VIII D1, and shall be certified for 1.03 MPa (150 psi) working pressure in the shell and 1.03 MPa (150 psi) working pressure in the coils. Shell shall be carbon steel with copper lining. Heads shall be cast iron, bronze, or carbon steel plate with copper lining. Coils shall be copper. Shell shall have metal sheathed fiberglass insulation, combination pressure and temperature relief valve, and thermometer. Insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.11 HOT-WATER STORAGE TANKS

Hot-water storage tanks shall be constructed by one manufacturer, ASME stamped for the working pressure, and shall have the National Board (ASME) registration. The tank shall be cement-lined or glass-lined steel type in accordance with AWWA D100. The heat loss shall conform to TABLE III as determined by the requirements of ASHRAE 90.1. Each tank shall be equipped with a thermometer, conforming to ASTM E 1, Type I, Class 3, Range C, style and form as required for the installation, and with 175 mm (7 inch) scale. Thermometer shall have a separable socket suitable for a 20 mm (3/4 inch) tapped opening. Tanks shall be equipped with a pressure gauge 155 mm (6 inch) minimum diameter face. Insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Storage tank capacity shall be as shown.

2.12 PUMPS

2.12.1 Sump Pumps

Sump pumps shall be of capacities indicated. The pumps shall be of the automatic, electric motor-driven, submerged type, complete with necessary control equipment and with a split or solid cast-iron or steel cover plate. The pumps shall be direct-connected by an approved flexible coupling to a vertical electric motor having a continuous oiling device or packed bearings sealed against dirt and moisture. Motors shall be totally enclosed, fan-cooled of sizes as indicated and shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 or 4 enclosure as indicated or required. Each pump shall be fitted with a high-grade thrust bearing mounted above the floor. Each shaft shall have an alignment bearing at each end, and the suction inlet shall be between 75 and 150 mm (3 and 6 inches) above the sump bottom. The suction side of each pump shall have a strainer of ample capacity. A float switch assembly, with the switch completely enclosed in a NEMA 250, Type 1 or 4 enclosure as indicated or required, shall start and stop each motor at predetermined water levels. Duplex pumps shall be equipped with an automatic alternator to change the lead operation from one pump to the other, and for starting the second pump if the flow exceeds the capacity of the first pump. The discharge line from each pump shall be provided with a union or flange, a nonclog swing check valve, and a stop valve in an accessible location near the pump.

2.12.2 Circulating Pumps

Domestic hot water circulating pumps shall be electrically driven, single-stage, centrifugal, with mechanical seals, suitable for the intended service. Pump capacities, efficiencies, motor sizes, speeds, and impeller types shall be as shown. Pump and motor shall be integrally mounted on a cast-iron or steel subbase, close-coupled with an overhung impeller, or supported by the piping on which it is installed. The shaft shall be one-piece, heat-treated, corrosion-resisting steel with impeller and smooth-surfaced housing of bronze. Motor shall be totally enclosed, fan-cooled and shall have sufficient wattage (horsepower) for the service required. Pump shall conform to HI 1.1-1.5. Each pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in cover. Pump motors smaller than 746 W (Fractional horsepower) pump motors shall have integral thermal overload protection in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Guards shall shield exposed moving parts.

2.12.3 Booster Pumps

2.12.3.1 Centrifugal Pumps

Horizontal split-case centrifugal-type booster pumps shall be furnished. The capacities shall be as shown, and the speed shall not exceed 1800 rpm. Pumps shall have a casing of close-grained iron or steel with smooth water passages. A gasket shall be provided between the upper and lower halves of the casing. Suction and discharge connections shall be flanged. Impellers shall be nonoverloading, bronze, balanced to eliminate vibration, and shall be keyed to corrosion-resisting steel shafts. The casings shall be fitted with bronze wearing or sealing rings. Bearings shall be cartridge type, enabling the entire rotating element to be removed without disturbing alignment or exposing the bearings to dirt, water, and other foreign matter. Pumps shall be provided with mechanical seals. Seal boxes shall be machined in the pump casing and at both sides of the pump, and shall be of sufficient depth to include a conventional bronze seal ring and rows of shaft packing. Bedplates shall be close-grain cast iron or steel with ribs and lugs, complete with foundation bolts, and shall have a drip lip with drain hole. Each pump shall be tested at the manufacturer's plant for operating characteristics at the rated capacity and under specified operating conditions. Test curves shall be furnished showing capacity in liters per second (gpm), head in meters (feet), efficiency, brake wattage (horsepower), and operation in parallel with similar pumps. Multiple pump installations shall have pump characteristics compatible for operation in parallel with similar pumps. The electric motor shall be sized for non-overload when operating at any point along the characteristic curve of the pump. Guards shall shield exposed belts and moving parts.

2.12.3.2 Controls

Each pump motor shall be provided with enclosed across-the-line-type magnetic controller complete in a NEMA 250 Type 1 enclosure with three position, "HAND-OFF-AUTOMATIC," selector switch in cover. Pumps shall be automatically started and stopped by float or pressure switches, as indicated. The pumps shall start and stop at the levels and pressures indicated. A multiposition sequence selector switch shall be provided so that any two pumps may be operated simultaneously beeping a third pump as a standby.

2.12.4 Flexible Connectors

Flexible connectors shall be provided at the suction and discharge of each pump that is 1 hp or larger. Connectors shall be constructed of neoprene, rubber, or braided bronze, with Class 150 standard flanges. Flexible connectors shall be line size and suitable for the pressure and temperature of the intended service.

2.13 WATER PRESSURE BOOSTER SYSTEM

2.13.1 Constant Speed Pumping System

Constant speed pumping system with pressure-regulating valves shall employ one lead pump for low flows, and one or more lag pumps for higher flows. Pressure-regulating valves shall be provided with nonslam check feature. The factory prepiped and prewired assembly shall be mounted on a steel frame, complete with pumps, motors, and automatic controls. The system capacity and capacity of individual pumps shall be as indicated. Current sensing relays shall provide staging of the pumps. The pumps shall be protected from thermal buildup, when running at no-flow, by a common thermal relief valve. Pressure gauges shall be mounted on the suction and discharge headers. The control panel shall bear the UL listing label for industrial control panels and shall be in a NEMA 250, Type 1 enclosure. The control panel shall include the following: No-flow shutdown; 7-day time clock; audiovisual alarm; external resets; manual alternation; magnetic motor controllers; time delays; transformer; current relays; "HAND-OFF-AUTOMATIC" switches for each pump; minimum run timers; low suction pressure cutout; and indicating lights for power on, individual motor overload, and low suction pressure. The control circuit shall be interlocked so that the failure of any controller shall energize the succeeding controller.

2.13.2 Hydro-Pneumatic Water Pressure System

An ASME code constructed tank stamped for 862 kPa (125 psig) water working pressure shall be provided. The tank shall have a flexible diaphragm made of material conforming to FDA requirements for use with potable water and shall be factory precharged to meet required system pressure.

2.13.3 Variable Speed Pumping System

Variable speed pumping system shall provide system pressure by varying speed and number of operating pumps. The factory prepiped and prewired assembly shall be mounted on a steel frame complete with pumps, variable speed drives, motors, and controls. The variable speed drives shall be the oil-filled type capable of power transmission throughout their complete speed range without vibration, noise, or shock loading. Each variable speed drive shall be run-tested by the manufacturer for rated performance, and the manufacturer shall furnish written performance certification. System shall have suppressors to prevent noise transmission over electric feed lines. Required electrical control circuitry and system function sensors shall be supplied by the variable speed drive manufacturer. The primary power controls and magnetic motor controllers shall be installed in the controls supplied by the drive manufacturer or the motor control center. The sensors shall be located in the system to control drive speed as a function of constant pump discharge pressure or constant system pressure at location indicated. Connection between the sensors and the variable speed drive controls shall be accomplished with copper wiring. Controls shall be in NEMA 250, Type 1 enclosures.

2.14 COMPRESSED AIR SYSTEM

2.14.1 Air Compressors

Air compressor unit shall be a factory-packaged assembly, including motor controls, switches, wiring, accessories, and motor controllers, in a NEMA 250, Type 1 or 4 enclosure as indicated or required. Tank-mounted air compressors shall be manufactured to comply with UL listing requirements. Air compressors shall have manufacturer's name and address, together with trade name, and catalog number on a nameplate securely attached to the equipment. Each compressor shall start and stop automatically at upper and lower pressure limits of the system or regulate pressure by constant speed compressor loading and unloading. Guards shall shield exposed moving parts. Each duplex compressor system shall be provided with automatic alternation system. Each compressor motor shall be provided with an across-the-line-type magnetic controller, complete with low-voltage release. An intake air filter and silencer shall be provided with each compressor. Aftercooler and moisture separator shall be installed between compressors and air receiver to remove moisture and oil condensate before the air enters the receiver. Aftercoolers shall be either air- or water-cooled, as indicated. The air shall pass through a sufficient number of tubes to affect cooling. Tubes shall be sized to give maximum heat transfer. Water to unit shall be controlled by a solenoid or pneumatic valve, which opens when the compressors start and closes when the compressors shut down. Cooling capacity of the aftercooler shall be sized for the total capacity of the compressors. Means shall be provided for draining condensed moisture from the receiver by an automatic float type trap. Capacities of air compressors and receivers shall be as indicated.

2.14.2 Lubricated Compressors

Compressors shall be two-stage, V-belt drive, capable of operating continuously against their designed discharge pressure, and shall operate at a speed not in excess of 1800 rpm. Compressors shall have the capacity and discharge pressure indicated. Compressors shall be assembled complete on a common subbase. The compressor main bearings shall be either roller or ball. The discharge passage of the high pressure air shall be piped to the air receiver with a copper pipe or tubing. A pressure gauge calibrated to 1.03

MPa (150 psi) and equipped with a gauge cock and pulsation dampener shall be furnished for installation adjacent to pressure switches.

2.14.3 Air Receivers

Receivers shall be designed for 1.38 MPa (200 psi) working pressure. Receivers shall be factory air tested to 1-1/2 times the working pressure. Receivers shall be equipped with safety relief valves and accessories, including pressure gauges and automatic and manual drains. The outside of air receivers may be galvanized or supplied with commercial enamel finish. Receivers shall be designed and constructed in accordance with ASME BPVC SEC VIII D1 and shall have the design working pressures specified herein. A display of the ASME seal on the receiver or a certified test report from an approved independent testing laboratory indicating conformance to the ASME Code shall be provided.

2.14.4 Intake Air Supply Filter

Dry type air filter shall be provided having a collection efficiency of 99 percent of particles larger than 10 microns. Filter body and media shall withstand a maximum 862 kPa (125 psi), capacity as indicated.

2.14.5 Pressure Regulators The air system shall be provided with the necessary regulator valves to maintain the desired pressure for the installed equipment. Regulators shall be designed for a maximum inlet pressure of 862 kPa (125 psi) and a maximum temperature of 93 degrees C (200 degrees F). Regulators shall be single-seated, pilot-operated with valve plug, bronze body and trim or equal, and threaded connections. The regulator valve shall include a pressure gauge and shall be provided with an adjustment screw for adjusting the pressure differential from 0 kPa to 862 kPa (0 to 125 psi). Regulator shall be sized as indicated.

2.15 DOMESTIC WATER SERVICE METER

Cold water meters 50 mm (2 inches) and smaller shall be positive displacement type conforming to AWWA C700. Cold water meters 64 mm (2-1/2 inches) and larger shall be turbine type conforming to AWWA C701. Meter register may be round or straight reading type. Meter shall be provided with a pulse generator, remote readout register and all necessary wiring and accessories.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Piping located in air plenums shall conform to NFPA 90A requirements. Plastic pipe shall not be installed in air plenums. Piping located in shafts that constitute air ducts or that enclose air ducts shall be noncombustible in accordance with NFPA 90A. Installation of plastic pipe where in compliance with NFPA may be installed in accordance with PPFA-01. The plumbing system shall be installed complete with necessary fixtures, fittings, traps, valves, and accessories. Water and drainage piping shall be extended 1.5 m (5 feet) outside the building, unless otherwise indicated. A gate valve, full port ball valve, ball valve and drain shall be installed on the water service line inside the building approximately 150 mm (6 inches) above the floor from point of entry. Piping shall be connected to the exterior service lines or capped or plugged if the exterior service is not in place. Sewer and water pipes shall be laid in separate trenches, except when otherwise shown. Exterior underground utilities shall be at least 300 mm (12 inches) below the average local frost depth or as indicated on the drawings. If trenches are closed or the pipes are otherwise covered before being connected to the service lines, the location of the end of each plumbing utility shall be marked with a stake or other acceptable means. Valves shall be installed with control no lower than the valve body.

3.1.1 Water Pipe, Fittings, and Connections

3.1.1.1 Utilities

The piping shall be extended to fixtures, outlets, and equipment. The hot-water and cold-water piping system shall be arranged and installed to permit draining. The supply line to each item of equipment or fixture, except faucets, flush valves, or other control valves which are supplied with integral stops, shall be equipped with a shutoff valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures. Supply piping to fixtures, faucets, hydrants, shower heads, and flushing devices shall be anchored to prevent movement.

3.1.1.2 Cutting and Repairing

The work shall be carefully laid out in advance, and unnecessary cutting of construction shall be avoided. Damage to building, piping, wiring, or equipment as a result of cutting shall be repaired by mechanics skilled in the trade involved.

3.1.1.3 Protection of Fixtures, Materials, and Equipment

Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water, chemicals, and mechanical injury. Upon completion of the work, the fixtures, materials, and equipment shall be thoroughly cleaned, adjusted, and operated. Safety guards shall be provided for exposed rotating equipment.

3.1.1.4 Mains, Branches, and Runouts

Piping shall be installed as indicated. Pipe shall be accurately cut and worked into place without springing or forcing. Structural portions of the building shall not be weakened. Aboveground piping shall run parallel with the lines of the building, unless otherwise indicated. Branch pipes from service lines may be taken from top, bottom, or side of main, using crossover fittings required by structural or installation conditions. Supply pipes, valves, and fittings shall be kept a sufficient distance from other work and other services to permit not less than 12 mm (1/2 inch) between finished covering on the different services. Bare and insulated water lines shall not bear directly against building structural elements so as to transmit sound to the structure or to prevent flexible movement of the lines. Water pipe shall not be buried in or under floors unless specifically indicated or approved. Changes in pipe sizes shall be made with reducing fittings. Use of bushings will not be permitted except for use in situations in which standard factory fabricated components are furnished to accommodate specific accepted installation practice. Change in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center-line radius of bends shall be not less than six diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be acceptable.

3.1.1.5 Pipe Drains

Pipe drains indicated shall consist of 20 mm (3/4 inch) inch hose bibb with renewable seat and gate, full port ball, or ball valve ahead of hose bibb. At other low points, 20 mm (3/4 inch) brass plugs or caps shall be provided. Disconnection of the supply piping at the fixture is an acceptable drain.

3.1.1.6 Expansion and Contraction of Piping

Allowance shall be made throughout for expansion and contraction of water pipe. Each hot-water and hot-water circulation riser shall have expansion loops or other provisions such as offsets, changes in direction, etc., where indicated and/or required. Risers shall be securely anchored as required or where indicated to force expansion to loops. Branch connections from risers shall be made with ample swing or offset to avoid undue strain on fittings or short pipe lengths. Horizontal runs of pipe over 15 m (50 feet) in length shall be anchored to the wall or the supporting construction about midway on the run to force expansion, evenly divided, toward the ends. Sufficient flexibility shall be provided on branch runouts from mains and risers to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that piping will spring enough to allow for expansion without straining. If mechanical grooved pipe coupling systems are provided, the deviation from design requirements for expansion and contraction may be allowed pending approval of Contracting Officer.

3.1.1.7 Thrust Restraint

Plugs, caps, tees, valves and bends deflecting 11.25 degrees or more, either vertically or horizontally, in waterlines 100 mm (4 inches) in diameter or larger shall be provided with thrust blocks, where indicated, to prevent movement. Thrust blocking shall be concrete of a mix not leaner than: 1 cement, 2-1/2 sand, 5 gravel; and having a compressive strength of not less than 14 MPa (2000 psi) after 28 days. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of the thrust block shall be poured against undisturbed earth. The side of the thrust block not subject to thrust shall be poured against forms. The area of bearing will be as shown. Blocking shall be placed so that the joints of the fitting are accessible for repair. Steel rods and clamps, protected by galvanizing or by coating with bituminous paint, shall be used to anchor vertical down bends into gravity thrust blocks.

3.1.1.8 Commercial-Type Water Hammer Arresters

Commercial-type water hammer arresters shall be provided on hot- and cold-water supplies and shall be located as generally indicated, with precise location and sizing to be in accordance with PDI WH 201. Water hammer arresters, where concealed, shall be accessible by means of access doors or removable panels. Commercial-type water hammer arresters shall conform to PDI WH 201. Vertical capped pipe columns will not be permitted.

3.1.2 Compressed Air Piping (Non-Oil Free)

Compressed air piping shall be installed as specified for water piping and suitable for 862 kPa (125 psig) working pressure. Compressed air piping shall have supply lines and discharge terminals legibly and permanently marked at both ends with the name of the system and the direction of flow.

3.1.3 Joints

Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints shall be made up with fittings of compatible material and made for the specific purpose intended.

3.1.3.1 Threaded

Threaded joints shall have American Standard taper pipe threads conforming to KS B 0222. Only male pipe threads shall be coated with graphite or with an approved graphite compound, or with an inert filler and oil, or shall have a polytetrafluoroethylene tape applied.

3.1.3.2 Unions and Flanges

Unions, flanges and mechanical couplings shall not be concealed in walls, ceilings, or partitions. Unions shall be used on pipe sizes 65 mm (2-1/2 inches) and smaller; flanges shall be used on pipe sizes 80 mm (3 inches) and larger.

3.1.3.3 Cast Iron Soil, Waste and Vent Pipe

Bell and spigot compression and hubless gasketed clamp joints for soil, waste and vent piping shall be installed per the manufacturer's recommendations.

3.1.3.4 Copper Tube and Pipe

The tube or fittings shall not be annealed when making connections.

a. Brazed. Brazed joints shall be made in conformance with AWS B2.2, MSS SP-73, and CDA A4015 with flux and are acceptable for all pipe sizes. Copper to copper joints shall include the use of copper-phosphorus or copper-phosphorus-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorus, copper-phosphorus-silver or a silver brazing filler metal.

b. Soldered. Soldered joints shall be made with flux and are only acceptable for piping 50 mm (2 inches) and smaller. Soldered joints shall conform to ASME B31.5 and CDA A4015. Soldered joints shall not be used in compressed air piping between the air comppressor and the receiver.

c. Copper Tube Extracted Joint. An extracted mechanical joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. Branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed in accordance with NAPHCC Plumbing Code using B-cup series filler metal in accordance with MSS SP-73. Soldered extracted joints will not be permitted.

3.1.3.5 Plastic Pipe

PVC pipe shall have joints made with solvent cement elastomeric, threading (threading of Schedule 80 Pipe is allowed only where required for disconnection and inspection; threading of Schedule 40 Pipe is not allowed), or mated flanged.

3.1.4 Dissimilar Pipe Materials

Connections between ferrous and non-ferrous copper water pipe shall be made with dielectric unions or flange waterways. Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways. Connecting joints between plastic and metallic pipe shall be made with transition fitting for the specific purpose.

3.1.5 Pipe Sleeves and Flashing

Pipe sleeves shall be furnished and set in their proper and permanent location.

3.1.5.1 Sleeve Requirements

Pipes passing through concrete or masonry walls or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves are not required for supply, drainage, waste and vent pipe passing through concrete slab on grade, except where penetrating a membrane waterproof floor. A modular mechanical type sealing assembly may be installed in lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve. The seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and sleeve using galvanized steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe and sleeve involved. Sleeves shall not be installed in structural members, except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective floor, or roof, and shall be cut flush with each surface, except for special circumstances. Pipe sleeves passing through floors in wet areas such as mechanical equipment rooms, lavatories, kitchens, and other plumbing fixture areas shall extend a minimum of 100 mm (4 inches) above the finished floor. Unless otherwise indicated, sleeves shall be of a size to provide a minimum of 6 mm (1/4 inch) clearance between bare pipe or insulation and inside of sleeve or between insulation and inside of sleeve. Sleeves in bearing walls and concrete slab on grade floors shall be steel pipe or cast-iron pipe. Sleeves in nonbearing walls or ceilings may be steel pipe, cast-iron pipe, galvanized sheet metal with lock-type longitudinal seam, or plastic. Except as otherwise specified, the annular space between pipe and sleeve, or between jacket over insulation and sleeve, shall be sealed as indicated with sealants conforming to ASTM C 920 and with a primer, backstop material and surface preparation as specified in Section 07900 JOINT SEALING. The annular space between pipe and sleeve, between bare insulation and sleeve or between jacket over insulation and sleeve shall not be sealed for interior walls which are not designated as fire rated. Sleeves through below-grade walls in contact with earth shall be recessed 12 mm (1/2 inch) from wall surfaces on both sides. Annular space between pipe and sleeve shall be filled with backing material and sealants in the joint between the pipe and concrete or masonry wall as specified above. Sealant selected for the earth side of the wall shall be compatible with dampproofing/waterproofing materials that are to be applied over the joint sealant. Pipe sleeves in fire-rated walls shall conform to the requirements in Section 07840 FIRESTOPPING.

3.1.5.2 Flashing Requirements

Pipes passing through roof shall be installed through a 4.9 kg per square meter (16 ounce) copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 200 mm (8 inches) from the pipe and shall be set over the roof or floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 250 mm (10 inches). For cleanouts, the flashing shall be turned down into the hub and caulked after placing the ferrule. Pipes passing through pitched roofs shall be flashed, using lead or copper flashing, with an adjustable integral flange of adequate size to extend not less than 200 mm (8 inches) from the pipe in all directions and lapped into the roofing to provide a watertight seal. The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Flashing for dry vents shall be turned down into the pipe to form a waterproof joint. Pipes, up to and including 250 mm (10 inches) in diameter, passing through roof or floor waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing-clamp device, and pressure ring with brass bolts. Flashing shield shall be fitted into the sleeve clamping device. Pipes passing through wall waterproofing membrane shall be sleeved as described above. A waterproofing clamping flange shall be installed.

3.1.5.3 Waterproofing

Waterproofing at floor-mounted water closets shall be accomplished by forming a flashing guard from soft-tempered sheet copper. The center of the sheet shall be perforated and turned down approximately 40 mm (1-1/2 inches) to fit between the outside diameter of the drainpipe and the inside diameter of the cast-iron or steel pipe sleeve. The turned-down portion of the flashing guard shall be embedded in sealant to a depth of approximately 40 mm (1-1/2 inches); then the sealant shall be finished off flush to floor level between the flashing guard and drainpipe. The flashing guard of sheet copper shall extend not less than 200 mm (8 inches) from the drainpipe and shall be lapped between the floor membrane in a solid coating of bituminous cement. If cast-iron water closet floor flanges are used, the space between the pipe sleeve and drainpipe shall be sealed with sealant and the flashing guard shall be upturned approximately 40 mm (1-1/2 inches) to fit the outside diameter of the drainpipe and the inside diameter of the water closet floor flange. The upturned portion of the sheet fitted into the floor flange shall be sealed.

3.1.5.4 Optional Counterflashing

Instead of turning the flashing down into a dry vent pipe, or caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may be accomplished by utilizing the following:

a. A standard roof coupling for threaded pipe up to 150 mm (6 inches) in diameter.

b. A tack-welded or banded-metal rain shield around the pipe.

3.1.6.5 Pipe Penetrations of Slab on Grade Floors Where pipes, fixture drains, floor drains, cleanouts or similar items penetrate slab on grade floors, except at penetrations of floors with waterproofing membrane as specified in paragraphs Flashing Requirements and Waterproofing, a groove 6 to 13 mm (1/4 to 1/2 inch) wide by 6 to 10 mm (1/4 to 3/8 inch) deep shall be formed around the pipe, fitting or drain. The groove shall be filled with a sealant as specified in Section 07900 JOINT SEALING.

3.1.7 Fire Seal

Where pipes pass through fire walls, fire-partitions, fire-rated pipe chase walls or floors above grade, a fire seal shall be provided as specified in Section 07840 FIRESTOPPING.

3.1.8 Supports

3.1.8.1 General

Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run. Threaded sections of rods shall not be formed or bent.

3.1.8.2 Pipe Hangers, Inserts, and Supports

Installation of pipe hangers, inserts and supports shall conform to MSS SP-58 or KS B 1527, and MSS SP-69, except as modified herein.

a. Types 5, 12, and 26 shall not be used.

b. Type 3 shall not be used on insulated pipe.

c. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for type 18 inserts.

d. Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and shall have both locknuts and retaining devices furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

e. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

g. Type 39 saddles shall be used on insulated pipe 100 mm (4 inches) and larger when the temperature of the medium is 15 degrees C (60 degrees F) or higher. Type 39 saddles shall be welded to the pipe.

h. Type 40 shields shall:

(1) Be used on insulated pipe less than 100 mm (4 inches).

(2) Be used on insulated pipe 100 mm (4 inches) and larger when the temperature of the medium is 15 degrees C (60 degrees F) or less.

(3) Have a high density insert for all pipe sizes. High density inserts shall have a density of 128 kg per cubic meter (8 pcf) or greater.

i. Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1.5 m (5 feet) apart at valves. Operating temperatures in determining hanger spacing for PVC pipe shall be 49 degrees C (120 degrees F). Horizontal pipe runs shall include allowances for expansion and contraction.

j. Vertical pipe shall be supported at each floor, except at slab-on-grade, at intervals of not more than 4.5 m (15 feet) nor more than 2 m (8 feet) from end of risers, and at vent terminations. Vertical pipe risers shall include allowances for expansion and contraction.

k. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided to allow longitudinal pipe movement. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered. Lateral restraints shall be provided as needed. Where steel slides do not require provisions for lateral restraint the following may be used:

(1) On pipe 100 mm (4 inches) and larger when the temperature of the medium is 15 degrees C (60 degrees F) or higher, a Type 39 saddle, welded to the pipe, may freely rest on a steel plate.

(2) On pipe less than 100 mm (4 inches), a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

(3) On pipe 100 mm (4 inches) and larger carrying medium less that 15 degrees C 60 degrees F a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

l. Pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation. The insulation shall be continuous through the hanger on all pipe sizes and applications.

m. Where there are high system temperatures and welding to piping is not desirable, the type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm (4 inches) or by an amount adequate for the insulation, whichever is greater.

n. Hangers and supports for plastic pipe shall not compress, distort, cut or abrade the piping, and shall allow free movement of pipe except where otherwise required in the control of expansion/contraction.

3.1.9 Welded Installation

Plumbing pipe weldments shall be as indicated. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connection may be made with either welding tees or forged branch outlet fittings. Branch outlet fittings shall be forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded. After filler metal has been removed from its original package, it shall be protected or stored so that its characteristics or welding properties are not affected. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.10 Pipe Cleanouts

Pipe cleanouts shall be the same size as the pipe except that cleanout plugs larger than 100 mm (4 inches) will not be required. A cleanout installed in connection with cast-iron soil pipe shall consist of a long-sweep 1/4 bend or one or two 1/8 bends extended to the place shown. An extra-heavy cast-brass or cast-iron ferrule with countersunk cast-brass head screw plug shall be caulked into the hub of the fitting and shall be flush with the floor. Cleanouts in connection with other pipe, where indicated, shall be T-pattern, 90-degree branch drainage fittings with cast-brass screw plugs, except plastic plugs shall be installed in plastic pipe. Plugs shall be the same size as the pipe up to and including 100 mm (4 inches). Cleanout tee branches with screw plug shall be installed at the foot of soil and waste stacks, at the foot of interior downspouts, on each connection to building storm drain where interior downspouts are indicated, and on each building drain outside the building. Cleanout tee branches may be omitted on stacks in single story buildings with slab-on-grade construction or where less than 450 mm (18 inches) of crawl space is provided under the floor. Cleanouts on pipe concealed in partitions shall be provided with chromium plated bronze, nickel bronze, nickel brass or stainless steel flush type access cover plates. Round access covers shall be provided and secured to plugs with securing screw. Square access covers may be provided with matching frames, anchoring lugs and cover screws. Cleanouts in finished walls shall have access covers and frames installed flush with the finished wall. Cleanouts installed in finished floors subject to foot traffic shall be provided with a chrome-plated cast brass, nickel brass, or nickel bronze cover secured to the plug or cover frame and set flush with the finished floor. Heads of fastening screws shall not project above the cover surface. Where cleanouts are provided with adjustable heads, the heads shall be cast iron.

3.2 WATER HEATERS AND HOT WATER STORAGE TANKS

3.2.1 Relief Valves

No valves shall be installed between a relief valve and its water heater or storage tank. The P&T relief valve shall be installed where the valve actuator comes in contact with the hottest water in the heater. Whenever possible, the relief valve shall be installed directly in a tapping in the tank or heater; otherwise, the P&T valve shall be installed in the hot-water outlet piping. A vacuum relief valve shall be provided on the cold water supply line to the hot-water storage tank or water heater and mounted above and within 150 mm (6 inches) above the top of the tank or water heater.

3.2.2 Installation of Gas- and Oil-Fired Water Heater

Installation shall conform to NFPA 54 for gas fired and NFPA 31 for oil fired. Storage water heaters that are not equipped with integral heat traps and having vertical pipe risers shall be installed with heat traps directly on both the inlet and outlet. Circulating systems need not have heat traps installed. An acceptable heat trap may be a piping arrangement such as elbows connected so that the inlet and outlet piping make vertically upward runs of not less than 600 mm (24 inches) just before turning downward or directly horizontal into the water heater's inlet and outlet fittings. Commercially available heat traps, specifically designed by the manufacturer for the purpose of effectively restricting the natural tendency of hot water to rise through vertical inlet and outlet piping during standby periods may also be approved.

3.2.3 Heat Traps

Piping to and from each water heater and hot water storage tank shall be routed horizontally and downward a minimum of 600 mm (2 feet) before turning in an upward direction.

3.2.4 Connections to Water Heaters

Connections of metallic pipe to water heaters shall be made with dielectric unions or flanges.

3.2.5 Expansion Tank

A pre-charged expansion tank shall be installed on the cold water supply between the water heater inlet and the cold water supply shut-off valve. The Contractor shall adjust the expansion tank air pressure, as recommended by the tank manufacturer, to match incoming water pressure.

3.3 FIXTURES AND FIXTURE TRIMMINGS

Polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Angle stops, straight stops, stops integral with the faucets, or concealed type of lock-shield, and loose-key pattern stops for supplies with threaded, sweat or solvent weld inlets shall be furnished and installed with fixtures. Where connections between copper tubing and faucets are made by rubber compression fittings, a beading tool shall be used to mechanically deform the tubing above the compression fitting. Exposed traps and supply pipes for fixtures and equipment shall be connected to the rough piping systems at the wall, unless otherwise specified under the item. Floor and wall escutcheons shall be as specified. Drain lines and hot water lines of fixtures for handicapped personnel shall be insulated and do not require polished chrome finish. Plumbing fixtures and accessories shall be installed within the space shown.

3.3.1 Fixture Connections

Where space limitations prohibit standard fittings in conjunction with the cast-iron floor flange, special short-radius fittings shall be provided. Connections between earthenware fixtures and flanges on soil pipe shall be made gastight and watertight with a closet-setting compound or neoprene gasket and seal. Use of natural rubber gaskets or putty will not be permitted. Fixtures with outlet flanges shall be set the proper distance from floor or wall to make a first-class joint with the closet-setting compound or gasket and fixture used.

3.3.2 Flushometer Valves

Flushometer valves shall be secured to prevent movement by anchoring the long finished top spud connecting tube to wall adjacent to valve with approved metal bracket. Flushometer valves for water closets shall be installed 1 m (39 inches) above the floor, except at water closets intended for use by the physically handicapped where flushometer valves shall be mounted at approximately 760 mm (30 inches) above the floor and arranged to avoid interference with grab bars. In addition, for water closets intended for handicap use, the flush valve handle shall be installed on the wide side of the enclosure.

3.3.3 Height of Fixture Rims Above Floor

Lavatories shall be mounted with rim 775 mm (31 inches) above finished floor. Wall-hung drinking fountains and water coolers shall be installed with rim 1020 mm (42 inches) above floor. Wall-hung service sinks shall be mounted with rim 700 mm (28 inches) above the floor. Installation of fixtures for use by the physically handicapped shall be in accordance with ICC A117.1.

3.3.4 Shower Bath Outfits

The area around the water supply piping to the mixing valves and behind the escutcheon plate shall be made watertight by caulking or gasketing.

3.3.5 Fixture Supports

Fixture supports for off-the-floor lavatories, urinals, water closets, and other fixtures of similar size, design, and use, shall be of the chair-carrier type. The carrier shall provide the necessary means of mounting the fixture, with a foot or feet to anchor the assembly to the floor slab. Adjustability shall be provided to locate the fixture at the desired height and in proper relation to the wall. Support plates, in lieu of chair carrier, shall be fastened to the wall structure only where it is not possible to anchor a floor-mounted chair carrier to the floor slab.

3.3.5.1 Support for Solid Masonry Construction

Chair carrier shall be anchored to the floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be imbedded in the masonry wall.

3.3.5.2 Support for Concrete-Masonry Wall Construction

Chair carrier shall be anchored to floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be fastened to the concrete wall using through bolts and a back-up plate.

3.3.5.3 Support for Steel Stud Frame Partitions

Chair carrier shall be used. The anchor feet and tubular uprights shall be of the heavy duty design; and feet (bases) shall be steel and welded to a square or rectangular steel tube upright. Wall plates, in lieu of floor-anchored chair carriers, shall be used only if adjoining steel partition studs are suitably reinforced to support a wall plate bolted to these studs.

3.3.5.4 Support for Wood Stud Construction

Where floor is a concrete slab, a floor-anchored chair carrier shall be used. Where entire construction is wood, wood crosspieces shall be installed. Fixture hanger plates, supports, brackets, or mounting lugs shall be fastened with not less than No. 10 wood screws, 6 mm (1/4 inch) thick minimum steel hanger, or toggle bolts with nut. The wood crosspieces shall extend the full width of the fixture and shall be securely supported.

3.3.5.5 Wall-Mounted Water Closet Gaskets

Where wall-mounted water closets are provided, reinforced wax, treated felt, or neoprene gaskets shall be provided. The type of gasket furnished shall be as recommended by the chair-carrier manufacturer.

3.3.6 Backflow Prevention Devices

Plumbing fixtures, equipment, and pipe connections shall not cross connect or interconnect between a potable water supply and any source of nonpotable water. Backflow preventers shall be installed where indicated and in accordance with ICC International Plumbing Code at all other locations necessary to preclude a cross-connect or interconnect between a potable water supply and any nonpotable substance. In addition backflow preventers shall be installed at all locations where the potable water outlet is below the flood level of the equipment, or where the potable water outlet will be located below the level of the nonpotable substance. Backflow preventers shall be located so that no part of the device will be submerged. Backflow preventers shall be of sufficient size to allow unrestricted flow of water to the equipment, and preclude the backflow of any nonpotable substance into the potable water system. Bypass piping shall not be provided around backflow preventers. Access shall be provided for maintenance and testing. Each device shall be a standard commercial unit.

3.3.7 Access Panels

Access panels shall be provided for concealed valves and controls, or any item requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced, maintained, or replaced. Access panels shall be as specified in Section 05500 MISCELLANEOUS METAL.

3.3.8 Sight Drains

Sight drains shall be installed so that the indirect waste will terminate 50 mm (2 inches) above the flood rim of the funnel to provide an acceptable air gap.

3.3.9 Traps

Each trap shall be placed as near the fixture as possible, and no fixture shall be double-trapped. Traps installed on cast-iron soil pipe shall be cast iron. Traps installed on steel pipe or copper tubing shall be recess-drainage pattern, or brass-tube type. Traps for acid-resisting waste shall be of the same material as the pipe.

3.3.10 Shower Pans

Before installing shower pan, subfloor shall be free of projections such as nail heads or rough edges of aggregate. Drain shall be a bolt-down, clamping-ring type with weepholes, installed so the lip of the subdrain is flush with subfloor.

3.3.10.1 General

The floor of each individual shower, the shower-area portion of combination shower and drying room, and the entire shower and drying room where the two are not separated by curb or partition, shall be made watertight with a shower pan fabricated in place. The shower pan material shall be cut to size and shape of the area indicated, in one piece to the maximum extent practicable, allowing a minimum of 150 mm (6 inches) for turnup on walls or partitions, and shall be folded over the curb with an approximate return of 1/4 of curb height. The upstands shall be placed behind any wall or partition finish. Subflooring shall be smooth and clean, with nailheads driven flush with surface, and shall be sloped to drain. Shower pans shall be clamped to drains with the drain clamping ring.

3.3.10.2 Metal Shower Pans

When a shower pan of required size cannot be furnished in one piece, metal pieces shall be joined with a flatlock seam and soldered or burned. The corners shall be folded, not cut, and the corner seam shall be soldered or burned. Pans, including upstands, shall be coated on all surfaces with one brush coat of asphalt. Asphalt shall be applied evenly at not less than 1 liter per square meter (1 gallon per 50 square feet). A layer of felt covered with building paper shall be placed between shower pans and wood floors. The joining surfaces of metal pan and drain shall be given a brush coat of asphalt after the pan is connected to the drain.

3.3.10.3 Nonplasticized Chlorinated Polyethylene Shower Pans

Corners of nonplasticized chlorinated polyethylene shower pans shall be folded against the upstand by making a pig-ear fold. Hot-air gun or heat lamp shall be used in making corner folds. Each pig-ear corner fold shall be nailed or stapled 12 mm (1/2 inch) from the upper edge to hold it in place. Nails shall be galvanized large-head roofing nails. On metal framing or studs, approved duct tape shall be used to secure pig-ear fold and membrane. Where no backing is provided between the studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding 12 mm (1/2 inch) from upper edge. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it will be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Surfaces to be solvent-welded shall be clean. Surfaces to be joined with xylene shall be initially sprayed and vigorously cleaned with a cotton cloth, followed by final coating of xylene and the joining of the surfaces by roller or equivalent means. If ambient or membrane temperatures are below 4 degrees C (40 degrees F) the membrane and the joint shall be heated prior to application of xylene. Heat may be applied with hot-air gun or heat lamp, taking precautions not to scorch the membrane. Adequate ventilation and wearing of gloves are required when working with xylene. Membrane shall be pressed into position on the drain body, and shall be cut and fit to match so that membrane can be properly clamped and an effective gasket-type seal provided. On wood subflooring, two layers of 0.73 kg per square meter (15 pound) dry felt shall be installed prior to installation of shower pan to ensure a smooth surface for installation.

3.3.10.4 Nonplasticized Polyvinyl Chloride (PVC) Shower Pans

Nonplasticized PVC shall be turned up behind walls or wall surfaces a distance of not less than 150 mm (6 inches) in room areas and 75 mm (3 inches) above curb level in curbed spaces with sufficient material to fold over and fasten to outside face of curb. Corners shall be pig-ear type and folded between pan and studs. Only top 25 mm (1 inch) of upstand shall be nailed to hold in place. Nails shall be galvanized large-head roofing type. Approved duct tape shall be used on metal framing or studs to secure pig-ear fold and membrane. Where no backing is provided between studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding at top inch of upstand. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it is to be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Trim for drain shall be exactly the size of drain opening. Bolt holes shall be pierced to accommodate bolts with a tight fit. Adhesive shall be used between pan and subdrain. Clamping ring shall be bolted firmly.

A small amount of gravel or porous materials shall be placed at weepholes so that holes remain clear when setting bed is poured. Membrane shall be solvent welded with PVC solvent cement. Surfaces to be solvent welded shall be clean (free of grease and grime). Sheets shall be laid on a flat surface with an overlap of about 50 mm (2 inches). Top edge shall be folded back and surface primed with a PVC primer. PVC cement shall be applied and surfaces immediately placed together, while still wet. Joint shall be lightly rolled with a paint roller, then as the joint sets shall be rolled firmly but not so hard as to distort the material. In long lengths, about 600 or 900 mm (2 or 3 feet) at a time shall be welded. On wood subflooring, two layers of 0.73 kg per square meter (15 pound) felt shall be installed prior to installation of shower pan to ensure a smooth surface installation.

3.4 VIBRATION-ABSORBING FEATURES

Mechanical equipment, including compressors and pumps, shall be isolated from the building structure by approved vibration-absorbing features, unless otherwise shown. Each foundation shall include an adequate number of standard isolation units. Each unit shall consist of machine and floor or foundation fastening, together with intermediate isolation material, and shall be a standard product with printed load rating. Piping connected to mechanical equipment shall be provided with flexible connectors. Isolation unit installation shall limit vibration as indicated.

3.4.1 Tank- or Skid-Mounted Compressors

Floor attachment shall be as recommended by compressor manufacturer.

3.4.2 Foundation-Mounted Compressors

Foundation attachment shall be as recommended by the compressor manufacturer.

3.5 WATER METER REMOTE READOUT REGISTER

The remote readout register shall be mounted at the location indicated or as directed by the Contracting Officer.

3.6 IDENTIFICATION SYSTEMS

3.6.1 Identification Tags

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and valve number shall be installed on valves, except those valves installed on supplies at plumbing fixtures. Tags shall be 35 mm (1-3/8 inch) minimum diameter, and marking shall be stamped or engraved. Indentations shall be black, for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain, or plastic straps designed for that purpose.

3.6.2 Pipe Color Code Marking

Color code marking of piping shall be as specified in Section 09900 PAINTS AND COATINGS.

3.6.3 Color Coding Scheme for Locating Hidden Utility Components

Scheme shall be provided in buildings having suspended grid ceilings. The color coding scheme shall identify points of access for maintenance and operation of operable components which are not visible from the finished space and installed in the space directly above the suspended grid ceiling. The operable components shall include valves, dampers, switches, linkages and thermostats. The color coding scheme shall consist of a color code board and colored metal disks. Each colored metal disk shall be approximately 12 mm (3/8 inch) in diameter and secured to removable ceiling panels with fasteners. The fasteners shall be inserted into the ceiling panels so that the fasteners will be concealed from view. The fasteners shall be manually removable without tools and shall not separate from the ceiling panels when panels are dropped from ceiling height. Installation of colored metal disks shall follow completion of the finished surface on which the disks are to be fastened. The color code board shall have the approximate dimensions of 1 m 3 foot width, 750 mm (30 inches) height, and 12 mm (1/2 inch) thickness. The board shall be made of wood fiberboard and framed under glass or 1.6 mm (1/16 inch) transparent plastic cover. Unless otherwise directed, the color code symbols shall be approximately 20 mm (3/4 inch) in diameter and the related lettering in 12 mm (1/2 inch) high capital letters. The color code board shall be mounted and located in the mechanical or equipment room. The color code system shall be as indicated below:

Color	System	Item	Location
[_____]	[_____]	[_____]	[_____]

3.7 ESCUTCHEONS

Escutcheons shall be provided at finished surfaces where bare or insulated piping, exposed to view, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

3.8 PAINTING

Painting of pipes, hangers, supports, and other iron work, either in concealed spaces or exposed spaces, is specified in Section 09900 PAINTS AND COATINGS.

3.9 TESTS, FLUSHING AND DISINFECTION

3.9.1 Plumbing System

The following tests shall be performed on the plumbing system in accordance with ICC International Plumbing Code.

a. Drainage and Vent Systems Test. The final test shall include a smoke test.

b. Building Sewers Tests.

c. Water Supply Systems Tests.

3.9.1.1 Test of Backflow Prevention Assemblies

Backflow prevention assembly shall be tested using gauges specifically designed for the testing of backflow prevention assemblies. Gauges shall be tested annually for accuracy in accordance with the University of Southern California's Foundation of Cross Connection Control and Hydraulic Research or the American Water Works Association Manual of Cross Connection (Manual M-14). Report form for each assembly shall include, as a minimum, the following:

Data on Device	Data on Testing Firm
Type of Assembly	Name
Manufacturer	Address
Model Number	Certified Tester
Serial Number	Certified Tester No.
Size	Date of Test
Location	Test Pressure Readings of Gauges and Test Data

If the unit fails to meet specified requirements, the unit shall be repaired and retested.

3.9.1.2 Shower Pans

After installation of the pan and finished floor, the drain shall be temporarily plugged below the weep holes. The floor area shall be flooded with water to a minimum depth of 25 mm (1 inch) for a period of 24 hours. Any drop in the water level during test, except for evaporation, will be reason for rejection, repair, and retest.

3.9.1.3 Compressed Air Piping (Nonoil-Free)

Piping systems shall be filled with oil-free dry air or gaseous nitrogen to 1.03 MPa (150 psig) and hold this pressure for 2 hours with no drop in pressure.

3.9.2 Defective Work

If inspection or test shows defects, such defective work or material shall be replaced or repaired as necessary and inspection and tests shall be repeated. Repairs to piping shall be made with new materials. Caulking of screwed joints or holes will not be acceptable.

3.9.3 System Flushing

3.9.3.1 During Flushing

Before operational tests or disinfection, potable water piping system shall be flushed with potable water. Sufficient water shall be used to produce a water velocity that is capable of entraining and removing debris in all portions of the piping system. This requires simultaneous operation of all fixtures on a common branch or main in order to produce a flushing velocity of approximately 1.2 meters per second (4 fps) through all portions of the piping system. In the event that this is impossible due to size of system, the Contracting Officer (or the designated representative) shall specify the number of fixtures to be operated during flushing. Contractor shall provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the facility. Contractor shall be responsible for any flood damage resulting from flushing of the system. Flushing shall be continued until entrained dirt and other foreign materials have been removed and until discharge water shows no discoloration.

3.9.3.2 After Flushing

System shall be drained at low points. Strainer screens shall be removed, cleaned, and replaced. After flushing and cleaning, systems shall be prepared for testing by immediately filling water piping with clean, fresh potable water. Any stoppage, discoloration, or other damage to the finish, furnishings, or parts of the building due to the Contractor's failure to properly clean the piping system shall be repaired by the Contractor. When the system flushing is complete, the hot-water system shall be adjusted for uniform circulation. Flushing devices and automatic control systems shall be adjusted for proper operation.

3.9.4 Operational Test

Upon completion of flushing and prior to disinfection procedures, the Contractor shall subject the plumbing system to operating tests to demonstrate satisfactory functional and operational efficiency. Such operating tests shall cover a period of not less than 8 hours for each system and shall include the following information in a report with conclusion as to the adequacy of the system:

a. Time, date, and duration of test.

b. Water pressures at the most remote and the highest fixtures.

c. Operation of each fixture and fixture trim.

d. Operation of each valve, hydrant, and faucet.

e. Pump suction and discharge pressures.

f. Temperature of each domestic hot-water supply.

g. Operation of each floor and roof drain by flooding with water.

h. Operation of each vacuum breaker and backflow preventer.

i. Complete operation of each water pressure booster system, including pump start pressure and stop pressure.

j. Compressed air readings at each compressor and at each outlet. Each indicating instrument shall be read at 1/2 hour intervals. The report of the test shall be submitted in quadruplicate. The Contractor shall furnish instruments, equipment, and personnel required for the tests; the Government will furnish the necessary water and electricity.

3.9.5 Disinfection

After operational tests are complete, the entire domestic hot- and cold-water distribution system shall be disinfected. System shall be flushed as specified, before introducing chlorinating material. The chlorinating material shall be hypochlorites or liquid chlorine. Water chlorination procedure shall be in accordance with AWWA M20. The chlorinating material shall be fed into the water piping system at a constant rate at a concentration of at least 50 parts per million (ppm). A properly adjusted hypochlorite solution injected into the main with a hypochlorinator, or liquid chlorine injected into the main through a solution-feed chlorinator and booster pump, shall be used. The chlorine residual shall be checked at intervals to ensure that the proper level is maintained. Chlorine application shall continue until the entire main is filled. The water shall remain in the system for a minimum of 24 hours. Each valve in the system being disinfected shall be opened and closed several times during the contact period to ensure its proper disinfection. Following the 24-hour period, no less than 25 ppm chlorine residual shall remain in the system. Water tanks shall be disinfected by the addition of chlorine directly to the filling water. Following a 6 hour period, no less than 50 ppm chlorine residual shall remain in the tank. If after the 24 hour and 6 hour holding periods, the residual solution contains less than 25 ppm and 50 ppm chlorine respectively, flush the piping and tank with potable water, and repeat the above procedures until the required residual chlorine levels are satisfied. The system including the tanks shall then be flushed with clean water until the residual chlorine level is reduced to less than one part per million. During the flushing period each valve and faucet shall be opened and closed several times. Samples of water in disinfected containers shall be obtained from several locations selected by the Contracting Officer. The samples of water shall be tested for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA EWW. The testing method used shall be either the multiple-tube fermentation technique or the membrane-filter technique. Disinfection shall be repeated until tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

3.10 PLUMBING FIXTURE SCHEDULE

P-1 WATER CLOSET:

Siphon-jet, elongated bowl, top supply spud, ASME A112.19.2M or KS L 1551, C1110C(R) or C2010C (one-piece), floor mounted or wall mounted as indicated. Floor flange shall be copper alloy, cast iron, or plastic. Gasket shall be wax type.

Seat - ANSI Z124.5, Type A, black or white plastic, elongated, open front.

Flushometer Valve - ASSE 1037, large diaphragm type with non-hold-open feature, backcheck angle control stop, and vacuum breaker. Minimum upper chamber inside diameter of not less than 66.7 mm (2-5/8 inches) at the point where the diaphragm is sealed between the upper and lower chambers. The maximum water use shall be 6 liters (1.6 gallons) per flush.

Flush Tank - An adequate quantity of water shall be provided to flush and clean the fixture served. The water supply to flush tanks equipped for manual flushing shall be controlled by a float valve or other automatic device designed to refill the tank after each discharge, and to completely shut off the water flow to the tank when the tank is filled to operational capacity. Water closets having their flush valve seat located below the flood level rim of the closet bowl shall have a ballcock installed within a sheath or in a separate and isolated compartment of the tank, both to have visible discharge onto the floor in case of failure. Provision shall be made to automatically supply water to the fixture so as to refill the trap seal after each flushing. The water supply to flush tanks equipped for automatic flushing shall be controlled by a suitable timing device. Ballcocks shall meet ASSE 1002.

Flush Valve in Flush Tank - Flush valve seats in tanks for flushing water closets shall be at least 25 mm (1 inch) above the flood level rim of the bowl connected thereto, except in approved water closet and flush tank combinations designed so that when the tank is flushed and the fixture is clogged or partially clogged, the flush valve shall close tightly so that water will not spill continuously over the rim of the bowl or back flow from the bowl to the tank.

P-2 WATER CLOSET HANDICAPPED:

Height of top rim of bowl shall be in accordance with ICC A117.1; other features are the same as P-1.

P-3 URINAL:

Wall hanging, with integral trap and extended shields, ASME A112.19.2M or KS L 1551, U410R, siphon jet or washout. Top supply connection, back outlet.

Flushometer Valve - Similar to Flushometer Valve for P-1. The maximum water use shall be 3.8 liters (1 gallon) per flush.

P-4 BATHTUB:

Straight front, recessed, 1.524 m x 812.8 mm x 406.4 mm (60 x 32 x 16 in), porcelain enameled formed steel with structural composite reinforcement ASME A112.19.4M or KS F 4806.

Drain Assembly - Plug, cup strainer, overflow assembly, washers, couplings, pop-up lever, trip lever, stopper, fittings, etc., shall be brass, cast copper alloy, or wrought copper alloy. See paragraph FIXTURES for optional plastic accessories.

P-5 LAVATORY:

Manufacturer's standard sink depth, vitreous china, ASME A112.19.2M or KS L1551, straight back, ledge back, shelf back, countertop, or rectangular as indicated.

Faucet - Faucets shall meet the requirements of NSF 61, Section 9. Faucets shall be single control, mixing type. Faucets shall have replaceable seats and washers. Faucets shall have metal replaceable cartridge control unit or metal cartridge units with diaphragm which can be replaced without special tools. Valves and handles shall be copper alloy. Connection between valve and spout for center-set faucet shall be of rigid metal tubing. Flow shall be limited to 1 liter (0.25 gallon) per cycle at a flowing water pressure of 549 kPa (80 psi) if a metering device or fitting is used that limits the period of water discharge such as a foot switch or fixture occupancy sensor. If a metering device is not used, the flow shall be limited to 0.16 liters per second (2.5 gpm) at a flowing pressure of 549 kPa (80 psi).

Handles - Lever type. Cast, formed, or drop forged copper alloy.

Drain - Pop-up drain shall include stopper, lift rods, jam nut, washer, and tail piece. See paragraph FIXTURES for optional plastic accessories.

P-6 WHEELCHAIR LAVATORY:

Vitreous china, ASME A112.19.2M, wheelchair lavatory with wrist or elbow controls 508.0 mm wide x 685.8 mm (20 inches wide x 27 inches) deep with gooseneck spout. Flow shall be limited to 1 liter (0.25 gallon) per cycle at a flowing water pressure of 549 kPa (80 psi) if a metering device or fitting is used that limits the period of water discharge such as foot switch or fixture occupancy sensor. If a metering device is not used, the flow shall be limited to 0.16 liters per second 2.5 gpm at a flowing water pressure of 549 kPa (80 psi).

Drain - Strainer shall be copper alloy or stainless steel.

P-7 KITCHEN SINK:

Ledge back with holes for faucet and spout single bowl, 609.6 x 533.4 mm (24 x 21 inches) or 609.6 x 762.0 mm (24 x 30 inches), or double bowl 812.8 x 533.4 mm (32 x 21 inches) or 1067.0 x 533.4 mm (42 x 21 inches) as indicated, stainless steel ASME A112.19.3M.

Faucet and Spout - Faucets shall meet the requirements of NSF 61, Section 9. Cast or wrought copper alloy. Aerator shall have internal threads. Flow shall be limited to 1 liter (0.25 gallon) per cycle at a flowing water pressure of 549 kPa (80 psi) if a metering device or fitting is used that limits the period of water discharge such as a foot switch or fixture occupancy sensor. If a metering device is not used, the flow shall be limited to 0.16 liters per second (2.5 gpm) at a flowing water pressure of 549 kPa (80 psi).

Handle - Cast copper alloy, wrought copper alloy, or stainless steel. Single lever type.

Drain Assembly - Plug, cup strainer, crossbars, jam nuts, washers, couplings, stopper, etc., shall be copper alloy or stainless steel.

P-8 SERVICE SINK:

Vitreous china, KS L 1551, S210.

Faucet and Spout - Cast or wrought copper alloy, with top or bottom brace, with backflow preventer. Faucets shall have replaceable seat and the washer shall rotate onto the seat. Handles shall be lever or four arm type. Strainers shall have internal threads.

Drain Assembly - Plug, cup strainer, crossbars, jam nuts, washers, couplings, stopper, etc., shall be copper alloy or stainless steel. Trap - Cast iron, minimum 7.5 cm (3 inch) diameter.

P-9 COMBINATION SINK AND LAUNDRY TRAY:

Ledge back, 1067 x 635.0 mm (42 x 25 inch), 101.6 mm (4 inch) splash back, 203.2 mm (8 inches) deep sink, 304.8 mm (12 inches) deep tray; or counter top, 1067 x 533.4 mm (42 x 21 inch), 101.6 mm (4 inch) splash back, 190.5 mm (7-1/2 inches) deep sink, 254 mm (10 inches) deep tray; left hand or right hand, porcelain enameled steel ASME A112.19.4M.

Faucet and Spout - Cast or wrought copper alloy, with top or bottom brace, with backflow preventer. Faucets shall have replaceable seat and the washer shall rotate onto the seat. Strainers shall have internal threads. Combination faucets with two valves and spouts shall be provided.

Handles - Cast or wrought copper alloy. Lever type.

P-10 LABORATORY SINK:

Ledge back, 584.2 mm wide x 381.0 mm (23 inches wide x 15 inches) deep or 762.0 mm wide x 508.0 mm (30 inches wide x 20 inches) deep; or countertop, 508.0 mm wide x 381.0 mm deep (20 inches wide x 15 inches deep) or 762.0 mm wide x 508.0 mm (30 inches wide x 20 inches) deep, corrosion-resisting steel ASME A112.19.3M. Thickness of sinks shall be manufacturer's standard. Drain and trap shall be stainless steel.

Faucet and Spout - Cast or wrought copper alloy, with top or bottom brace, with backflow preventer. Faucets shall have replaceable seat and the washer shall rotate onto the seat. Strainers shall have internal threads.

Handles - Cast copper alloy, wrought copper alloy, or stainless steel, lever type.

P-11 SCULLERY SINK:

Stainless steel, ASME A112.19.3M with drainboard, 914.4 x 609.6 mm (36 x 24 inch) compartments, 685.8 mm (27 inch) deep, 381.0 mm (15 inch) splashback, single compartment - 1549 mm (61 inches) wide, double compartment - 2743 mm (108 inches) wide, or triple compartment - 3505.2 mm (138 inches) wide. Drain shall have quick opening valve. Support on stainless steel legs.

Faucet and Spout - Cast or wrought copper alloy, with backflow preventer. Faucets shall have replaceable seat and the washer shall rotate onto the seat. Strainers shall have internal threads. Combination faucets with two valves and spouts shall be provided.

Handles - Cast copper alloy, wrought copper alloy, or stainless steel, four arm type.

Drain Assembly - Plug, cup strainer, crossbars, jam nuts, washers, couplings, stopper, etc., shall be copper alloy or stainless steel.

P-12 LAUNDRY SINK:

Double bowl, countertop 1067 x 533.4 mm (42 x 21 inches); ledge back 1067 x 609.6 mm (42 x 24 inches); pedestal 1219 x 508.0 mm (48 x 20 inches); or leg support 1219 x 508.0 mm (48 x 20 inches), stainless steel ASME A112.19.3M.

Faucet and Spout - Cast copper alloy, wrought copper alloy, cast iron, or stainless steel, with backflow preventer. Faucets shall have replaceable seat and the stem shall rotate onto the seat. Strainers shall have internal threads. Combination faucets shall be mounted on the tub back. Spouts shall be externally threaded for hose connection.

Handles - Cast copper alloy, wrought copper alloy, or stainless steel, lever type.

Traps - Copper alloy, or cast iron.

P-13 Shower:

Shower heads, CID A-A-240 other than emergency showers, shall be adjustable spray type and shall include a non-removable, tamperproof device to limit water flow to 0.16 liters per second (2.5 gpm) when tested in accordance with ASME A112.18.1M.

Wall Mounted: Shower head shall be adjustable spray, stainless steel or chromium plated brass with ball joint. Handles shall be manufacturer's option. Control valves shall be copper alloy and have metal integral parts of copper alloy, nickel alloy, or stainless steel. Valves shall be thermostatic mixing or mechanical mixing, single lever type as indicated. Shower head shall be vandalproof with integral back.

Column Showers: Column showers shall have a 1.8 m (6 foot) column height measured from floor to shower head, 12 mm (1/2 inch) IPS threads.

Bath Showers: Bath showers shall include bathtub spout, shower head, valves, and diverters. A shower head mounting with ball joint and head integral with a formed wall plate shall be provided. Diverter shall be integral with single mixing valves. Tub spout shall be copper alloy.

Cabinet Showers: Free standing cabinet, single unit with receptor; 863.6 mm (34 inches) wide by 863.6 mm (34 inches) deep, fiberglass reinforced plastic with terrazzo or plastic receptor. Cabinet shall include curtain rod, trim, and concealed fittings.

Emergency Showers: Head for Emergency and Emergency Eye and Face Wash. Shower control shall be 25 mm (1 inch) or 40 mm (1-1/2 inch) stay-open type control valve. Unit shall be corrosion-resisting steel and shall be wall mounted or pedestal mounted. Emergency showers shall comply with ANSI Z358.1.

Emergency Eye Wash: Fountain, ANSI Z358.1, eye wash, wall mounted self-cleaning, non-clogging eye and face wash with quick opening, full-flow valves, corrosion-resisting steel eye and face wash receptor. Unit shall deliver 0.19 L/s (3 gpm) of aerated water at 207 kPa (gage) flow pressure, with eye and face wash nozzles 838 to 1143 mm (33 to 45 inches) above finished floor. Copper alloy control valves shall be provided. An air-gap shall be provided with the lowest potable eye and face wash water outlet located above the overflow rim by not less than the ICC International Plumbing Code minimum per IPC Table 608.15.1. The Contractor shall provide packaged, U.L. listed, alarm system; including an amber strobe lamp, horn with externally adjustable loudness and horn silencing switch, mounting hardware, and waterflow switch, assembled and prewired for NEMA 3 waterproof and NEMA 4 explosion proof service, complete with 15 mm (1/2 inch) pipe connection and 32 mm (1-1/4 inch) standard chrome drain fitting.

P-14 BUBBLER DRINKING FOUNTAINS:

Drinking fountains shall meet the requirements of NSF 61, Section 9. Bubbler drinking fountains shall have self-closing valves. Self-closing valves shall have automatic stream regulators, flow control capability, a push button actuation or a cross-shaped index metal turn handle without a hood. Spouts shall provide a flow of water at least 100 mm (4 inches) high so as to allow the insertion of a cup or glass under the flow of water. Stops, stream regulators, flow controls, pushbuttons, handles, and traps shall be made of copper zinc alloy. Strainers and drains shall be made of copper zinc alloy or stainless steel. Surface Wall-Mounted - Surface wall-mounted units shall be 336.6 mm (13-1/4 inches) wide, 330.2 mm (13 inches) deep, 254.0 mm (10 inches) high, and have a back height of 152.4 to 203.2 mm (6 to 8 inches). The bowl shall be made of corrosion-resisting steel. The unit shall have concealed fasteners and be for interior or exterior installation as indicated.

Semi-Recessed Wall-Mounted - Semi-recessed wall-mounted units shall be 55.6 mm (14 inches) wide, 279.4 mm (11 inches) deep, 676.3 mm (26-5/8 inches) high, and have a back height of 330.2 to 558.8 mm (13 to 22 inches). The bowl shall be made of corrosion-resisting steel. The unit shall be for interior or exterior installation as indicated.

Recessed Wall-Mounted - Recessed wall-mounted units shall be 425.5 mm 16-3/4 inches) wide, 279.4 mm (11 inches) deep, 762.0 mm (30 inches) high, and have a back height of 330.2 to 558.8 mm (13 to 22 inches). The bowl shall be made of corrosion-resisting steel. The unit shall be for interior or exterior installation as indicated.

Handicapped - Handicapped units shall be surface wall-mounted. The dimensions shall be 381.0 mm (15 inches) wide, 508.0 mm (20 inches) deep, with a back height of 152.4 to 203.2 mm (6 to 8 inches). The unit shall clear the floor or ground by at least 200 mm (8 inches). A clear knee space shall exist between the bottom of the bowl and the floor or ground of at least 685 mm (27 inches) and between the front edge of the bowl and the body of the unit of at least 200 mm (8 inches). A 200 mm (8 inch) wide clear space shall exist on both sides of the unit. The spout height shall be no more than 915 mm (36 inches) above the floor or ground to the outlet. The spout shall be at the front of the unit and direct the water flow in a trajectory that is parallel or nearly parallel to the front of the unit. The bowl shall be 165.1 mm (6-1/2 inches) high and made of corrosion-resisting steel. The unit shall be for interior or exterior installation as indicated.

Interior Free Standing - Free standing units shall be 1016 to 1054.1 mm (40 to 41-1/2 inches) high, 304.8 to 457.2 mm (12 to 18 inches), and 304.8 to 355.6 mm (12 to 14 inches) deep. The bowl shall be made of corrosion-resisting steel. The unit shall be for interior installation.

Exterior Free Standing - Free standing units shall be 914.4 mm (36 inches) high, and 304.8 to 457.2 mm (12 to 18 inches) in diameter. The bowl shall be made of stainless steel. The unit shall be for exterior installation.

P-15 WATER COOLER DRINKING FOUNTAINS:

Drinking fountains shall meet the requirements of NSF 61, Section 9. Water cooler drinking fountains shall: be self contained, conform to ARI 1010, use one of the fluorocarbon gases conforming to ARI 700 and ASHRAE 34 which has an Ozone Depletion Potential of less than or equal to 0.05, have a capacity to deliver 30.2 liters per hour (8 gph) of water at 10 degrees C (50 degrees F) with an inlet water temperature of 27 degrees C (80 degrees F) while residing in a room environment of 32 degrees C (90 degrees F), and have self-closing valves. Self-closing valves shall have automatic stream regulators, have a flow control capability, have a push button actuation or have a cross-shaped index metal turn handle without a hood. Exposed surfaces of stainless steel shall have No. 4 general polish finish. Spouts shall provide a flow of water at least 100 mm (4 inches) high so as to allow the insertion of a cup or glass under the flow of water.

Surface Wall-Mounted - Surface wall-mounted units shall be 336.6 mm (13-1/4 inches) wide, 330.2 mm (13 inches) deep, and have a back height of 152.4 to 203.2 mm (6 to 8 inches). The bowl shall be made of stainless steel. The unit shall have concealed fasteners and be for interior or exterior installation as indicated.

Semi-Recessed Wall-Mounted - Semi-recessed wall-mounted units shall be 355.6 mm (14 inches) wide, 279.4 mm (11 inches) deep, and have a back height of 330.2 to 558.8 mm (13 to 22 inches). The bowl shall be made of stainless steel and be for interior or exterior installation as indicated.

Recessed Wall-Mounted - Recessed wall-mounted units shall be 425.5 mm (16-3/4 inches) wide, 279.4 mm (11 inches) deep, and have a back height 330.2 to 558.8 mm (13 to 22 inches). The bowl shall be made of stainless steel and be for interior or exterior installation as indicated.

Handicapped - Handicapped units shall be surface wall-mounted. The dimensions shall be 381.0 mm (15 inches) wide, 508.0 mm (20 inches) deep, with a back height of 152.4 to 203.2 mm (6 to 8 inches). The unit shall clear the floor or ground by at least 200 mm (8 inches). A clear knee space shall exist between the bottom of the bowl and the floor or ground of at least 685 mm (27 inches) and between the front edge of the bowl and the body of the unit of at least 200 mm (8 inches). A 200 mm (8 inch) wide clear space shall exist on both sides of the unit. The spout height shall be no more than 1 m (36 inches) above the floor or ground to the outlet. The spout shall be at the front of the unit and direct the water flow in a trajectory that is parallel or nearly parallel to the front of the unit. The bowl shall be 165.1 mm (6-1/2 inches) high, made of stainless steel and be for interior or exterior installation as indicated.

Interior Free Standing - Free standing units shall be 1016 to 1054.1 mm (40 to 41-1/2 inches) high, 304.8 to 457.2 mm (12 to 18 inches) wide, and 304.8 to 355.6 mm (12 to 14 inches) deep. The bowl shall be made of stainless steel and be for interior installation.

P-16 FOOD WASTE DISPOSER:

Food waste disposers shall be in accordance with UL 430.

P-17 GARBAGE DISPOSAL MACHINES:

Garbage disposals machines shall be in accordance with CID A-A-50012.

P-18 WASH FOUNTAIN:

Circular - 6 or 8 station, Semicircular - 3, 4, 5 station, or Corner - 2 or 3 station, 1.9837 mm (14 gauge) stainless steel, galvanized steel or masonry bowl as indicated.

P-19 DISHWASHING MACHINES:

Commercial dishwashing machines shall conform to NSF 3, NSF 5 and UL 921. Household dishwashing machines shall conform to UL 749 and ASSE 1006, sized as indicated.

3.11 POSTED INSTRUCTIONS

Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

3.12 PERFORMANCE OF WATER HEATING EQUIPMENT

Standard rating condition terms are as follows:

EF = Energy factor, overall efficiency.

ET = Thermal efficiency with 21 degrees C (70 degrees F) delta T.

EC = Combustion efficiency, 100 percent - flue loss when smoke = o (trace is permitted).

SL = Standby loss in W/0.093 sq. m (W/sq. ft) based on 27 degrees C (80 degrees F) delta T, or in percent per hour based on nominal 38 degrees C (90 degrees F) delta T.

HL = Heat loss of tank surface area.

V = Storage volume in liters

3.12.1 Storage Water Heaters

3.12.1.1 Electric

a. Storage capacity of 454 liters (120 gallons) or less, and input rating of 12 kW or less: minimum energy factor (EF) shall be 0.95-0.00132V per 10 CFR 430.

b. Storage capacity of more than 454 liters (120 gallons) or input rating more than 12 kW: maximum SL shall be 1.9 w/0.093 sq. m (1.9 W/sq. ft) per ASHRAE 90.1, Addenda B.

3.12.1.2 Gas

a. Storage capacity of 379 liters (100 gallons) or less, and input rating of 21980 W (75,000 Btu/h) or less: minimum EF shall be 0.62-0.0019V per 10 CFR 430.

b. Storage capacity of more than 379 liters (100 gallons) or input rating more than 21980 W (75,000 Btu/h): Et shall be 77 percent; maximum SL shall be 1.3+38/V, per ANSI Z21.10.3.

3.12.1.3 Oil

a. Storage capacity of 189 liters (50 gallons) or less and input rating of 30773 W (105,000 Btu/h) or less: minimum EF shall be 0.59-0.0019V per 10 CFR 430.

b. Storage capacity of more than 189 liters (50 gallons) or input rating more than 30773 W (105,000 Btu/h): EC shall be 83 percent; maximum SL shall be 1.3+38/V, per 10 CFR 430.

3.12.2 Unfired Hot Water Storage

Volumes and inputs: maximum HL shall be 20.5 W/sq. meter (6.5 Btu/h/sq. ft).

3.12.3 Instantaneous Water Heater

3.12.3.1 Gas

Volumes and inputs: ET shall be 80 percent per ANSI Z21.10.3.

3.12.3.2 Oil

Capacities and inputs: EC shall be 83 percent per ANSI Z21.10.3.

3.12.4 Pool Heaters

Gas/oil fuel, capacities and inputs: ET shall be 78 percent per ANSI Z21.56.

3.13 TABLES

TABLE I

PIPE AND FITTING MATERIALS FOR
DRAINAGE, WASTE, AND VENT PIPING SYSTEMS

		SERVICE					
Item #	Pipe and Fitting Materials	A	B	C	D	E	F
1	Cast iron soil pipe and fittings, hub and spigot, KS D 4307, Class 1	X	X	X			
2	Cast iron soil pipe and fittings hubless, KS D 4307		X				
3	Malleable-iron threaded fittings, galvanized, KS B 1531, for use with Item 4				X	X	
4	Steel pipe, seamless galvanized, KS D 3562, schedule 40				X	X	
5	Polyvinyl Chloride plastic drain, waste and vent pipe and fittings, KS M 3404 VG1and KS M 3410.						X

SERVICE:

A - Underground Building Soil, Waste and Storm Drain
B - Aboveground Soil, Waste, Drain In Buildings
C - Underground Vent
D - Aboveground Vent
E - Interior Rainwater Conductors Aboveground
F - Corrosive Waste And Vent Above And Belowground

TABLE II

PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

		SERVICE			
Item No.	Pipe and Fitting Materials	A	B	C	D
1	Malleable-iron threaded fittings, Galvanized, KS B 1531 for use with Item 2			X	
2	Steel pipe, Seamless, galvanized, KS D 3562, SPPS 42, schedule 40			X	
3	Seamless copper water tube, KS D 5301, C1020 or C1220	X**	X**		X***
4	Copper Alloy Solder-Joint Fittings, KS B 1544, for use with Item 3	X	X		X
5	Pipe Fittings of Copper and Copper Alloys, KS D 5578, for use with Item 3	X	X		X

A - Cold Water Aboveground
B - Hot Water 82 degree C (180 degrees F) Maximum Aboveground
C - Compressed Air Lubricated
D - Cold Water Service Belowground

Indicated types are minimum wall thicknesses.
** - Type L - Hard
*** - Type K - Hard temper with brazed joints only or type K-soft temper without joints in or under floors
**** - In or under slab floors only brazed joints

TABLE III

STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT

FUEL	STORAGE CAPACITY LITERS		INPUT RATING	TEST PROCEDURE	REQUIRED PERFORMANCE
A. STORAGE WATER HEATERS					
Elect.	454 max.		12 kW max.	10 CFR 430	EF = 0.95-0.00132V minimum
Elect.	454 min.	OR	12 kW min.	ASHRAE 90.1 (Addenda B)	SL = 1.9 W/0.09 sq. m. maximum
Gas	380 max.		22 kW max.	10 CFR 430	EF = 0.62-0.0019V minimum
Gas	380 min.	OR	22 kW min.	ANSI Z21.10.3	ET= 77 percent; SL = 1.3+38/V max.
Oil	190 max.		30.8 kW	10 CFR 430	EF = 0.59-0.0019V minimum
Oil	190 min.	OR	30.8 kW	10 CFR 430	EC = 83 percent; SL = 1.3+38/V maximum
B. Unfired Hot Water Storage, Instantaneous water heater, and pool heater. Volumes and inputs: maximum HL shall be 20.5 W/sq. meter					
C. Instantaneous Water Heater					
Gas	All		All	ANSI Z21.10.3	ET = 80 percent
Oil	All		All	ANSI Z21.10.3	EC = 83 percent
D. Pool Heater					
Gas or Oil	All		All	ANSI Z21.56	ET = 78 percent

TERMS:
EF = Energy factor, overall efficiency.
ET = Thermal efficiency with 21 degrees C delta T.
EC = Combustion efficiency, 100 percent - flue loss when smoke = 0 (trace is permitted).
SL = Standby loss in W/0.09 sq. m. based on 27 degrees C delta T, or in percent per hour based on nominal 32 degrees C delta T.
HL = Heat loss of tank surface area
V = Storage volume in gallons

TABLE III

STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS
FOR WATER HEATING EQUIPMENT

FUEL	STORAGE CAPACITY GALLONS	INPUT RATING	TEST PROCEDURE	REQUIRED PERFORMANCE
A. STORAGE WATER HEATERS				
Elect.	120 max.	12 kW max.	10 CFR 4 30	EF = 0.95-0.00132V minimum
Elect.	120 min. OR	12 kW min.	ASHRAE 90.1 (Addenda B)	SL = 1.9 W/sq. ft. maximum
Gas	100 max.	75,000 Btu/h	10 CFR 430	EF = 0.62-0.0019V max. minimum
Gas	100 min. OR	75,000 Btu/h	ANSI Z21.10.3	ET = 77 percent; SL = 1.3+38/V max.
Oil	50 max.	105,000 Btu/h	10 CFR 430	EF = 0.59-0.0019V minimum
Oil	51 min. OR	105,000 Btu/h	10 CFR 430	EC = 83 percent; SL = 1.3+38/V maximum
B. Unfired Hot Water Storage, instantaneous water heater, and pool heater.				
Volumes and inputs: maximum HL shall be 6.5 Btu/h/sq. ft.				
C. Instantaneous Water Heater				
Gas	All	All	ANSI Z21.10.3	ET = 80 percent
Oil	All	All	ANSI Z21.10.3	EC = 83 percent
D. Pool Heater				
Gas or Oil	All	All	ANSI Z21.56	ET = 78 percent

TERMS:
EF = Energy factor, overall efficiency.
ET = Thermal efficiency with 70 degrees F delta T.
EC = Combustion efficiency, 100 percent - flue loss when smoke = 0 (trace is permitted).
SL = Standby loss in W/sq. ft. based on 80 degrees F delta T, or in percent per hour based on nominal 90 degrees F delta T.
HL = Heat loss of tank surface area
V = Storage volume in gallons

SECTION 15566

WARM AIR HEATING SYSTEMS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR DIFFUSION COUNCIL (ADC)

ADC 1062:GRD (1984) Test Codes for Grilles, Registers and Diffusers

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.47 (1998) Gas-Fired Furnaces

ANSI Z21.66 (1996) Automatic Vent Damper Devices for Use with

Gas-Fired Appliances

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123	(2001) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 653	(2000) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM D 520	(2000) Zinc Dust Pigment
ASTM D 1654	(1992) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 3359	(1997) Measuring Adhesion by Tape Test
ASTM F 872	(1984; R 1990) Filter Units, Air Conditioning: Viscous-Impingement Type, Cleanable

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 52.1	(1992) Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter

INTERNATIONAL APPROVAL SERVICES (IAS)

IAS Directory	(1998) IAS Directory of AGA & CGA Certified Appliances and Accessories

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(1998) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 211	(2000) Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances
NFPA 31	(1997; TIA 97-1) Installation of Oil Burning Equipment
NFPA 54	(1999) National Fuel Gas Code
NFPA 90A	(1999) Installation of Air Conditioning and Ventilating Systems
NFPA 90B	(1999) Installation of Warm Air Heating and Air Conditioning Systems

NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION (NAIMA)

NAIMA AH115	(1993) Fibrous Glass Duct Construction Standards

SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA HVAC Duct Const Stds	(1995; Addenda Nov 1997) HVAC Duct Construction Standards - Metal and Flexible
SMACNA Install Fire Damp HVAC	(1992) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
SMACNA Leakage Test Manual	(1985) HVAC Air Duct Leakage Test Manual

UNDERWRITERS LABORATORIES (UL)

UL 1738	(1993; Rev thru Mar 1998) Venting Systems for Gas-Burning Appliances, Categories II, III and IV
UL 181	(1996; Rev Dec 1998) Factory-Made Air Ducts and Air Connectors
UL 214	(1997) Tests for Flame-Propagation of Fabrics and Films
UL 296	(1994; Rev Sep 1998) Oil Burners
UL 441	(1996; Rev Dec 1999) Gas Vents
UL 555	(1999) Fire Dampers
UL 641	(1995; Rev Apr 1999) Type L, Low-Temperature Venting Systems
UL 727	(1994; Rev thru Jan 1999) Oil Fired Central Furnaces
UL 900	(1994; Rev thru Nov 1999) Test Performance of Air Filter Units
UL Bld Mat Dir	(1999) Building Materials Directory
UL Elec Const Dir	(1999) Electrical Construction Equipment Directory
UL Fire Resist Dir	(1999) Fire Resistance Directory (2 Vol.)

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506	(2001) Hot-Dip Zinc-Coated Steel Sheets and Coils
KS D 3562	(1989) Carbon Steel Pipes for Pressure Service
KS D 8308	(2001) Zinc Hot Dip Galvanizings

KS M 3404 (2001) Unplasticized Polyvinyl Chloride Pipes for General Service

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Heating Equipment; G
Installation; G

Drawings shall consist of a complete list of equipment and material including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Drawings shall contain complete equipment wiring diagrams, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout and anchorage of equipment and appurtenance and equipment relationship to other parts of the work including clearances required for maintenance and operation.

SD-03 Product Data

Spare Parts

Spare parts data for each different item of material and equipment specified, after approval of detail drawings and not later than 1 month prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 12 months operation, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 years of service.

Tests

Proposed test procedures for ductwork leak and performance tests, at least 2 weeks prior to the start of related testing.

Proposed test schedules for ductwork leak test and performance tests, at least 2 weeks prior to the start of related testing.

System Diagrams; G

Proposed diagrams, at least 2 weeks prior to start of related testing. System diagrams that show the layout of equipment and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

Similar Services

Statement demonstrating successful completion of similar services on at least 5 projects of similar size and scope, at least 2 weeks prior to submittal of other items required by this section.

Field Training

Proposed schedule for field training, at least 2 weeks prior to the start of related training.

SD-06 Test Reports

Tests; G

Test reports for the ductwork leak test and the performance tests in booklet form, upon completion of testing. Reports shall document phases of tests performed including initial test summary, repairs/adjustments made, and final test results.

SD-10 Operation and Maintenance Data

Heating Equipment; G

Six manuals listing step-by-step procedures required for system startup, operation, shutdown and routine maintenance, at least 2 weeks prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tool that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

1.3 GENERAL REQUIREMENTS

1.3.1 Standard Products

Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the products. Equipment shall essentially duplicate equipment that has been in satisfactory use at least 2 years prior to bid opening.

1.3.2 Nameplates

Each major component of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the equipment.

1.3.3 Verification of Dimensions

After becoming familiar with all details of the work and working conditions, the Contractor shall verify all dimensions in the field and shall advise the Contracting Officer of any discrepancy before performing any work.

1.4 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.5 ELECTRICAL WORK

Electrical motor-driven equipment specified shall be provided complete with motor, motor starter, and controls. Unless otherwise specified, electric equipment, including wiring and motor efficiencies, shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Electrical characteristics and enclosure type shall be as shown. Unless otherwise indicated, motors of 746 W (1 hp) and above shall be high efficiency type. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary. Each motor shall be in accordance with NEMA MG 1 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Solid-state variable-speed controllers shall be utilized for motors rated 7.45 kW (10 hp) or less. Adjustable frequency drives shall be used for larger motors.

PART 2 PRODUCTS

2.1 SELF-CONTAINED FURNACE

Furnace shall be a manufacturer's standard, self-contained, forced circulated air heating type furnace as indicated. Furnace and furnace components shall be completely factory-assembled and wired. Furnace casing shall be factory insulated and be compatible with the operating temperatures. Furnace shall be provided with removable service panels which allow access to all internal components requiring cleaning, servicing, or adjustment.

2.1.1 Gas-Fired Unit

Gas-fired furnace shall be the high efficiency, condensing type in accordance with ANSI Z21.47. Furnace design shall be certified by the AMERICAN GAS ASSOCIATION LABORATORIES (AGA). Furnace shall have a minimum certified Annual Fuel Utilization Efficiency (AFUE) of not less than 90 percent.

2.1.2 Oil-Fired Unit

Oil-fired furnace shall be in accordance with UL 727. Oil-fired units with capacities less than 65.9 kW (225 MBtuh) shall have a minimum certified AFUE of 78 percent. Oil-fired units with capacities greater than 65.9 kW (225 MBtuh) shall have a minimum certified AFUE of 81 percent.

2.2 FURNACE COMPONENTS

2.2.1 Oil-Burning Components

The equipment shall include the oil burner motor, ignition equipment safety devices, and accessories necessary for a full automatic system that conforms to UL 296. Oil-fired units equipped with programming controls shall be furnished with low oil-pressure switches in the fuel supply piping. Oil-fired units not equipped with programming controls shall be equipped with a delayed opening or shutoff valve. The valve shall automatically delay delivery of oil to the burner until such time as the combustion air fan and, when applicable, the induced draft fan are operated at rated speed.

2.2.2 Gas-Burning Components

Gas-burning equipment shall include the gas burners, ignition equipment, gas-control valve, gas piping, gas-pressure regulating valve, when applicable, and accessories necessary for a fully automatic system that is listed in IAS Directory. Gas-fired units equipped with programming controls shall be furnished both with high and with low gas supply pressure switches in the fuel supply piping.

2.2.3 Ignition Systems

2.2.3.1 Gas-Fired Units

Ignition systems shall be of the direct spark, hot surface, or interrupted intermittent type with automatic electric ignition. The pilots shall be of the electrically-ignited proven type. Continuous pilots will not be permitted. Burner shall be designed in accordance with NFPA 54 and located so that parts are protected against overheating. Provisions shall be made in the burner housing for inspection of the pilot flame.

2.2.3.2 Oil-Fired Units

Ignition systems for oil-fired units shall be of the direct-electric spark type or interrupted type in accordance with UL 296.

2.2.4 Supply Blowers

Blowers shall be centrifugal type. Blowers shall be statically and dynamically balanced. Lubrication points shall be located or extended, as required, to provide ready access for periodic lubrication. The direction of rotation shall be clearly and permanently marked on each blower housing. Blower speeds shall be single, or multispeed, as indicated, to provide the specified range of air temperature rises. Direct-drive blowers may have multiple speed motors to change blower speed. Belt-drive blowers shall be provided with an adjustable base and guard or enclosed in the unit casing. The belt drive shall be designed in accordance with the applicable Rubber Manufacturer's Association (RMA) power transmission belt specifications, with a service factor of at least 1.2. Shafts shall be supported by a minimum of two self-alining bearings. Blower speed shall be adjusted by the use of variable pitch drive sheaves.

2.2.5 Vents for Oil-Fired Furnaces

Vent piping shall be in accordance with UL 641, Type L. Vent shall conform to NFPA 211. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. A 8 mm (0.3125 inch) diameter hole shall be provided in the vent stack not greater than 152 mm (6 inches) from the furnace flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the indoor space when samples are not being taken. Each exhaust stack shall be provided complete with bird screen and rain hood.

2.2.6 Vents for Gas-Fired High Efficiency, Condensing Type Furnaces

Direct venting shall be used for condensing type furnaces. Both the air intake and exhaust vents shall be sized and located as indicated on the drawings and as recommended by the boiler manufacturer. A separate combustion air intake vent and exhaust shall be provided for each furnace. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.2.6.1 Combustion Air Intake Vent

The combustion air intake piping shall be constructed of PVC in accordance with KS M 3404, VG1. The vent shall be suitable for the temperature at the furnace combustion air intake connection point. Each intake shall be provided complete with bird screen.

2.2.6.2 Exhaust Vent

The exhaust vent piping shall be constructed of Schedule 40 CPVC or stainless steel in accordance with UL 1738 and the furnace manufacturer's recommendations. The exhaust vent shall be suitable for the maximum anticipated furnace exhaust temperature and shall withstand the corrosive effects of the condensate. A 8 mm (0.3125 inch) diameter hole shall be provided in the stack not greater than 152 mm (6 inches) from the furnace flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the indoor space when samples are not being taken. Each exhaust stack shall be provided complete with bird screen.

2.3 AIR CONDITIONING EQUIPMENT

Cooling coils, condensers and related equipment shall be as specified in Section 15700 UNITARY HEATING AND COOLING EQUIPMENT.

2.4 CONTROLS

Furnace controls shall be provided by the furnace manufacturer as an integral part of the furnace. Electronic controls shall be provided. The controls shall allow for single stag, two stage, or variable speed operation as indicated. Controls shall be provided as specified in Section 15950 HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS.

2.5 AUTOMATIC VENT DAMPERS

Automatic vent dampers shall be provided in the vents of all gas burning equipment that uses indoor air for combustion. Vent dampers shall conform to ANSI Z21.66.

2.6 HUMIDIFIERS

2.6.1 Steam Spray Type

Steam spray humidifiers shall inject steam directly into the surrounding air or air stream as indicated. Single grid humidifiers shall consist of a single copper distribution grid with pipe connection on one end and cap on the other end. Automatic steam control valves and condenser traps shall be field-installed. Enclosed grid shall be housed in a copper enclosure with a build-in condensate drain connection. Exposed grid shall be wick wrapped. Package type steam spray humidifiers shall be equipped to trap out and to re-evaporate condensate and to supply dry steam to a single distribution grid. Grid shall be steam jacketed and condensate drained. Unit shall trap excess condensate to return system. Package type steam spray humidifiers shall have modulating electric, electronic, or pneumatic steam control valve, as indicated. Steam spray humidifiers shall be rated for humidifying capacity in kg (pounds) of steam per hour and at steam pressure as indicated.

2.6.2 Steam Diffuser Type

Diffuser units shall be of a design that will separate any condensate from steam supply and provide positive drain of condensate to waste and supply dry steam only to air stream. Humidifiers may be installed on single or multiple units. All materials shall be noncorrosive materials or Type 300 stainless steel.

2.6.3 Operation

Humidifier shall be controlled by a manually adjustable humidistat located in living spaces or with sensing bulb in return or supply. Humidifier shall operate when the furnace operates. Humidistat shall be calibrated in percent relative humidity and shall be furnished by the humidifier manufacturer.

2.7 AIR FILTERS

Air Filters shall be listed in accordance with requirements of UL 900.

2.7.1 Replaceable Media filters

Replaceable media filters shall be the dry-media or viscous adhesive type, of the size required to suit the application. Filtering media shall be not less than 50 mm (2 inches) thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Pad shall be enclosed in a holding frame of not less than 1.6 mm (16 gauge) galvanized steel, and equipped with quick-opening mechanism for changing filter media. The air flow capacity of the filter shall be based on net filter face velocity not exceeding 1.5 m/s (300 feet per minute), with initial resistance of 32 Pa (0.13 inches water gauge). Average efficiency shall be not less than 60 percent when tested according to ASHRAE 52.1.

2.7.2 Sectional Cleanable Filters

Cleanable filters shall conform to ASTM F 872, and shall be 25 or 50 mm (1 or 2 inches) thick as indicated. Viscous adhesive shall be provided in 20 liter (5 gallon) containers in sufficient quantity for 12 cleaning operations and not less than 1 liter (1 quart) for each filter section. One washing and charging tank shall be provided foe every 100 filter sections or fraction thereof. Each washing and charging unit shall consist of a tank and single or double drain rack mounted on legs. Drain rack shall be provided with dividers and partitions to properly support the filters in the draining position. Initial pressure drop for the clean filters shall not exceed the applicable values listed in ASTM F 872.

2.8 FUEL-OIL SYSTEMS

Fuel oil systems shall conform to Section 13202 FUEL STORAGE SYSTEMS.

2.9 FUEL-GAS SUPPLY SYSTEM

Fuel-gas supply system shall be as specified in Section 15190 GAS PIPING SYSTEMS and Section 02556 GAS DISTRIBUTION SYSTEM.

2.10 DUCTWORK COMPONENTS

2.10.1 Metal Ductwork

All aspects of metal ductwork construction, including all fittings and components, shall comply with SMACNA HVAC Duct Const Stds unless otherwise specified. Elbows shall be radius type with a centerline radius of 1-1/2 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes may be used. Static pressure Class 125, 250, and 500 Pa (1/2, 1, and 2 inch w.g.) ductwork shall meet the requirements of Seal Class C. Class 750 through 2500 Pa (3 through 10 inch) shall meet the requirements of Seal Class A. Sealants shall conform to fire hazard classification specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Pressure sensitive tape shall not be used as a sealant. Spiral lock seam duct, and flat oval shall be made with duct sealant and locked with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA HVAC Duct Const Stds. The sealant shall be applied to the exposed male part of the fitting collar so that the sealer will be on the inside of the joint and fully protected by the metal of the duct fitting. One brush coat of the sealant shall be applied over the outside of the joint to at least 50 mm (2 inch) band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar will not be acceptable.

2.10.1.1 Transitions

Diverging air flow transitions shall be made with each side pitched out a maximum of 15 degrees, for an included angle of 30 degrees. Transitions for converging air flow shall be made with each side pitched in a maximum of 30 degrees, for an included angle of 60 degrees, or shall be as indicated. Factory-fabricated reducing fittings for systems using round duct sections when formed to the shape of the ASME short flow nozzle, need not comply with the maximum angles specified.

2.10.1.2 Insulated Nonmetallic Flexible Duct Runouts

Flexible duct runouts shall be used only where indicated. Runouts length shall be as shown on the drawings, but shall not exceed 3 m (10 feet). Runouts shall be preinsulated, factory fabricated, and shall comply with NFPA 90A and UL 181. Either field or factory applied vapor barrier shall be provided. Where coil induction or high velocity units are supplied with vertical air inlets, a streamlined and vaned and mitered elbow transition piece shall be provided for connection to the flexible duct or hose. The last elbow to these units, other than the vertical air inlet type, shall be a die-stamped elbow and not a flexible connector. Insulated flexible connectors may be used as runouts. The insulated material and vapor barrier shall conform to the requirements of Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation material surface shall not be exposed to the air stream.

2.10.1.3 General Service Duct Connectors

A flexible duct connector approximately 150 mm (6 inches) in width shall be provided where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, the flexible material shall be secured by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, the flexible material locked to metal collars shall be installed using normal duct construction methods. The composite connector system shall comply with UL 214 and be classified as "flame-retarded fabrics" in UL Bld Mat Dir.

2.10.2 Fibrous Glass Ductwork

Fibrous glass ductwork may be provided in lieu of sheet metal ductwork except that fibrous glass ductwork will not be allowed in fan and equipment rooms, where subject to traffic or weather damage, for outside air intakes, for risers of more than two stories, in kitchen or fume exhaust ducts, to convey solids or corrosive gases, in concrete, for burial below grade, as casings or housings, or in systems used for life support systems. Fibrous glass ductwork, including components, shall be fabricated in accordance with NAIMA AH115 where the velocity and the static pressure are within its scope. Where the velocity or static pressure exceeds these limits, the ductwork manufacturer shall certify that the ductwork is intended for the velocities and pressures to be encountered, and that the proposed installation meets all performance criteria specified herein for metal ductwork. Fibrous glass ductwork shall have the thermal equivalent of the insulation specified for metal ductwork in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Field or factory fabricated fibrous glass ductwork shall conform to UL 181, Class 1. Duct wall penetrations, traverse joints and longitudinal seams shall be sealed as instructed by the manufacturer by one of the methods prescribed by NAIMA AH115, where applicable, except that pressure sensitive tape shall not be used as a sealant. All items necessary for a complete installation shall be provided as specified for sheet metal duct systems.

2.10.3 Ductwork Accessories

2.10.3.1 Duct Access Doors

Access doors shall be provided in ductwork where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system, and unless otherwise shown, shall conform to SMACNA HVAC Duct Const Stds. Access doors shall be provided upstream and downstream of air flow measuring primaries and heating and cooling coils. Doors shall be minimum 375 by 450 mm (15 by 18 inches), unless otherwise shown. Where duct size will not accommodate this size door, the doors shall be made as large as practicable. Doors 600 by 600 mm (24 by 24 inches) or larger shall be provided with fasteners operable from both sides. Doors in insulated ducts shall be the insulated type.

2.10.3.2 Fire Dampers

Fire dampers shall be 1-1/2 hour fire rated unless otherwise indicated. Fire dampers shall conform to the requirements of NFPA 90A and UL 555. Fire dampers shall be automatic operating type and shall have a dynamic rating suitable for the maximum air velocity and pressure differential to which it will be subjected. Fire dampers shall be approved for the specified application, and shall be installed in accordance with their listing. Fire dampers shall be equipped with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, will not impair the operation of the damper. Sleeves or frames shall be equipped with perimeter mounting angles attached on both sides of the wall or floor opening. Ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies shall be constructed in conformance with UL Fire Resist Dir. Fire dampers shall be curtain type with damper blades out of the air stream. Dampers shall not reduce the duct or the air transfer opening cross-sectional area. Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition of floor slab depth or thickness. Unless otherwise indicated, the installation details given in SMACNA Install Fire Damp HVAC and in manufacturer's instructions for fire dampers shall be followed.

2.10.3.3 Splitters and Manual Balancing Dampers

Splitters and manual balancing dampers shall be furnished with accessible operating mechanisms. Where operators occur in finished portion of the building, operators shall be chromium plated with all exposed edges rounded. Splitters shall be operated by quadrant operators or 5 mm (3/16 inch) rod brought through the side of the duct with locking setscrew and bushing. Two rods are required on splitters over 200 mm (8 inches). Manual volume control dampers shall be operated by locking-type quadrant operators. Dampers and splitters shall be 2 gauges heavier than the duct in which installed. Unless otherwise indicated, multileaf dampers shall be opposed blade type with maximum blade width of 300 mm (12 inches). Access doors or panels shall be provided for all concealed damper operators and locking setscrew. Unless otherwise indicated, the locking-type quadrant operators for dampers, when installed on ducts to be thermally insulated, shall be provided with stand-off mounting brackets, bases, or adapters to provide clearance between the duct surface and the operator not less than the thickness of the insulation.

Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer. Volume dampers shall be provided where indicated.

2.10.3.4 Air Deflectors and Branch Connections

Air deflectors shall be provided at duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections may be used in lieu of deflectors or extractors for branch connections. All air deflectors, except those installed in 90 degree elbows, shall be provided with an approved means of adjustment. Adjustment shall be made from easily accessible means inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, external adjustments shall be provided with stand-off mounting brackets integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Air deflectors shall be factory-fabricated units consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Air deflectors shall be factory or field assembled. Blade air deflectors, also called blade air extractors, shall be approved factory fabricated units consisting of equalizing grid and adjustable blade and lock. Adjustment shall be easily made from the face of the diffuser or by position adjustment and lock external to the duct. Stand-off brackets shall be provided on insulated ducts and are described herein. Fixed air deflectors, also called turning vanes, shall be provided in all 90 degree elbows.

2.10.4 Duct Sleeves, Framed Prepared Openings, Closure Collars

2.10.4.1 Duct Sleeves

Duct sleeves shall be provided for round ducts 375 mm (15 inches) in diameter or less passing through floors, walls, ceilings, or roof, and installed during construction of the floor, wall, ceiling, or roof. Round ducts larger than 375 mm (15 inches) in diameter and square, rectangular, and oval ducts passing through floors, walls, ceilings, or roof shall be installed through framed prepared openings. The Contractor shall be responsible for the proper size and location of sleeves and prepared openings. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Framed prepared openings shall be fabricated from 1.0 mm (20 gauge) galvanized steel, unless otherwise indicated. Where sleeves are installed in bearing walls or partitions, black steel pipe, KS D 3562, Schedule 20 shall be used. Sleeve shall provide 25 mm (1 inch) clearance between the duct and the sleeve or 25 mm (1 inch) clearance between the insulation and the sleeve for insulated ducts.

2.10.4.2 Framed Prepared Opening

Openings shall have 25 mm (1 inch) clearance between the duct and the opening or 25 mm (1 inch) clearance between the insulation and the opening for insulated ducts.

2.10.4.3 Closure Collars

Collars shall be fabricated of galvanized sheet metal not less than 100 mm (4 inches) wide, unless otherwise indicated, and shall be installed on exposed ducts on each side of walls or floors where sleeves or prepared openings are provided. Collars shall be installed tight against surfaces. Collars shall fit snugly around the duct or insulation. Sharp edges of the collar around insulated duct shall be ground smooth to preclude tearing or puncturing the insulation covering or vapor barrier. Collars for round ducts 375 mm (15 inches) in diameter or less shall be fabricated from 1.0 mm (20 gauge) galvanized steel. Collars for round duct larger than 375 mm (15 inches) and all square, and rectangular ducts shall be fabricated from 1.3 mm (18 gauge) galvanized steel. Collars shall be installed with fasteners on maximum 150 mm (6 inch) centers, except that not less than 4 fasteners shall be used.

2.10.5 Diffusers, Registers, and Grilles

Units shall be factory-fabricated of steel, corrosion-resistant steel, or aluminum and shall distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 0.25 m/s (50 fpm) in occupied zone, or dead spots anywhere in the conditioned area. Outlets for diffusion, spread, throw, and noise level shall be as required for specified performance. Performance shall be certified in accordance with ADC 1062:GRD. Inlets and outlets shall be sound rated and certified in accordance with ADC 1062:GRD. Sound power level shall be as indicated. Diffusers and registers shall be provided with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device will be acceptable. Volume dampers shall be opposed blade type for all diffusers and registers, except linear slot diffusers. Linear slot diffusers shall be provided with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 2 m (7 feet) above the floor, they shall be protected by a grille or screen in accordance with NFPA 90A.

2.10.5.1 Diffusers

Diffuser types shall be as indicated. Ceiling mounted units shall be furnished with antismudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Diffusers shall be provided with air deflectors of the type indicated. Air handling troffers or combination light and ceiling diffusers shall conform to the requirements of UL Elec Const Dirfor the interchangeable use as cooled or heated air supply diffusers or return air units. Ceiling mounted units shall be installed with rims tight against ceiling. Sponge rubber gaskets shall be provided between ceiling and surface mounted diffusers for air leakage control. Suitable trim shall be provided for flush mounted diffusers. Duct collar connecting the duct to diffuser shall be airtight and shall not interfere with volume controller. Return or exhaust units shall be similar to supply diffusers.

2.10.5.2 Registers and Grilles

Units shall be four-way directional-control type, except that return and exhaust registers may be fixed horizontal or vertical louver type similar in appearance to the supply register face. Registers shall be provided with sponge-rubber gasket between flanges and wall or ceiling. Wall supply registers shall be installed at least 150 mm (6 inches) below the ceiling unless otherwise indicated. Return and exhaust registers shall be located 150 mm (6 inches) above the floor unless otherwise indicated. Four-way directional control may be achieved by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Grilles shall be as specified for registers, without volume control damper.

2.10.6 Louvers

Louvers for installation in exterior walls which are associated with the air supply and distribution system shall be as specified in Section 07600 SHEET METALWORK, GENERAL.

2.11 FACTORY PAINTING

Units which are not of galvanized construction according to ASTM A 123/KS D 8308 or ASTM A 653/KS D 3506 shall be factory painted with a corrosion resisting paint finish. Internal and external ferrous metal surfaces shall be cleaned, phosphated and coated with a paint finish which has been tested according to ASTM B 117, ASTM D 1654, and ASTM D 3359. Evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors shall be submitted. Rating of failure at the scribe mark shall be not less than 6, average creepage not greater than 10, no failure. On units constructed of galvanized steel which have been welded, exterior surfaces of welds or welds that have burned through from the interior shall receive a final shop docket of zinc-rich protective paint in accordance with ASTM D 520, Type I.

PART 3 EXECUTION

3.1 INSTALLATION

The warm air heating installation shall conform to the requirements contained in NFPA 90A or NFPA 90B, as applicable. Combustion air supply and ventilation shall be in accordance with NFPA 31 or NFPA 54.

3.1.1 Furnaces

Foundations, settings, or suspensions for mounting equipment and accessories including supports, vibration isolators, stands, guides, anchors, clamps, and brackets shall be provided. Foundations and suspension for equipment shall conform to the recommendations of the manufacturer, unless otherwise indicated on drawings. Anchor bolts and sleeves shall be set accurately using properly constructed templates. Anchor bolts, when embedded in concrete, shall be provided with welded-on plates on the head end and guarded against damage until equipment is installed. Equipment bases shall be leveled, using jacks or steel wedges, and when resting on concrete shall be neatly grouted-in with a nonshrinking type of grout. Equipment shall be located as indicated and in such a manner that working space is available for all necessary servicing, such as shaft removal, replacing, or adjusting drives, motors, or shaft seals, air filters, access to automatic controls, humidifiers, and lubrication. Electrical isolation shall be provided between dissimilar metals for the purpose of minimizing galvanic corrosion. The interior of cabinets or casings shall be cleaned before completion of installation. The furnace shall be connected to the vent or chimney with the specified connectors, draft regulators, draft loads, and induced draft fans, as applicable, in accordance with NFPA 211.

3.1.2 Automatic Vent Dampers

Automatic vent dampers shall be installed in accordance with ANSI Z21.66.

3.1.3 Humidifiers

Humidifiers shall be installed in accordance with manufacturer's instructions and in an arrangement that will permit access and ease of maintenance. Piping, draining, manual shut-off valve, and solenoid valves when required for type of humidifier furnished shall be provided. Drain lines shall be provided for humidifiers and shall be piped to drains shown. Humidifiers installed in a bypass arrangement shall be provided with an integral damper that can be conveniently operated to regulate or shut off flow through the humidifier. To permit humidifier operation, a manual ON-OFF switch shall be provided near the humidifier. The ON-OFF switch may be integral with the humidifier. When humidifier is installed in glass fiber ductwork, ductwork shall be adequately reinforced to support the humidifier.

3.1.4 Access Panels

Access panels shall be provided for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance. Access panels shall be of sufficient size and so located that the concealed items may be serviced and maintained or completely removed for replacement. Access panels shall be as specified in Section 05500 MISCELLANEOUS METAL.

3.1.5 Flexible Connectors

Pre-insulated flexible connectors and flexible duct shall be attached to other components in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the connector or duct manufacturer and shall be provided at the intervals recommended.

3.1.6 Sleeved and Framed Openings

Space between the sleeved or framed opening and the duct or the duct insulation shall be packed as specified in Section 07840 FIRESTOPPING for fire rated penetrations. For non-fire rated penetrations, the space shall be packed as specified in Section 07900 JOINT SEALING.

3.1.7 Metal Ductwork

Installation shall be in accordance with SMACNA HVAC Duct Const Stds unless otherwise indicated. Duct supports for sheet metal ductwork shall be in accordance with SMACNA HVAC Duct Const Stds, unless otherwise specified. Friction beam clamps indicated in SMACNA HVAC Duct Const Stds shall not be used. Risers on high velocity ducts shall be anchored in the center of the vertical run to allow ends of riser to move due to thermal expansion.

Supports shall be attached only to structural framing members and concrete slabs. Supports shall not be anchored to metal decking unless a means is provided and approved for preventing the anchor form puncturing the metal decking. Where supports are required between structural framing members, suitable intermediate metal framing shall be provided. Where C-clamps are used, retainer clips shall be provided. Where threaded rods are used, they not be formed or bent.

3.1.8 Fibrous glass Ductwork

Installation shall be in accordance with the manufacturer's written recommendations unless otherwise required in NAIMA AH115. Duct supports for fibrous glass ductwork shall conform to NAIMA AH115. In those cases not covered in NAIMA AH115, the written recommendation of the fibrous duct manufacturer shall be followed.

3.1.9 Air Filters

Air filters shall be installed in in return air ducts at furnaces. Fans or blowers shall not be operated until filters are installed. After completion of tests and before the building is accepted by the Government, the Contractor shall furnish a new second set of replaceable filters, where utilized or clean the permanent type filters.

3.1.10 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, temporary dust control protection shall be provided. The distribution system (supply and return) shall be protected with temporary seal-offs at all inlets and outlets at the end of each day's work. Temporary protection shall remain in place until system is ready for startup.

3.1.11 Insulation

Thickness and application of insulation materials for ductwork and equipment shall be in accordance with Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.1.12 Duct Test Holes

Holes with closures or threaded holes with plugs shall be provided in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Extensions, complete with cap or plug, shall be provided where the ducts are insulated.

3.1.13 Fuel-Oil System

Fuel oil systems shall be installed in accordance with Section 13202 FUEL STORAGE SYSTEMS.

3.2 FIELD PAINTING

Finish painting of items only primed at the factory or surfaces not specifically noted, otherwise are specified in Section 09900 PAINTING, GENERAL.

3.3 CLEANING

Ducts, plenums, and casings shall be thoroughly cleaned of all debris and blown free of all small particles of rubbish and dust and then shall be vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided prior to startup of all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. All equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.4 TESTS

Upon completion and prior to acceptance of the installation, the Contractor shall furnish all equipment, instruments, materials, labor, and supervision required for the tests as specified. Water, electricity, and fuel required for testing shall be furnished by the Government. Defects disclosed by the tests shall be rectified. Tests shall be made under the direction and subject to the approval of the Contracting Officer. All indicating instruments shall be read at 1/2-hour intervals unless otherwise directed by the Contracting Officer.

3.4.1 Ductwork Leak Test

Ductwork leak test shall be performed for the entire air distribution system, including fans, coils, filters etc. designated as static pressure Class 750 Pa (3 inch w.g.) through Class 2500 Pa (10 inch w.g.). Test procedure, apparatus, and report shall conform to SMACNA Leakage Test Mnl. The maximum allowable leakage rate shall be as indicated. Ductwork leak test shall be completed with satisfactory results prior to applying insulation to ductwork exterior.

3.4.2 Testing, Adjusting, and Balancing

Testing, adjusting, and balancing shall be as specified in Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Testing, adjusting, and balancing shall begin only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.4.3 Performance Tests

After testing, adjusting, and balancing has been completed as specified, each system shall be tested as a whole to see all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Corrections and adjustments shall be conducted by an experienced engineer. Tests shall cover a period of not less than 2 days for each system and shall demonstrate that the entire system is functioning according to the specifications. Coincidental chart recordings shall be made at points indicated on the drawings for the duration of the time period and shall record the temperature at space thermostats or space sensors, the humidity in a shaded and weather protected area.

3.5 FIELD TRAINING

The Contractor shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of 24 hours of normal working time shall start after the system is functionally complete but prior to the performance tests. The field instruction shall cover all of the items contained in the approved operating and maintenance instructions.

SECTION 15569

WATER AND STEAM HEATING; OIL, GAS OR BOTH; UP TO 6,000 kW

TABLE OF CONTENTS

NOTE: This guide specification shall be applied for packaged hot water and steam boiler systems (oil, gas or combination oil/gas fired) of up to 6000 kW (20,000,000 Btuh) output capacity; hot water boiler systems operating at water temperatures below 120 degrees C (250 degrees F) and water working pressures less than 1100 kPa (160 psi) and steam heating systems operating up to 100 kPa (15 psig).

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 801	(1992) Industrial Process/Power Generation Fans: Specification Guidelines

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.13	(1991; Z21.13a; Z21.13b) Gas-Fired Low-Pressure Steam and Hot Water Boilers

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 167	(1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 366/A 366M	(1997el) Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality
ASTM A 653/A 653M	(2000) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B 32	(1996) Solder Metal
ASTM B 813	(2000) Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube
ASTM C 155	(1997) Standard Classification of Insulating Firebrick
ASTM C 27	(1998) Fireclay and High-Alumina Refractory Brick
ASTM C 34	(1996) Structural Clay Load-Bearing Wall Tile
ASTM C 401	(1991; R 1995el) Alumina and Alumina-Silicate Castable Refractories
ASTM F 1097	(1991; R 1996) Mortar, Refractory (High-Temperature, Air-Setting)
ASTM F 1139	(1988; R 1998) Standard Specification for Steam Traps and Drains
ASTM F 872	(1984; R 1990) Filter Units, Air Conditioning: Viscous-Impingement Type, Cleanable

ASTM F 876 (2000) Crosslinked Polyethylene (PEX) Tubing

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8 (1992) Filler Metals for Brazing and Braze Welding

AWS B2.2 (1991) Brazing Procedure and Performance Qualification

ASME INTERNATIONAL (ASME)

ASME B16.21 (1992) Nonmetallic Flat Gaskets for Pipe Flanges

ASME B16.5 (1996; B16.5a) Pipe Flanges and Flanged Fittings NPS 1/2 thru NPS 24

ASME B31.1 (1998) Power Piping

ASME B31.5 (1992; B31.5a1994) Refrigeration Piping

ASME B40.1 (1991) Gauges - Pressure Indicating Dial Type – Elastic Element

ASME BPVC SEC IV (1998) Boiler and Pressure Vessel Code; Section IV, Heating Boilers

ASME BPVC SEC IX (1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications

ASME BPVC SEC VIII D1 (1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ASME CSD-1 (1998) Controls and Safety Devices for Automatically Fired Boilers

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA Tube Handbook (1995) Copper Tube Handbook

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds (1998; 7th Edition) EJMA Standards

HYDRONICS INSTITUTE DIVISION OF GAMA (HYI)

HYI-01 (1998) I=B=R Ratings for Boilers, Baseboard Radiation and Finned Tube (Commercial) Radiation

HYI-400 (1998) I=B=R Product Floor Heating

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58 (1993) Pipe Hangers and Supports - Materials, Design and Manufacture

MSS SP-69	(1996) Pipe Hangers and Supports - Selection and Application

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 211	(2000) Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances
NFPA 31	(2001) Installation of Oil Burning Equipment
NFPA 54	(1999) National Fuel Gas Code
NFPA 70	(2002) National Electrical Code
NFPA 85	(2001) Boiler and Combustion Systems Hazards Code

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1419	(Rev D; Canc. Notice 1) Filter Element, Air Conditioning (Viscous-Impingement and Dry Types, Replaceable)

UNDERWRITERS LABORATORIES (UL)

UL 296	(1994; Rev Sep 1998) Oil Burners
UL 726	(1995; Rev thru Jan 1999) Oil-Fired Boiler Assemblies
UL 795	(1999) Commercial-Industrial Gas Heating Equipment
UL Gas&Oil Dir	(1999) Gas and Oil Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS B 0222	(1987) Taper Pipe Threads
KS B 1503	(1999) Steel Welding Pipe Flanges
KS B 1527	(2001) Pipe Supports
KS B 1531	(1997) Screwed Type Malleable Cast-Iron Pipe Fitting
KS B 1541	(1992) Steel Butt-Welding Pipe Fittings
KS B 1542	(1990) Steel Socket-Welding Pipe Fittings
KS B 1543	(1986) Steel Plate Butt-Welding Pipe Fittings
KS B 2301	(1999) Bronze Gate, Globe, Angle and Check Valves
KS B 2308	(2002) Ball Valve
KS B 2350	(2002) Gray Cast-Iron Valves

KS B 2371	(1997) Screwed Bronze Plug Cocks and Gland Cocks
KS D 3512	(2002) Cold Rolled Carbon Steel Sheets and Strip
KS D 3562	(1989) Carbon Steel Pipes for Pressure Service
KS D 3706	(2001) Stainless Steel Bars
KS D 3710	(2001) Carbon Steel Forging
KS D 5578	(2000) Pipe Fittings of Copper and Copper Alloys

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Heating System; G
Piping Installation; G
Installation; G

Detail drawings consisting of equipment layout including installation details and electrical connection diagrams; combustion and safety control diagrams; ductwork layout showing the location of supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of guides and anchors, the load imposed on each support or anchor (not required for radiant floor tubing), and typical support details. Drawings shall include any information required to demonstrate that the system has been coordinated and will properly function as a unit and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance.

SD-03 Product Data

Manufacturer's Catalog Data; G

Manufacturer's catalog data shall be included with the detail drawings for the following items:

Boilers
Fuel Burning Equipment
Combustion Control Equipment
Pumps
Fittings and Accessories
Fuel Oil Storage System
Water Treatment System
Radiant floor heating system including tubing, joints, and manifold for radiant floor heating systems.

The data shall show model, size, options, etc., that are intended for consideration. Data submitted shall be adequate to demonstrate compliance with contract requirements.

Spare Parts Data

Spare parts data for each different item of material and equipment, after approval of the detail drawings and no later than 2 months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 years of service.

Heating System Tests
Fuel System Tests

Proposed test procedures for the heating system tests and fuel system tests, at least 2 weeks prior to the start of related testing.

Welding

A copy of qualified welding procedures, at least 2 weeks prior to the start of welding operations. A list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations.

Qualification

A statement from the firms proposed to prepare submittals and perform installation and testing, demonstrating successful completion of similar services of at least five projects of similar size or scope, at least 2 weeks prior to the submittal of any other item required by this section.

Field Instructions; G

System layout diagrams that show the layout of equipment, piping, and ductwork and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system, framed under glass or laminated plastic, at least 2 weeks prior to the start of related testing. After approval, these items shall be posted where directed.

Tests

Proposed test schedules for the heating system and fuel system tests, at least 2 weeks prior to the start of related testing.

SD-06 Test Reports

Heating System Tests; G
Fuel System Tests; G

Test reports for the heating system tests and the fuel system test, upon completion of testing complete with results.

SD-07 Certificates

Bolts

Written certification by the bolt manufacturer that the bolts furnished comply with the requirements of this specification. The certification shall include illustrations of product markings, the date of manufacture, and the number of each type of bolt to be furnished based on this certification.

Continuous Emissions Monitoring

Written certification by the boiler manufacturer that each boiler furnished complies with Federal, state, and local regulations for emissions. The certification shall also include a description of applicable emission regulations. If any boiler is exempt from the emission regulations, the certification shall indicate the reason for the exemption.

SD-10 Operation and Maintenance Data

Heating System; G

Six complete manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to field training. The manuals shall include the manufacturer's name, model number, parts list, simplified wiring and control diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

1.3 GENERAL REQUIREMENTS

1.3.1 Standard Products

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

1.3.2 Asbestos Prohibition

Asbestos and asbestos-containing products shall not be used.

1.3.3 Nameplates

Each major component of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the equipment. Each pressure vessel shall have an approved ASME stamp.

1.3.4 Equipment Guards

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded in accordance with OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. Catwalks, operating platforms, ladders, and guardrails shall be provided where shown and shall be constructed in accordance with Section 05500 MISCELLANEOUS METAL.

1.3.5 Verification of Dimensions

The Contractor shall become familiar with details of the work, verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work or ordering any materials.

1.3.6 Welding

Boilers and piping shall be welded and brazed in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests, and the tests shall be performed at the work site if practical. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Structural members shall be welded in accordance with Section 05090 WELDING, STRUCTURAL.

1.4 MANUFACTURER'S SERVICES

Services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified shall be provided. The representative shall supervise the installing, adjusting, and testing of the equipment.

1.5 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be protected from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

PART 2 PRODUCTS

2.1 BOILERS

Each boiler shall have the output capacity in kilowatts (kW)or British thermal units per hour (Btuh) as indicated when fired with the specified fuels. The boiler shall be furnished complete with the oil, gas, or combination oil/gas burning equipment, boiler fittings and trim, automatic controls, forced or induced draft fan, electrical wiring, insulation, piping connections, and protective jacket. The boiler shall be completely assembled and tested at the manufacturer's plant. Boiler auxiliaries including fans, motors, drives, and similar equipment shall be provided with at least 10 percent excess capacity to allow for field variations in settings and to compensate for any unforeseen increases in pressure losses in appurtenant piping and ductwork. However, the boiler safety devices shall not be sized for a 10 percent excess capacity. The boiler and its accessories shall be designed and installed to permit ready accessibility for operation, maintenance, and service. Boilers shall be designed, constructed, and equipped in accordance with ASME BPVC SEC IV. Each boiler shall be of the firetube, watertube, cast iron, or condensing type and designed for water or steam service as specified herein. The boiler capacity shall be based on the ratings shown in HYI-01 or as certified by the American Boiler Manufacturers Association, or American Gas Association.

2.1.1 Firetube Boiler

Boiler shall be self-contained, multipass, packaged type, complete with all accessories, mounted on a structural steel base. When the boilers are operating at maximum output, the heat output rates shall not be greater than 21 Kw per square meter (6,700 Btu/hr per square ft) of fireside heating surface.

2.1.2 Watertube Boiler

The boiler shall be a standard, finned, bent or flexible type of water tube boiler. Boiler shall be self-contained, packaged type, complete with all accessories, mounted on a structural steel base. The boiler heating surface area for bent or flexible tube boilers shall be at least 0.03 square meters per kW (4 square feet per boiler horse power). Bent or flexible tube boilers shall be provided with single or multiple downcomers for circulation without the need for exterior pumping. The tubes for bent or flexible tube boilers shall be designed for replacement without requiring welding or rolling of tubes. Any special tools required for bent or flexible tube removal or installation shall be provided with the boiler.

2.1.3 Cast Iron Boiler

oiler shall be of the rectangular, sectional type, self-contained, packaged type, complete with accessories, mounted on a structural steel base. Cast iron sections shall be free of leaks under all operating conditions. Access shall be provided to permit cleaning of internal tube surfaces.

2.1.4 Condensing Boiler

Each boiler shall be a self-contained packaged type, complete with accessories, mounted on a structural steel base or a steel base which is integral to the boiler shell. Each boiler shall conform to the commercial design used by the manufacturer and shall permit free thermal expansion without placing undue stress on any part of the boiler. Each boiler which experiences the formation of condensate within the flue gas shall be specifically designed for condensing application. Each boiler shall withstand the corrosive effects of condensate for each part which may be in contact with the condensate at all possible operating conditions. Each boiler shall be provided with a separate air intake, exhaust, and condensate drain. Each boiler shall be designed to withstand the water temperature differentials anticipated at the required operating conditions without experiencing any damage due to thermal shock.

2.1.5 Modular Configuration

Modular boilers shall be of the cast iron or condensing type. Modular boilers shall have the capability of independent operation. Upon failure of any module, the remaining modules shall be capable of operating at their designed capacity. The size of the individual modules shall be as indicated.

2.1.6 Hot Water Heating Boilers

The hot water heating boiler shall be capable of operating at the specified maximum continuous capacity without damage or deterioration to the boiler, its setting, firing equipment, or auxiliaries. The rated capacity shall be the capacity at which the boiler will operate continuously while maintaining at least the specified minimum efficiency. The boiler design conditions shall be as indicated. Boilers with a capacity less than 90 kW (300,000 Btuh) shall have an Annual Fuel Utilization Efficiency of at least 80 percent. Gas fired boilers with a capacity of greater than or equal to 90 kW (300,000 Btuh) shall have a thermal efficiency of at least 80 percent when fired at the maximum and minimum ratings allowed by the controls. Oil fired boilers with a capacity of greater than or equal to 90 kW (300,000 Btuh) shall have a thermal efficiency of at least 83 percent when fired at the maximum and minimum ratings allowed by the controls. Condensing boilers shall have an Annual Fuel Utilization Efficiency of at least 90 percent.

2.1.7 Steam Heating Boilers

The boiler shall be provided with a water column with gauge glass and fittings including water column and gauge glass drain valves of the straight through type. The steam heating boiler shall be capable of operating at the specified maximum continuous capacity without damage or deterioration to the boiler, its setting, firing equipment, or auxiliaries. The rated capacity shall be the capacity at which the boiler will operate continuously while maintaining at least the specified minimum efficiency. Design conditions shall be as indicated. Boilers with a capacity less than 90 kW (300,000 Btuh) shall have an Annual Fuel Utilization Efficiency of at least 75 percent. Gas fired boilers with a capacity of greater than or equal to 90 kW (300,000 Btuh) and less than or equal to 733 kW (2,500,000 Btuh) shall have a thermal efficiency of at least 79 percent. Gas fired boilers with a capacity greater than 733 kW (2,500,000 Btuh) shall have a thermal efficiency of at least 80 percent. Oil fired boilers with a capacity greater than or equal to 90 kW (300,000 Btuh) shall have a thermal efficiency of at least 83 percent when fired at the maximum and minimum ratings allowed by the controls.

2.2 FUEL BURNING EQUIPMENT

Boiler shall be designed to burn gas, oil, or combination gas and oil. Each boiler shall comply with Federal, state, and local emission regulations.

2.2.1 Burners

2.2.1.1 Gas and Combination Gas-Oil Fired Burners and Controls

Burners shall be UL approved mechanical draft burners with all air necessary for combustion supplied by a blower where the operation is coordinated with the burner or natural draft/atmospheric burners. Burner shall be provided complete with fuel supply system in conformance with the following safety codes or standards:

a. Gas-fired units with inputs greater than 0.117 MW (400,000 Btuh per) combustion chamber shall conform to UL 795. Gas fired units less than 3.66 MW (12,500,000 Btuh) input shall conform to ANSI Z21.13. Single and multiple burner gas-fired units greater than or equal to 3.66 MW (12,500,000 Btuh) input shall conform to NFPA 85.

b. Combination gas and oil-fired units shall conform to UL 296. Combination gas and oil-fired units less than 3.66 MW (12,500,000 Btuh) input shall conform to ASME CSD-1. Single and multiple burner combination gas and oil-fired units equal to or greater than 3.66 MW (12,500,000 Btuh) input shall conform to NFPA 85.

2.2.1.2 Oil-Fired Burners and Controls

Oil-fired burners and controls for oil-fired units firing JP-8 oil shall be atomizing, forced-draft type in conformance with UL 726. Oil-fired units less than 3.66 MW (12,500,000 Btuh) input shall conform to ASME CSD-1. Oil-fired units greater than or equal to 3.66 MW (12,500,000 Btuh) input shall conform to NFPA 85.

2.2.1.3 Steam or Air Atomizer

Steam or air atomizer shall be of the inside mix type utilizing steam or air mixing with the oil inside the nozzle. No moving parts shall be required within the atomizer assembly. Unit shall be capable of completely atomizing the oil through a minimum capacity range of 4 to 1 without changing nozzles or sprayer plates and when supplied with steam or air at a maximum pressure of 100 kPa (15 psig). Capacity of unit shall be adjustable. Unit shall be furnished with a blowout valve so that steam or air may be blown through the oil passages to clear them of any accumulation. A diffuser designed to stabilize the flame shall be mounted near the furnace end of the atomizer in such a position that oil will not strike it.

2.2.1.4 Mechanical pressure atomizer

Mechanical pressure atomizer shall operate solely by the use of oil pressure and shall have no moving parts within the atomizer. Unit shall be capable of completely atomizing the oil through a minimum capacity range of 4 to 1 without changing nozzles or sprayer plates and when furnished with oil at a constant pressure of 700 kPa (100 psig). A constant volume of oil shall be supplied to the atomizer. Variable capacity shall be obtained by adjusting control valve. A diffuser provided to stabilize the flame shall be mounted near the furnace end of the atomizer, but in such a position that oil will not strike it.

2.2.2 Draft Fans

Fans conforming to AMCA 801 forced-draft shall be furnished as an integral part of boiler design. Fans shall be centrifugal with backward-curved blades, radial-tip blades or axial flow type. Each fan shall be sized for output volume and static pressure rating sufficient for pressure losses, excess air requirements at the burner, leakages, temperature, and elevation corrections for worst ambient conditions, all at full combustion to meet net-rated output at normal firing conditions, plus an overall excess air volume of 10 percent against a 20 percent static overpressure. Noise levels for fans shall not exceed 85 decibels in any octave band at a .914 meters (3 foot) station. Forced draft fan bearings shall be air cooled.

2.2.2.1 Draft Fan Control

Forced-draft centrifugal fans shall have inlet vane controls or shall have variable speed control where indicated. Inlet vanes shall be suitable for use with combustion control equipment.

2.2.2.2 Draft Fan Drives

Fans shall be driven by electric motors. Electric motor shall be drip proof, totally enclosed nonventilated, totally enclosed fan cooled, or totally enclosed fan-cooled suitable for installation in a Class II, Division 1, Group F, hazardous location conforming to NFPA 70 as indicated or required. Motor starter shall be magnetic across-the-line or reduced voltage start type with general purpose, weather-resistant, watertight, dust-tight, or explosion-proof enclosure as indicated or required and shall be furnished with four auxiliary interlock contacts.

2.2.3 Draft Damper

Boilers shall be provided with manual or automatic dampers, draft hoods, or barometric dampers as recommended by the boiler manufacturer to maintain proper draft in the boiler. Draft damper shall be provided in a convenient and accessible location in the flue gas outlet from the boiler. Automatic damper shall be arranged for automatic operation by means of a damper regulator, furnace draft regulator or damper motor.

2.3 COMBUSTION CONTROL EQUIPMENT

Combustion control equipment shall be provided as a system by a single manufacturer. Field installed automatic combustion control system shall be installed in accordance with the manufacturer's recommendations and under the direct supervision of a representative of the control manufacturer. The boiler water temperature shall be controlled by a water temperature controller. The boiler pressure shall be controlled by a steam pressure controller. The equipment shall operate electrically. On multiple boiler installations, each boiler unit shall have a completely independent system of controls responding to the load and to a plant master controller. If recording instruments are provided, a 1 year supply of ink and 400 blank charts for each recorder shall be furnished.

2.3.1 Electrical controls

Electrical control devices shall be rated at 120 or 24 volts as indicated and shall be connected as specified in Section 16415 ELECTRICAL WORK, INTERIOR.

2.3.2 Water Temperature Controller

The controller shall be of sturdy construction and shall be protected against dust and dampness. The thermostatic element shall be inserted in a separable socket installed in the upper part of the boiler near the water outlet or in the boiler return piping as indicated. Fixed position (on-off) and three position (high-low-off) controller shall operate on a 5.56 degree C (10 degree F) differential over an adjustable temperature range of approximately 60 to 104.4 degrees C (140 to 220 degrees F). Modulating controllers shall control the fuel burning equipment to maintain set boiler water temperature within 2 percent. Controller shall be furnished with necessary equipment to automatically adjust the setting to suit the outside weather conditions. The outside air reset controller shall be operated in such a manner that the operating temperatures required by the boiler manufacturer are not compromised.

2.3.3 Steam Pressure Controller

The controller shall be of sturdy construction and shall be protected against dust and dampness. The sensing elements of the steam controller shall be in direct contact with the steam. Fixed position (on-off) and three position (high-low-off) type controllers shall operate on a 6.9 kPa (1 pound) differential over a pressure range of 0 to 103.4 kPa (0 to 15 psig). Modulating controllers shall automatically maintain, within 2 percent, the desired steam pressure by regulating the burner.

2.3.4 Boiler Plant Master Controller

A master controller shall be provided for multiple boilers arranged in a modular configuration. A boiler plant master controller, sensitive to a temperature transmitter in the return water header for the boiler or steam pressure transmitter in the boiler steam discharge header shall be furnished to provide anticipatory signals to all boiler controllers. Boiler controllers shall react to anticipatory signals from the plant master controller as necessary in response to the boiler temperature or pressure indication to maintain the preset temperature or pressure. An automatic-manual switch shall be provided to allow the sequence of boiler loading to be varied to distribute equal firing time on all boilers in the plant. The plant master controller shall load the boilers one at a time as the plant load increases.

2.3.5 Boiler Combustion Controls and Positioners

Combustion controls shall be fixed-rate, on-off for gross outputs up to 200 kW (700,000 Btuh); high-low-off or fixed-rate on-off, depending on anticipated load profile, for gross output from 200 to 600 kW (700,000 to 2,000,000 Btuh); high-low-off or modulating, depending on anticipated load profile, for gross output from 600 to 12000 kW (2,000,000 to 4,000,000 Btuh); and modulating for gross outputs above 1200 kW (4,000,000 Btuh). Modular boilers shall be fixed-rate on-off for each module. Modulating controls shall be provided with a means for manually controlling the firing rate.

a. Gas or Combination gas-oil fired boiler units shall be provided with combustion controls with gas pilot or spark ignition.

b. Oil fired boiler units shall be provided with combustion controls with direct electric spark ignition system or spark ignited No. 2 oil pilot.

c. Modulating control function shall be accomplished using positioning type controls. Air flow ratio and fuel control valve shall be controlled by relative positions of operative levers on a jackshaft responding to a water temperature controller or steam pressure controller. Positioning type combustion control equipment shall include draft controls with synchronized fuel feed and combustion air supply controls, while and shall maintain the proper air/fuel ratio. The desired furnace draft shall be maintained within 0.01 inch of water column.

d. Fixed rate on-off or High-low-off controls for boilers with capacities up to 600 kW (2,000,000 Btuh) shall use a water temperature controller in a temperature well in direct contact with the water or steam pressure controller in direct contact with the steam.

2.3.6 Combustion Safety Controls and Equipment

Combustion safety controls and equipment shall be UL listed, microprocessor-based distributed process controller. The system shall include mounting hardware, wiring and cables, and associated equipment. The controller shall be mounted completely wired, programmed, debugged, and tested to perform all of its functions. The controller shall process the signals for complete control and monitoring of the boiler. This shall include maintaining boiler status, starting and stopping all control functions, sequencing control functions and signaling alarm conditions. The program shall be documented and include cross references in description of coils and contacts. Microprocessor shall be able to perform self diagnostics and contain a message center to provide operator with status and failure mode information. Controllers for each boiler shall be mounted on a separate, free standing panel adjacent to the boiler or for packaged boilers on the boiler supporting structure. Control systems and safety devices for automatically fired boilers shall conform to ASME CSD-1. Electrical combustion and safety controls shall be rated at 120 volts, single phase, 60 Hz and shall be connected as specified in Section 16415 ELECTRICAL WORK, INTERIOR. A 100 mm (4 inch) diameter alarm bell shall be provided and shall be located where indicated or directed. The alarm bell shall ring when the boiler is shut down by any safety control or interlock. Indicating lights shall be provided on the control panel. A red light shall indicate flame failure, and a green light shall indicate that the main fuel valve is open. The following shutdown conditions shall require a manual reset before the boiler can automatically recycle:

a. Flame failure.
b. Failure to establish pilot flame.
c. Failure to establish main flame.
d. Low-water and supplementary low-water cutoff.
e. High temperature cutoff and High pressure cutoff.

2.3.6.1 Low-water Cutoff

Low water cutoff shall be float actuated switch or electrically actuated probe type low-water cutoff. Float chamber shall be provided with a blow-down connection. Cutoff shall cause a safety shutdown and sound an alarm when the boiler water level drops below a safe minimum level. A safety shutdown due to low water shall require manual reset before operation can be resumed and shall prevent recycling of the burner. The cutoff shall be in strict accordance to the latest version of code,ASME CSD-1 Controls and Safety Devices for Automatically Fired Boilers.

a. Feedwater Regulator with Low-Water Cutoff: Regulator shall be an approved design sized for the application. A regulator shall be provided for each boiler. The feeder shall be so arranged that water will be fed to the boiler automatically when the water level in the boiler drops below a preset point and will actuate the alarm bell when the water level reaches the low danger point. The boiler feeder shall be arranged so that the burner and forced-draft fan will stop whenever the water level drops below a preset danger point. The boiler feeder shall be constructed so that the feedwater valve and seat are isolated from the float chamber to prevent overheating of the feed water and precipitation of scale on either the valve or seat. Each float mechanism, valve, and seat shall be constructed of an approved, durable, corrosion-resistant steel alloy. Valve seats shall be removable and renewable. The regulator shall be equipped with a large, self-cleaning strainer. The drain valve on the regulator shall be the gate or other straight-through type.

b. Pump Controller with Low-Water Cutoff: Controller shall be a design approved by the boiler manufacturer. A pump controller shall be provided for each boiler which is used for space heating and process steam loads or long distribution lines. Pump controller shall control the operation of the burner, forced-draft fan, and pump. Pump controller and low-water cutoff shall have a float-operated mercury switch arranged to start and stop the pump at preset boiler water levels. If the water level in the boiler reaches the low danger point, a second mercury switch shall shut down the burner and actuate the alarm bell.

c. Supplementary Low-Water Cutoff: Supplementary low-water cutoff of the electrically operated probe type or float activated type shall be provided in addition to the low-water cutoff required above on each boiler. Supplementary low-water cutoff shall be mounted directly in the boiler shell and shall be set below the low-water cutoff required above.

2.3.6.2 Water Flow Interlock

Hot water boiler limit controls shall be provided to include protection or low boiler water flow and high boiler water temperature. The limit controls shall be interlocked with the combustion control system to effect boiler alarm and shutdown. The controls shall not allow boiler startup unless hot water flow is proven.

2.4 PUMPS

2.4.1 Hot Water and Boiler Circulating Pumps

Circulating pumps for hot water shall be electrically driven single-stage centrifugal type and have a capacity not less than indicated. Hot water circulating pumps shall be supported on a concrete foundation with a cast iron or structural steel base or by the piping on which installed and shall have a closed-coupled shaft or flexible-coupled shaft. The hot water circulating pumps shall be horizontal split case or vertical split case type. The pump shaft shall be constructed of corrosion-resistant alloy steel, sleeve bearings and glands of bronze designed to accommodate a mechanical seal, and the housing of close-grained cast iron. Pump seals shall be capable of withstanding 115 degrees C (240 degrees F) temperature without external cooling. The motor shall have sufficient power for the service required, shall be of a type approved by the manufacturer of the pump, shall be suitable for the available electric service, and shall conform to the requirements of paragraph ELECTRICAL EQUIPMENT. Each pump suction and discharge connection shall be provided with a pressure gauge as specified. Switch shall be a SPDT with 120-volt, 15-ampere rating.

2.4.2 Condensate Pumping Unit

Each pump shall have a capacity not less than that indicated when discharging against the specified pressure. The minimum capacity of the tank shall be as indicated. The condensate pumping unit shall be the duplex, horizontal shaft or vertical shaft type as indicated. The unit shall consist of two pumps with electric motor drive, and a single receiver, all mounted on a suitable cast-iron or steel base. The motor may be mounted on the top of the receiving tank. Pump shall be the centrifugal or turbine type, bronze-fitted throughout, with impellers of bronze or other approved corrosion-resisting metal. Pump shall be free from air binding when handling condensate of temperatures up to 93 degrees C (200 degrees F). Pump shall be directly connected to suitable drip-proof enclosed motors. Receiver shall be cast iron or not less than 4.75 mm (3/16 inch) thick black iron or steel and shall be provided with all the necessary reinforced threaded openings, including condensate return, vent, overflow, and pump suction connections. Inlet strainer shall be provided either integral in the tank or separate in the inlet line to the tank. Vent pipe shall be galvanized steel, and the fittings shall be galvanized malleable iron. Vent pipe shall be extended through the roof and shall be properly flashed. The pump, motor, and receiving tank may be mounted on a single base with the receiver piped to the pump suctions. A gate valve and check valve shall be provided in the discharge connection from each pump and a strainer and gate valve shall be provided in the suction line to each pump except where pumps are directly mounted on top of the receiver.

2.4.2.1 Controls for Space Heating Steam Loads Only

An enclosed float switch complete with float mechanisms shall be installed in the head of the receiver. Each condensate pump shall be controlled by a float switch which shall automatically start the motor when the water in the receiving tank reaches the high level and stop the motor when the water reaches the low level. The motors shall be provided with magnetic across-the-line starters equipped with general-purpose enclosures and three-position, "Manual-Off-Automatic" selector switches in the cover. Automatic alternator shall be provided for duplex units.

2.4.2.2 Space Heating and Steam Loads or Distribution Lines

The condensate pump shall be provided with an approved float-actuated valve or water feeder in the cold-water makeup connection either external to or integral with the receiver. Where a de-aerating feedwater heater is not included, the condensate pumping unit shall be controlled automatically by a pump controller with low-water cutout on each boiler. The pump controller and low-water cutout shall have two float-operated mercury switches arranged to start and stop the condensate pump at preset boiler water levels. One switch shall control the operation of the condensate pump by starting the pump when the water in the boiler reaches a preset low level and by stopping the pump when the water in the boiler rises to a preset high level. The second switch shall ring an alarm bell and simultaneously shut down the burner. Relays shall be provided if necessary. A minimum 100 mm (4 inch) alarm bell with bell-ringing transformer shall be installed where directed. A gate valve and a check valve or a stop-check (nonreturn) valve shall be installed in the feed line between the boiler and the pump adjacent to the boiler connection. The condensate pump motor shall be provided with a magnetic, across-the-line starter equipped with thermal-overload protection conforming to the requirements of paragraph ELECTRICAL EQUIPMENT. Where two or more boilers are provided, a pump controller and low-water cutout shall be installed at the normal waterline of each boiler. An automatic feed valve shall be installed in the feed line to each boiler. When any boiler requires water, the pump controller shall open the feed valve by actuating an end switch which, in turn, operates the condensate pump. When the normal water level is restored, the pump controller shall close the feed valve, and the end switch of the valve shall stop the condensate pump.

2.4.2.3 Rating and Testing

The pump manufacturer shall submit a certified test report covering the actual test of the unit and certifying that the equipment complies with the indicated requirements.

2.5 COLD WATER CONNECTIONS

Connections shall be provided which includes consecutively in line a strainer, backflow prevention device, and water pressure regulator in that order in the direction of the flow. The backflow prevention device shall be provided as indicated and in compliance with Section 15400 PLUMBING, GENERAL PURPOSE. Cold water fill connections shall be made to the water supply system as indicated. Necessary pipe, fittings, and valves required for water connections between the boiler and cold water main shall be provided as shown. The pressure regulating valve shall be of a type that will not stick or allow pressure to build up on the low side. The valve shall be set to maintain a terminal pressure of approximately,lately 35 kPa (5 psi) in excess of the static head on the system and shall operate within a 15 kPa (2 psi) tolerance regardless of cold water supply piping pressure and without objectionable noise under any condition of operation.

2.6 RADIATORS AND CONVECTORS

The radiator and convector shall be the type and size indicated. The supply and return connections shall be the same size. Cast iron radiators and nonferrous convectors shall be tested hydrostatically at the factory and proved tight under a pressure of not less than 689 kPa (100 psig). A certified report of these tests shall be furnished in accordance with paragraph SUBMITTALS.

2.6.1 Cast Iron Radiators

Cast iron radiators shall be gray cast iron, free from sandholes and other defects. The sections shall be connected with malleable iron nipples not less than 2.286 mm (0.09 inch) thick at any point. Cast iron radiators shall be the legless type mounted on the walls by means of hangers as specified. Adjustable radiator hangers shall be secured to the wall and shall hold the radiators near both ends, at both top and bottom, is such manner that the radiators cannot be removed without the use of tools. Not less than two bolts shall be used to secure each hanger to the wall. Necessary angles, bolts, bearing plates, toggles, radiator grips, and other parts required for complete installation of the radiators shall be provided.

2.6.2 Extended-Surface, Steel, or Nonferrous Tube-Type Radiators

Radiators shall consist of metal fins permanently bonded to steel or nonferrous pipe cores, with threaded or sweat fittings at each end for connecting to external piping. Radiators shall have capacities not less than those indicated, determined in accordance with HYI-01. Radiators shall be equipped with solid-front, slotted sloping-top cover grilles fabricated from black steel sheets not less than 1.519 mm (16 gauge), independently secured to masonry with brackets.

2.6.3 Convectors

Convectors shall be constructed of cast iron or of nonferrous alloys, and shall be installed where indicated. Capacity of convectors shall be as indicated. Overall space requirements for convectors shall not be greater than the space provided. Convectors shall be complete with heating elements and enclosing cabinets having bottom recirculating opening, manual control damper and top supply grille. Convector cabinets shall be constructed of black sheet steel not less than 0.912 mm (20 gauge).

2.6.4 Radiators and Convectors Control

The space temperature shall be maintained automatically by regulating water flow to the radiators and convectors by the self contained, automatic thermostatic radiator control valves.

2.7 RADIANT FLOOR HEATING SYSTEMS

The radiant floor heating system shall include all piping, manifolds, valves, pumps, expansion tank, pressure relief valves, and controls to provide a complete and operational heating system.

2.7.1 Tubing

The tubing material shall comply with ASTM F 876. The pipings shall be provided with a factory applied oxygen barrier with a diffusion rate that does not exceed 0.1 grams per cubic meter per day. The piping shall be rated at 689 kPa 100 psi and 82.5 degrees C (180 degrees F).

2.7.2 Joints

The manifold manufacturer shall be consulted to determine the proper joint for connection of tubing to the manifold. The joints required to connect the tubing to the manifold shall be compression type fittings using crimp rings, a combination of inserts and O-rings, gripper type fittings using a retainer ring and O-rings, or as otherwise recommended by the manifold and tubing manufacturer.

2.7.3 Manifold

The design and construction of the manifold shall be compatible with the tubing manufacture's requirements. The piping manifold material shall be compatible with the piping material. The manifold shall be capable of providing the number of circuits as indicated on the drawings. The manifold shall be suitable for an operating pressure of 689 kPa (100 psi) and 82.5 degrees C (180 degrees F). Balancing valves shall be provided for each circuit. Isolation valves shall be provided for each supply and return connection. Each manifold shall be provided with an air vent. The manifold shall allow for the measurement of temperature for each circuit. The manifold shall be provided with all required mounting hardware.

2.8 HEATING AND VENTILATING UNITS

Heating and ventilating units and associated equipment shall be in accordance with Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.9 AIR HANDLING UNITS

Air handling units and associated equipment shall be in accordance with Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.10 FITTINGS AND ACCESSORIES

Boiler fittings and accessories shall be installed with each boiler in accordance with ASME BPVC SEC IV, unless otherwise specified.

2.10.1 Conventional Breeching and Stacks

2.10.1.1 Breeching

Each boiler shall be connected to the stack or flue by breeching constructed of black steel sheets not less than 1.2 mm (0.0478 inch) thick nor less than thickness of stack, whichever is larger. The clear distance between any portion of the breeching surface and any combustible material shall not be less than that specified in NFPA 211. Joints and seams shall be securely fastened and made airtight. Suitable hinged and gasketed cleanouts shall be provided, which will permit cleaning the entire smoke connection without dismantling. Flexible-type expansion joints shall be provided as required and shall not require packing.

2.10.1.2 Stacks

Individual stub stacks shall extend above the roof to the heights indicated. Individual stub stacks shall be 6 m (20 feet) in height when assembled on the boiler and measured from the ground line. Stack section shall be sheet steel having a thickness of not less than 2.47 mm (0.0972 inch). A 7.92 mm (0.3125 inch) diameter hole shall be provided in the stack not greater than 150 mm (6 inches) from the furnace flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the boiler room when samples are not being taken. Each stack shall be provided complete with rain hood.

2.10.2 Expansion Tank

The hot water pressurization system shall include a diaphragm-type expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The only air in the system shall be the permanent sealed-in air cushion contained in the diaphragm-type tank. The sizes shall be as indicated. The expansion tank shall be welded steel, constructed, tested, and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 850 kPa (125 psi) and precharged to the minimum operating pressure. The tank's air chamber shall be fitted with an air charging valve and pressure gauge. The tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The tank shall have lifting rings and a drain connection. All components shall be suitable for a maximum operating temperature of 120 degrees C (250 degrees F).

2.10.3 Air Separator

External air separation tank shall be steel, constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 850 kPa (125 psi). The capacity of the air separation tank indicated is minimum.

2.10.4 Filters

Filters shall conform to ASTM F 872 or CID A-A-1419.

2.10.5 Foundation (Setting) Materials

2.10.5.1 Firebrick

Firebrick shall be ASTM C 27 class as recommended by boiler manufacturer.

2.10.5.2 Tile

Tile shall be ASTM C 34, Grade LBX.

2.10.5.3 Insulating Brick

Insulating brick shall comply with ASTM C 155.

2.10.5.4 Refractory Mortar

Refractory mortar shall comply with ASTM F 1097.

2.10.5.5 Castable Refractories

Castable refractories shall be ASTM C 401. The minimum modulus of rupture for transverse strength shall be not less than 4136 kPa (600 psi) after being heat soaked for 5 hours or more at a temperature in excess of 1371.1 degrees C (2500 degrees F).

2.10.6 Steel Sheets

2.10.6.1 Galvanized Steel

Galvanized steel shall be ASTM A 653 or KS D 3506.

2.10.6.2 Uncoated Steel

Uncoated steel shall be ASTM A 366 or KS D 3512, composition, condition, and finish best suited to the intended use. Gauge numbers specified refer to manufacturer's standard gauge.

2.10.7 Gaskets

Gaskets shall be nonasbestos material in accordance with ASME B16.21, full face or self-centering type. The gaskets shall be of the spiral wound type with graphite filler material.

2.10.8 Steel Pipe and Fittings

2.10.8.1 Steel Pipe

Steel pipe shall be KS D 3562, Type E or S, Grade A or B, black steel, schedule 40.

2.10.8.2 Steel Pipe Fittings

Fittings shall have the manufacturer's trademark affixed in accordance with KS so as to permanently identify the manufacturer.

2.10.8.3 Steel Flanges

Flanged fittings including flanges, bolts, nuts, bolt patterns, etc. shall be in accordance with KS B 1503, Class 10K. Flange material shall conform to KS D 3710. Flanges for high temperature water systems shall be serrated or raised-face type. Bolts shall be high or intermediate strength material conforming to KS D 3503.

2.10.8.4 Welded Fittings

Buttwelded fittings shall conform to KS B 1541 or KS B 1543, and socket-welded fittings shall conform to KS B 1542.

2.10.8.5 Malleable-Iron Fittings

Fittings shall be KS B 1531, type as required to match connecting piping.

2.10.8.6 Unions

Unions shall be KS B 1531.

2.10.8.7 Threads

Pipe threads shall conform to KS B 0222.

2.10.9 Copper Tubing and Fittings

2.10.9.1 Copper Tubing

Tubing shall be KS D 5301, Type K or L. Adapters for copper tubing shall be brass or bronze for brazed fittings.

2.10.9.2 Solder-Joint Pressure Fittings

Wrought copper and bronze solder-joint pressure fittings shall conform to KS D 5578. Cast copper alloy solder-joint pressure fittings shall conform to KS B 1544.

2.10.9.3 Flared Fittings

Cast copper alloy fittings for flared copper tube shall conform to KS B 1545.

2.10.9.4 Adapters

Adapters may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

2.10.9.5 Brazing Material

Brazing material shall conform to AWS A5.8 or KS D 8050, BcuP-5.

2.10.9.6 Brazing Flux

Flux shall be in paste or liquid form appropriate for use with brazing material. Flux shall be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides, and contain fluorides. Silver brazing materials shall be in accordance with AWS A5.8 or KS D 8319.

2.10.9.7 Solder Material

Solder metal shall conform to ASTM B 32 or KS D 6704, 95-5 tin-antimony.

2.10.9.8 Solder Flux

Flux shall be either liquid or paste form, non-corrosive and conform to ASTM B 813.

2.10.10 Dielectric Waterways and Flanges

Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

2.10.11 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 861.8 kPa (125 psi) or 1034.2 kPa (150 psi) service. Connectors shall be installed where indicated. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. Materials used and the configuration shall be suitable for the pressure, vacuum, and temperature medium. The flexible section shall be suitable for service intended and may have threaded, welded, soldered, flanged, or socket ends. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Covers to protect the bellows shall be provided where indicated.

2.10.12 Pipe Supports

Pipe supports shall conform to MSS SP-58 or KS B 1527, and MSS SP-69.

2.10.13 Pipe Expansion

2.10.13.1 Expansion Loops

Expansion loops and offsets shall provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. The loops and offsets shall be cold-sprung and installed where indicated. Pipe guides and anchors shall be provided as indicated.

2.10.13.2 Expansion Joints

Expansion joints shall provide for either single or double slip of the connected pipes, as required or indicated, and for not less than the transverse indicated. The joints shall be designed for a hot water or steam working pressure not less than 1050 kPa (150 psig) and shall be in accordance with applicable requirements of EJMA Stds and ASME B31.1. End connection shall be flanged. Anchor bases or support bases shall be provided as indicated or required. Sliding surfaces and water wetted surfaces shall be chromium plated or fabricated of corrosion resistant steel. Initial setting shall be made in accordance with the manufacturer's recommendations to compensate for an ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer, but in any case shall not be more than 1.5 m (5 feet) from expansion joint, except in lines 100 mm (4 inches) or smaller guides shall be installed not more than 600 mm (2 feet) from the joint. Service outlets shall be provided where indicated.

a. Bellows-type joints shall be flexible, guided expansion joints. The expansion element shall be stabilized corrosion resistant steel. Bellows-type expansion joints shall conform to the applicable requirements of EJMA Stds and ASME B31.1 with internal lines. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint. The joints shall be designed for the working temperature and pressure suitable for the application but shall not be less than 1135 kPa (150 psig).

b. Flexible ball joints shall be constructed of alloys as appropriate for the service intended. The joints shall be threaded, flanged, or welded end as required and shall be capable of absorbing the normal operating axial, lateral, or angular movements or combination thereof. Balls and sockets shall be polished, chromium-plated when materials are not of corrosion-resistant steel. The ball type joint shall be designed and constructed in accordance with ASME B31.1 and EJMA Stds. Flanges shall conform to the diameter and drilling of ASME B16.5. Molded gaskets shall be suitable for the service intended.

c. Slip type expansion joints shall be EJMA Stds and ASME B31.1, Class 1 or 2. Type II joints shall be suitable for repacking under full line pressure.

2.10.14 Valves

Valves shall be Class 10K and shall be suitable for the application. Valves in nonboiler external piping shall meet the material, fabrication and operating requirements of Korean Industrial Standards (KS). The connection type of all valves shall match the same type of connection required for the piping on which installed.

2.10.14.1 Gate Valves

Gate valves 65 mm (2-1/2 inches) and smaller shall conform to KS B 2301, bronze body, rising stem, threaded, solder, or flanged ends. Gate valves 80 mm (3 inches) and larger shall conform to KS B 2350 or KS B 2356, gray cast iron or malleable iron body, bronze trim, outside screw and yoke, flanged or threaded ends.

2.10.14.2 Globe Valves

Globe valves 65 mm (2-1/2 inches) and smaller shall conform to KS B 2301, bronze body, and threaded, soldered or flanged ends. Globe valves 80 mm (3 inches) and larger shall conform to KS B 2350 or KS B 2356, gray cast iron or malleable iron body, bronze trim, flanged or threaded ends.

2.10.14.3 Check Valves

Check valves 65 mm (2-1/2 inches) and smaller shall conform to KS B 2301, bronze body, and threaded, soldered or flanged ends. Check valves 80 mm (3 inches) and larger shall conform to KS B 2350 or KS B 2356, gray cast iron or malleable iron body, bronze trim, flanged or threaded ends.

2.10.14.4 Angle Valves

Angle valves 65 mm (2-1/2 inches) and smaller shall conform to KS B 2301, bronze body, and threaded, soldered or flanged ends. Angle valves 80 mm (3 inches) and larger shall conform to KS B 2350 or KS B 2356, gray cast iron or malleable iron body, bronze trim, flanged or threaded ends.

2.10.14.5 Ball Valves

Ball valves 15 mm (1/2 inch) and larger shall conform to KS B 2308, brass body, and threaded, soldered or flanged ends.

2.10.14.6 Plug Valves

Plug valves shall conform to KS B 2371.

2.10.14.7 Balancing Valves

Balancing valves shall have meter connections with positive shutoff valves. An integral pointer shall register the degree of valve opening. Valves shall be calibrated so that flow rate can be determined when valve opening in degrees and pressure differential across valve is known. Each balancing valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation. Valves shall be suitable for 120 degrees C (250 degrees F) temperature and working pressure of the pipe in which installed. Valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential. One portable differential meter shall be furnished. The meter suitable for the operating pressure specified shall be complete with hoses, vent, and shutoff valves, and carrying case. In lieu of the balancing valve with integral metering connections, a ball valve or plug valve with a separately installed orifice plate or venturi tube may be used for balancing.

2.10.14.8 Automatic Flow Control Valves

In lieu of the specified balancing valves, automatic flow control valves may be provided to maintain constant flow and shall be designed to be sensitive to pressure differential across the valve to provide the required opening. Valves shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Valves shall control the flow within 5 percent of the tag rating. Valves shall be suitable for the maximum operating pressure of 850 kPa (125 psi) or 150 percent of the system operating pressure, whichever is greater. Where the available system pressure is not adequate to provide the minimum pressure differential that still allows flow control, the system pump head capability shall be increased. Valves shall be suitable for 120 degrees C (250 degrees F) temperature service. Valve materials shall be same as specified for the heating system check, globe, angle, and gate valves. Valve operator shall be the electric motor type or pneumatic type as applicable. Valve operator shall be capable of positive shutoff against the system pump head. Valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential across the automatic flow control valve. A portable meter shall be provided with accessory kit as recommended for the project by the automatic valve manufacturer.

2.10.14.9 Butterfly Valves

Butterfly valves shall be 2-flange type or lug wafer type, and shall be bubbletight at 1135 kPa (150 psig). Valve bodies shall be cast iron, malleable iron, or steel. ASTM A 167 or KS D 3706, Type 404 or Type 316 corrosion resisting steel stems, bronze or corrosion resisting steel discs, and synthetic rubber seats shall be provided. Valves smaller than 200 mm (8 inches) shall have throttling handles with a minimum of seven locking positions. Valves 200 mm (8 inches) and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Valves in insulated lines shall have extended neck to accommodate insulation thickness.

2.10.14.10 Drain valves

Drain valves shall be provided at each drain point of blowdown as recommended by the boiler manufacturer. Piping shall conform to ASME BPVC SEC IV and KS D 3562.

2.10.14.11 Safety Valves

Safety valves shall have steel bodies and shall be equipped with corrosion-resistant trim and valve seats. The valves shall be properly guided and shall be positive closing so that no leakage can occur. Adjustment of the desired back-pressure shall cover the range between 15 and 70 kPa.(2 and 10 psig). The adjustment shall be made externally, and any shafts extending through the valve body shall be provided with adjustable stuffing boxes having renewable packing. Boiler safety valves of proper size and of the required number, in accordance with ASME BPVC SEC IV, shall be installed so that the discharge will be through piping extended to a location as indicated. Each discharge pipe for steam service shall be provided with a drip pan elbow to prevent accumulation of water on the valve. A slip joint shall be provided between drip pan elbow and riser. Each discharge pipe for hot water service shall be pitched away from the valve seat.

2.10.15 Strainers

Basket and "Y" type strainers shall be the same size as the pipelines in which they are installed. The strainer bodies shall be heavy and durable, fabricated of cast iron, and shall have bottoms drilled and tapped with a gate valve attached for blowdown purposes. Strainers shall be designed for 860 kPa (125 psig) service and 120 degrees C (250 degrees F). The bodies shall have arrows clearly cast on the sides indicating the direction of flow. Each strainer shall be equipped with an easily removable cover and sediment screen. The screen shall be made of 0.795 mm thick (22 gauge) brass sheet, monel or corrosion-resistant steel with small perforations numbering not less than

620,000 per square m (400 per square inch) to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.10.16 Pressure Gauges

Gauges shall conform to ASME B40.1 and shall be provided with throttling type needle valve or a pulsation dampener and shutoff valve. Minimum dial size shall be 90 mm (3-1/2 inches). A pressure gauge shall be provided for each boiler in a visible location on the boiler. Pressure gauges shall be provided with readings in Kpa and psi. Pressure gauges shall have an indicating pressure range that is related to the operating pressure of the fluid in accordance with the following table:

Operating Pressure (kPA)	Pressure Range (kPA)
519-1030	0-1400
105-518	0-690
14-104	0-210 (retard)

Operating Pressure (psi)	Pressure Range (psi)
6-150	0-200
16-75	0-100
2-15	0-30 (retard)

2.10.17 Thermometers

Thermometers shall be provided with wells and separable corrosion-resistant steel sockets. Mercury shall not be used in thermometers. Thermometers for inlet water and outlet water for each hot water boiler and the feedwater for each steam boiler shall be provided in a visible location on the boiler. Thermometers shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a minimum 225 mm (9 inch) scale. The operating range of the thermometers shall be 0-100 degrees centigrade (32-212 degrees Fahrenheit). The thermometers shall be provided with readings in degrees centigrade and Fahrenheit.

2.10.18 Air Vents

2.10.18.1 Manual Air Vents

Manual air vents shall be brass or bronze valves or cocks suitable for the pressure rating of the piping system and furnished with threaded plugs or caps.

2.10.18.2 Automatic Air Vents

Automatic air vents shall be 20 mm (3/4 inch) quick-venting float and vacuum air valves. Each air vent valve shall have a large port permitting the expulsion of the air without developing excessive back pressure, a noncollapsible metal float which will close the valve and prevent the loss of water from the system, an air seal that will effectively close and prevent the re-entry of air into the system when subatmospheric pressures prevail therein, and a thermostatic member that will close the port against the passage of steam from the system. The name of the manufacturer shall be clearly stamped on the outside of each valve. The air vent valve shall be suitable for the pressure rating of the piping system.

2.10.19 Steam Traps

2.10.19.1 Thermostatic Traps

Thermostatic traps shall conform to the requirements of ASTM F 1139 and shall be installed in the return connection from each radiator and elsewhere as indicated. Drip traps for mains, risers, and similar lines shall be installed with a cooling leg of 1.50 m (5 feet) of uncovered 20 mm (3/4 inch) pipe. The capacity of traps shall be based on a pressure differential of 15 kPa (2 psi). The traps shall be designed for a steam working pressure of 100 kPa (15 psig) but shall operate with a supply pressure of approximately 15 kPa (2 psig). The traps shall be angle or straight-through pattern with union inlet connections as indicated. The trap bodies and covers shall be brass. Valve mechanisms and seats shall be monel, stainless steel or hard bronze and shall be removable for servicing or replacement.

2.10.19.2 Float-and-Thermostatic Traps

Float-and-thermostatic traps shall conform to the requirements of ASTM F 1139 and be designed for a steam working pressure of 100 kPa (15 psig) but shall operate with a supply pressure of approximately 34 kPa (5 psig). The trap capacity shall be based on a pressure differential of 15 kPa (2 psig). Each float-and-thermostatic trap shall have a cast iron body and shall be provided with a hard bronze, monel, or corrosion-resisting steel valve seat and mechanism, an open- or closed-type float of brass or equally corrosion-resistant metal, and a corrosion-resisting steel thermostatic air vent, all of which can be easily removed for inspection or replacement without disturbing the piping connections. The inlet to each trap shall have a brass or stainless steel strainer, either as an integral part of the trap or as a separate item of equipment.

2.10.19.3 Inverted Bucket Traps

Inverted bucket traps shall conform to the requirements of ASTM F 1139 and be designed for a steam working pressure of 100 kPa (15 psig) but shall operate with a supply pressure of approximately 35 kPa (5 psig). Each trap shall have a cast iron body and shall have a corrosion-resistant steel valve and seat and a brass or corrosion-resistant steel bucket, all of which can be easily removed for inspection or replacement without disturbing the piping connections. The inlet to each trap shall have a brass or stainless steel strainer, either as an integral part of the trap or as a separate item of equipment.

2.11 ELECTRICAL EQUIPMENT

Electric motor-driven equipment shall be provided complete with motors, motor starters, and necessary control devices. Electrical equipment, motor control devices, motor efficiencies and wiring shall be as specified in Section 16415 ELECTRICAL WORK, INTERIOR. Motors which are not an integral part of a packaged boiler shall be rated for high efficiency service. Motors which are an integral part of the packaged boiler shall be the highest efficiency available by the manufacturer of the packaged boiler. Motor starters shall be provided complete with properly sized thermal overload protections and other appurtenances necessary for the motor control specified. Starters shall be furnished in general purpose, watertight, or explosion-proof, Class I, division I enclosures as indicated or required. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices but not shown shall be provided.

2.11.1 Motor Ratings

Motors shall be suitable for the voltage and frequency provided. Motors 375 W (1/2 hp) and larger shall be three-phase, unless otherwise indicated. Motors shall be of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating on the motor.

2.11.2 Motor Controls

Motor controllers shall be provided complete with properly sized thermal overload protection. Manual or automatic control and protective or signal devices required for the operation specified and any wiring required to such devices shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Solid state variable speed controllers shall be utilized for fractional through 7.46 kW (10 hp)10 hp ratings. Adjustable frequency drives shall be used for larger motors.

2.12 INSULATION

Shop and field-applied insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.13 TOOLS

Special tools shall be furnished. Special tools shall include uncommon tools necessary for the operation and maintenance of boilers, burners, pumps, fans, controls, meters, special piping systems, and other equipment. Small hand tools shall be furnished within a suitable cabinet, mounted where directed.

2.13.1 Breeching Cleaner

A cleaner shall be provided to clean the breeching. The cleaner shall have a jointed handle of sufficient length to clean the breeching without dismantling.

2.13.2 Tube Cleaner

If a watertube boiler is being furnished, a water-driven tube cleaner with three rotary cutters and rotary wire brush complete with the necessary length of armored water hose, valves, and other appurtenances necessary for operation shall be provided. Tube cleaner and rotary brush shall be provided for each size of water tube in the boiler, with one extra set of cutters for each size cleaner. Necessary valves and fittings shall be provided to permit ready connection of the cleaner hose to a high-pressure pump for cold water supply to operate the cleaner.

2.13.3 Tube Brush

If a firetube boiler is being furnished, a tube brush, with steel bristles and jointed handle of sufficient length to clean full length of firetubes, shall be provided.

2.13.4 Wrenches

Wrenches shall be provided as required for specialty fittings such as manholes, handholes, and cleanouts. One set of extra gaskets shall be provided for all manholes and handholes, for pump barrels, and other similar items of equipment. Gaskets shall be packaged and properly identified.

2.14 FUEL OIL STORAGE SYSTEM

The fuel oil storage system shall be as specified in Section 13202 FUEL STORAGE SYSTEMS unless noted otherwise.

2.15 Chemical Shot Feeder

A shot feeder shall be provided as indicated. Size and capacity of feeder shall be based upon local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

PART 3 EXECUTION

3.1 ERECTION OF BOILER AND AUXILIARY EQUIPMENT

Boiler and auxiliary equipment shall be installed in accordance with manufacturer's written instructions. Proper provision shall be made for expansion and contraction between boiler foundation and floor. This joint shall be packed with suitable nonasbestos rope and filled with suitable compound that will not become soft at a temperature of 40 degrees C (100 degrees F). Boilers and firing equipment shall be supported from the foundations by structural steel completely independent of all brickwork. Boiler supports shall permit free expansion and contraction of each portion of the boiler without placing undue stress on any part of the boiler or setting. Boiler breeching shall be as indicated with full provision for expansion and contraction between all interconnected components.

3.2 PIPING INSTALLATION

Unless otherwise specified, nonboiler external pipe and fittings shall conform to the requirements of ASME B31.1. Pipe installed shall be cut accurately to suit field conditions, shall be installed without springing or forcing, and shall properly clear windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted. Pipes shall be free of burrs, oil, grease and other foreign material and shall be installed to permit free expansion and contraction without damaging the building structure, pipe, pipe joints, or pipe supports. Changes in direction shall be made with fittings, except that bending of pipe 100 mm 4 inches and smaller will be permitted provided a pipe bender is used and wide sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Vent pipes shall be carried through the roof as directed and shall be properly flashed. Unless otherwise indicated, horizontal supply mains shall pitch down in the direction of flow with a grade of not less than 0.2 percent (1 inch in 40 feet). Open ends of pipelines and equipment shall be properly capped or plugged during installation to keep dirt or other foreign materials out of the systems. Pipe not otherwise specified shall be uncoated. Unless otherwise specified or shown, final connections to equipment shall be made with malleable-iron unions for steel pipe 65 mm (2-1/2 inches) or less in diameter and with flanges for pipe 80 mm 3 inches or more in diameter. Unions for copper pipe or tubing shall be brass or bronze. Reducing fittings shall be used for changes in pipe sizes. In horizontal hot water lines, reducing fittings shall be eccentric type to maintain the top of the lines at the same level to prevent air binding.

3.2.1 Hot Water Piping and Fittings

Pipe shall be black steel or copper tubing. Fittings for steel piping shall be black malleable iron or cast iron to suit piping. Fittings adjacent to valves shall suit valve material. Grooved mechanical fittings will not be allowed for water temperatures above 110 degrees C (230 degrees F).

3.2.2 Vent Piping and Fittings

Vent piping shall be black steel. Fittings shall be black malleable iron or cast iron to suit piping.

3.2.3 Gauge Piping

Piping shall be copper tubing.

3.2.4 Steam Piping and Fittings

Piping shall be black steel. Fittings shall be black, malleable iron, cast iron or steel. Fittings adjacent to valves shall suit valves specified.

3.2.5 Condensate Return Pipe and Fittings

Piping shall be black steel. Fittings shall be malleable iron, cast iron, or steel.

3.2.6 Joints

Joints between sections of steel pipe and between steel pipe and fittings shall be threaded, grooved, flanged or welded as indicated or specified. Except as otherwise specified, fittings 25 mm (1 inch) and smaller shall be threaded; fittings 32 mm (1-1/4 inches) and up to but not including 80 mm (3 inches) shall be either threaded or welded; and fittings 80 mm (3 inches) and larger shall be either flanged or welded. Pipe and fittings 32 mm (1-1/4 inches) and larger installed in inaccessible conduit or trenches beneath concrete floor slabs shall be welded. Connections to equipment shall be made with black malleable-iron unions for pipe 65 mm (2-1/2 inches) or smaller in diameter and with flanges for pipe 80 mm (3 inches) inches or larger in diameter. Joints between sections of copper tubing or pipe shall be flared, soldered, or brazed.

3.2.6.1 Threaded Joints

Threaded joints shall be made with tapered threads properly cut and shall be made perfectly tight with a stiff mixture of graphite and oil or with polytetrafluoroethylene tape applied to the male threads only and in no case to the fittings.

3.2.6.2 Welded Joints

Welded joints shall be in accordance with paragraph GENERAL REQUIREMENTS unless otherwise specified. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connections may be made with either welding tees or forged branch outlet fittings, either being acceptable without size limitation. Branch outlet fittings, where used, shall be forged, flared for improved flow characteristics where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength. Socket weld joints shall be assembled so that the space between the end of the pipe and the bottom of the socket is no less than 1.5 mm (1/16 inch) and no more than 3 mm (1/8 inch).

3.2.6.3 Flared and Brazed Copper Pipe and Tubing

Tubing shall be cut square, and burrs shall be removed. Both inside of fittings and outside of tubing shall be cleaned thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing shall not occur when making connections. Installation shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Brazed joints shall be made in conformance with AWS B2.2, KS D 5578, and CDA Tube Handbook with flux. Copper-to-copper joints shall include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorous, copper-phosphorous-silver or a silver brazing filler metal. Joints for flared fittings shall be of the compression pattern. Swing joints or offsets shall be provided in all branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing. Flared or brazed copper tubing to pipe adapters shall be provided where necessary for joining threaded pipe to copper tubing.

3.2.6.4 Soldered Joints

Soldered joints shall be made with flux and are only acceptable for lines 50 mm (2 inches) and smaller. Soldered joints shall conform to ASME B31.5 and CDA Tube Handbook.

3.2.6.5 Copper Tube Extracted Joint

An extruded mechanical tee joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. The branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.2.7 Flanges and Unions

Flanges shall be faced true, provided with 1.6 mm (1/16 inch) thick gaskets, and made square and tight. Where steel flanges mate with cast-iron flanged fittings, valves, or equipment, they shall be provided with flat faces and full face gaskets. Union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Dielectric pipe unions shall be provided between ferrous and nonferrous piping to prevent galvanic corrosion. The dielectric unions shall have metal connections on both ends. The ends shall be threaded, flanged, or brazed to match adjacent piping. The metal parts of the union shall be separated so that the electrical current is below 1 percent of the galvanic current which would exist upon metal-to-metal contact. Gaskets, flanges, and unions shall be installed in accordance with manufacturer's recommendations.

3.2.8 Branch Connections

3.2.8.1 Branch Connections for Hot Water Systems

Branches from the main shall pitch up or down as shown to prevent air entrapment. Connections shall ensure unrestricted circulation, eliminate air pockets, and permit complete drainage of the system. Branches shall pitch with a grade of not less than 8 mm in 1 m (1 inch in 10 feet). When indicated, special flow fittings shall be installed on the mains to bypass portions of the water through each radiator. Special flow fittings shall be standard catalog products and shall be installed as recommended by the manufacturer.

3.2.8.2 Branch Connections for Steam Systems

Branches shall be taken from the supply mains at an angle of 45 degrees above the horizontal, unless otherwise indicated. The branches from return mains shall be taken from the top or sides, unless indicated otherwise. Branches shall pitch up from the mains toward the undripped risers or radiator connections with a grade of not less than 8 mm in 1 m (1 inch in 10 feet). Connections to ensure unrestricted circulation, eliminate air pockets, and permit the complete drainage of the system.

3.2.9 Steam Connections to Equipment

Steam supply and return connections shall be provided as shown. Connections shall be made with malleable-iron unions or with steel flanges, to match equipment. Valves and traps shall be installed in accordance with the manufacturer's recommendations. The size of the supply and return pipes to each piece of equipment shall not be smaller than the outlets on the equipment.

3.2.10 Steam Risers

The location of risers is approximate. The exact locations of the risers shall be approved. Downfeed risers shall terminate in a dirt pocket and shall be dripped through a trap to the return line.

3.2.11 Air Vents for Steam Systems

Automatic balanced pressure thermostatic air vents shall be installed at the ends of the steam lines and where shown on the drawings. The vents shall be rated for 862 kPa 125 psi steam service. The outlet of the vent shall be routed to a point designated by the Contracting Officer's Representative. The inlet line shall have a gate valve or ball valve.

3.2.12 Flared, Brazed, and Soldered Copper Pipe and Tubing

Copper tubing shall be flared, brazed, or soldered. Tubing shall be cut square, and burrs shall be removed. Both inside of fittings and outside of tubing shall be cleaned thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing shall not occur when making connections. Installation shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints for flared fittings shall be of the compression pattern. Swing joints or offsets shall be provided on branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing. Pipe adapters shall be provided where necessary for joining threaded pipe to copper tubing. Brazed joints shall be made in conformance with KS D 5578, and CDA Tube Handbook. Copper-to-copper joints shall include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorous, copper-phosphorous-silver, or a silver brazing filler metal. Soldered joints shall be made with flux and are only acceptable for lines 50 mm 2 inches or smaller. Soldered joints shall conform to ASME B31.5 and shall be in accordance with CDA Tube Handbook.

3.2.13 Copper Tube Extracted Joint

An extracted mechanical tee joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. The branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.2.14 Supports

Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. Threaded rods which are used for support shall not be formed or bent.

3.2.14.1 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 or KS 1527, and MSS SP-69, except as modified herein.

a. Types 5, 12, and 26 shall not be used.

b. Type 3 shall not be used on insulated pipe which has a vapor barrier. Type 3 may be used on insulated pipe that does not have a vapor barrier if clamped directly to the pipe, if the clamp bottom does not extend through the insulation, and if the top clamp attachment does not contact the insulation during pipe movement.

c. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.

d. Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices furnished by the manufacturer. Field fabricated C-clamp bodies or retaining devices are not acceptable.

e. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

g. Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm (1 foot) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1500 mm 5 feet apart at valves.

h. Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4500 mm (15 feet), not more than 2400 mm (8 feet) from end of risers, and at vent terminations.

i. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

(1) Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) and larger, a Type 39 saddle may be welded to the pipe and freely rested on a steel plate. On piping under 100 mm (4 inches), a Type 40 protection shield may be attached to the pipe or insulation and freely rested on a steel slide plate.

(2) Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide shall include a pipe cradle welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm (4 inches) or by an amount adequate for the insulation, whichever is greater.

j. Except for Type 3, pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation.

k. Piping in trenches shall be supported as indicated.

l. Structural steel attachments and brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material and installation shall be as specified under Section 05120A STRUCTURAL STEEL. Pipe hanger loads suspended from steel joist between panel points shall not exceed 22 kg (50 pounds). Loads exceeding 22 kg 50 pounds shall be suspended from panel points.

3.2.14.2 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support member shall not exceed the hanger and support spacing required for any individual pipe in the multiple pipe run. The clips or clamps shall be rigidly attached to the common base member. A clearance of 3 mm (1/8 inch) shall be provided between the pipe insulation and the clip or clamp for piping which may be subjected to thermal expansion.

3.2.15 Anchors

Anchors shall be provided where necessary to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results, using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline.

3.2.16 Valves

Valves shall be installed where indicated, specified, and required for functioning and servicing of the systems. Valves shall be safely accessible. Swing check valves shall be installed upright in horizontal lines and in vertical lines only when flow is in the upward direction. Gate and globe valves shall be installed with stems horizontal or above. Valves to be brazed shall be disassembled prior to brazing and all packing removed. After brazing, the valves shall be allowed to cool before reassembling.

3.2.17 Pipe Sleeves

Pipe passing through concrete or masonry walls or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. A waterproofing clamping flange shall be installed as indicated where membranes are involved. Sleeves shall not be installed in structural members except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective wall, floor, or roof. Sleeves through walls shall be cut flush with wall surface. Sleeves through floors shall be cut flush with floor surface. Sleeves through roofs shall extend above the top surface of roof at least 150 mm (6 inches) for proper flashing or finishing. Unless otherwise indicated, sleeves shall be sized to provide a minimum clearance of 6 mm (1/4 inch) between bare pipe and sleeves or between jacket over insulation and sleeves. Sleeves in waterproofing membrane floors, bearing walls, and wet areas shall be galvanized steel pipe or cast-iron pipe. Sleeves in nonbearing walls, floors, or ceilings may be galvanized steel pipe, cast-iron pipe, or galvanized sheet metal with lock-type longitudinal seam. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve in nonfire rated walls shall be sealed as indicated and specified in Section 07900 JOINT SEALING. Metal jackets shall be provided over insulation passing through exterior walls, firewalls, fire partitions, floors, or roofs.

a. Metal jackets shall not be thinner than 0.1524 mm (0.006 inch) thick aluminum, if corrugated, and 0.4 mm (0.016 inch) thick aluminum, if smooth.

b. Metal jackets shall be secured with aluminum or stainless steel bands not less than 9 mm (3/8 inch) wide and not more than 200 mm (8 inches) apart. When penetrating roofs and before fitting the metal jacket into place, a 15 mm (1/2 inch) wide strip of sealant shall be run vertically along the inside of the longitudinal joint of the metal jacket from a point below the backup material to a minimum height of 1000 mm (36 inches) above the roof. If the pipe turns from vertical to horizontal, the sealant strip shall be run to a point just beyond the first elbow. When penetrating waterproofing membrane for floors, the metal jacket shall extend from a point below the back-up material to a minimum distance of 50 mm (2 inches) above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 300 mm (12 inches) above material to a minimum distance of 50 mm (2 inches) above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 300 mm (12 inches) above the floor; when passing through walls above grade, the jacket shall extend at least 100 mm (4 inches) beyond each side of the wall.

3.2.17.1 Pipes Passing Through Waterproofing Membranes

In addition to the pipe sleeves referred to above, pipes passing through waterproofing membranes shall be provided with a 1.6 mm (4 pound) lead flashing or a 0.55 mm (16 ounce) copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 200 mm (8 inches) from the pipe and shall set over the membrane in a troweled coating of bituminous cement. The flashing shall extend above the roof or floor a minimum of 250 mm (10 inches). The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Pipes up to and including 250 mm (10 inches) in diameter which pass through waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts.

Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

3.2.17.2 Optional Modular Mechanical Sealing Assembly

At the option of the Contractor, a modular mechanical type sealing assembly may be installed in the annular space between the sleeve and conduit or pipe in lieu of a waterproofing clamping flange and caulking and sealing specified above. The seals shall include interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion-protected carbon steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved.

3.2.17.3 Optional Counterflashing

As alternates to caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may consist of standard roof coupling for threaded pipe up to 150 mm (6 inches) in diameter, lead flashing sleeve for dry vents with the sleeve turned down into the pipe to form a waterproof joint, or a tack-welded or banded-metal rain shield around the pipe, sealed as indicated.

3.2.17.4 Fire Seal

Where pipes pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07840 FIRESTOPPING.

3.2.18 Balancing Valves

Balancing valves shall be installed as indicated.

3.2.19 Thermometer Wells

A thermometer well shall be provided in each return line for each circuit in multicircuit systems.

3.2.20 Air Vents

Air vents shall be installed where shown or directed. Air vents shall be installed in piping at all system high points. The vent shall remain open until water rises in the tank or pipe to a predetermined level at which time it shall close tight. An overflow pipe from the vent shall be run to a point designated by the Contracting Officer's representative. The inlet to the air vent shall have a gate valve or ball valve.

3.2.21 Escutcheons

Escutcheons shall be provided at all finished surfaces where exposed piping, bare or insulated, passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be chromium-plated iron or chromium-plated brass, either one-piece or split pattern, held in place by internal spring tension or setscrews.

3.2.22 Drains

A drain connection with a 25 mm (1 inch) gate valve or 20 mm (3/4 inch) hose bib shall be installed at the lowest point in the return main near the boiler. In addition, threaded drain connections with threaded cap or plug shall be installed on the heat exchanger coil on each unit heater or unit ventilator and wherever required for thorough draining of the system.

3.2.23 Strainer Blow-Down Piping

Strainer blow-down connections shall be fitted with a black steel blow-down pipeline routed to an accessible location and provided with a blow-down valve.

3.2.24 Direct Venting for Combustion Intake Air and Exhaust Air

The intake air and exhaust vents shall be installed in accordance with NFPA 54 and boiler manufacturer's recommendations. The exhaust vent shall be sloped 20.8 mm per m (1/4 inch per ft) toward the boiler's flue gas condensate collection point.

3.3 GAS FUEL SYSTEM

Gas piping, fittings, valves, regulators, tests, cleaning, and adjustments shall be in accordance with the US Army Corps of Engineers, Unified Facilities Guide Specifications (UFGS), Section 15190 GAS PIPING SYSTEMS. NFPA 54 shall be complied with unless otherwise specified. Burners, pilots, and all accessories shall be listed in UL Gas&Oil Dir. The fuel system shall be provided with a gas tight, manually operated, UL listed stop valve at the gas-supply connections, a gas strainer, a pressure regulator, pressure gauges, a burner-control valve, a safety shutoff valve suitable for size of burner and sequence of operation, and other components required for safe, efficient, and reliable operation as specified. Approved permanent and ready facilities to permit periodic valve leakage tests on the safety shutoff valve or valves shall be provided.

3.4 FUEL OIL SYSTEM

Fuel oil system shall be installed in accordance with NFPA 31, unless otherwise indicated.

3.4.1 Piping and Storage Tank

Fuel oil piping and storage tanks shall be installed in accordance with Section 13202 FUEL STORAGE SYSTEMS, unless indicated otherwise.

3.4.2 Automatic Safety Shutoff Valve

Oil supply line to each oil burner shall be equipped with an automatically operated valve designed to shut off the oil supply in case of fire in the immediate vicinity of the burner. The valve shall be thermoelectrically actuated or thermomechanically actuated type and shall be located immediately downstream of the manual shutoff valve at the day tank inside of the building. If a day tank is not used, the automatic safety valve shall be located immediately downstream of the building shutoff devices where oil supply line enters the building. A thermoelectrical or thermomechanical detection device shall be located over the oil burner to activate the valve. A fire shutoff valve may be combined with other automatic shutoff devices if listed in UL Gas&Oil Dir.

3.4.3 Earthwork

Excavation and backfilling for tanks and piping shall be as specified in Section 02316 EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS.

3.5 RADIANT FLOOR HEATING SYSTEM

The radiant floor heating system shall be installed in accordance with HYI-400, unless otherwise indicated by the tubing manufacturer's installation instructions. During the installation, all tubing shall be plugged on each end to prevent foreign materials from entering the tubing. All tubing shall be checked for abrasions prior to installation. Tubing with excessive abrasions that damage the oxygen barrier coating will not be acceptable. Tubing with any abrasion that is greater than 10 percent of the minimum wall thickness will not be acceptable. All tubing embedded or concealed by the floor shall be installed without joints. The bending radius of the tubing shall not exceed the values recommended by the tubing manufacturer. The tubing shall be installed in such a manner as to evenly distribute the heat across the floor. Tubing shall not be placed near heat sensitive materials such as water closet seals. Isolation valves shall be installed on each side of each tubing manifold. The manifold and fittings shall be accessible for maintenance. After the system is filled with water or glycol, all air shall be vented from the system. After the system is allowed to stabilize at the operating temperatures of the heating fluid, the system shall be vented again.

3.5.1 Concrete Slab construction

In areas where tubing must cross expansion joints, control joints, or other crack control measures, the tubing shall be installed below the joints. The tubing shall be fastened to the reinforcing steel in accordance with the tubing manufacturer's recommendations. The tubing shall be pressurized prior to and during the concrete pour to ensure system integrity.

3.5.2 Wooden Floor Construction

Tubing shall be fastened to the wood subflooring in accordance with the drawings and the tubing manufacturer's recommendations. The method of attaching the tubing to the flooring shall not cause abrasions on the tubing.

3.5.3 Penetrations to Fire Rated Assemblies

Where pipe pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07840 FIRESTOPPING.

3.6 COLOR CODE MARKING AND FIELD PAINTING

Color code marking of piping shall be as specified in Section 09900 PAINTS AND COATINGS. Ferrous metal not specified to be coated at the factory shall be cleaned, prepared, and painted as specified in Section 09900 PAINTS AND COATINGS. Exposed pipe covering shall be painted as specified in Section 09900 PAINTS AND COATINGS. Aluminum sheath over insulation shall not be painted.

3.7 TEST OF BACKFLOW PREVENTION ASSEMBLIES

Backflow prevention assemblies shall be tested in accordance with Section 15400 PLUMBING, GENERAL PURPOSE.

3.8 HEATING SYSTEM TESTS

Before any covering is installed on pipe or heating equipment, the entire heating system's piping, fittings, and terminal heating units shall be hydrostatically tested and proved tight at a pressure of 1-1/2 times the design working pressure, but not less than 689 kPa (100 psi). Before pressurizing system for test, items or equipment (e.g., vessels, pumps, instruments, controls, relief valves) rated for pressures below the test pressure shall be blanked off or replaced with spool pieces. Before balancing and final operating test, test blanks and spool pieces shall be removed; and protected instruments and equipment shall be reconnected. With equipment items protected, the system shall be pressurized to test pressure. Pressure shall be held for a period of time sufficient to inspect all welds, joints, and connections for leaks, but not less than 2 hours. No loss of pressure will be allowed. Leaks shall be repaired and repaired joints shall be retested. Repair joints shall not be allowed under the floor for floor radiant heating systems. If a leak occurs in tubing located under the floor in radiant heating systems, the entire zone that is leaking shall be replaced. If any repair is made above the floor for floor radiant heating systems, access shall be provided for the installed joint. Caulking of joints shall not be permitted. System shall be drained and after instruments and equipment are reconnected, the system shall be refilled with service medium and maximum operating pressure applied. The pressure shall be held while inspecting these joints and connections for leaks. The leaks shall be repaired and the repaired joints retested. Upon completion of hydrostatic tests and before acceptance of the installation, the Contractor shall balance the heating system in accordance with Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS; and operating tests required to demonstrate satisfactory functional and operational efficiency shall be performed. The operating test shall cover a period of at least 24 hours for each system, and shall include, as a minimum, the following specific information in a report, together with conclusions as to the adequacy of the system:

a. Certification of balancing.

b. Time, date, and duration of test.

c. Outside and inside dry bulb temperatures.

d. Temperature of hot water supply leaving boiler or Steam pressure.

e. Temperature of heating return water from system at boiler inlet or condensate feed to boiler inlet.

f. Quantity of water feed to boiler.

g. Boiler make, type, serial number, design pressure, and rated capacity.

h. Fuel burner make, model, and rated capacity; ammeter and voltmeter readings for burner motor.

i. Circulating or Condensate pump make, model, and rated capacity, and ammeter and voltmeter readings for pump motor during operation.

j. Flue-gas temperature at boiler outlet.

k. Percent carbon dioxide in flue-gas.

l. Grade or type and calorific value of fuel.

m. Draft at boiler flue-gas exit.

n. Draft or pressure in furnace.

o. Quantity of water circulated.

p. Quantity of fuel consumed.

q. Stack emission pollutants concentration.

Indicating instruments shall be read at half-hour intervals unless otherwise directed. The Contractor shall furnish all instruments, equipment, and personnel required for the tests and balancing. Fuels, water, and electricity shall be obtained as specified in the SPECIAL CONTRACT REQUIREMENTS. Operating tests shall demonstrate that fuel burners and combustion and safety controls meet the requirements of ASME CSD-1, ANSI Z21.13 and NFPA 85

3.9 CLEANING

3.9.1 Boilers and Piping

After the hydrostatic tests have been made and before the system is balanced and operating tests are performed, the boilers and feed water piping shall be thoroughly cleaned by filling the system with a solution consisting of either 0.5 kg (1 pound) of caustic soda or 0.5 kg (1 pound) of trisodium phosphate per 100 L (50 gallons) of water. The proper safety precautions shall be observed in the handling and use of these chemicals. The water shall be heated to approximately 65 degrees C (150 degrees F) and the solution circulated in the system for a period of 48 hours. The system shall then be drained and thoroughly flushed out with fresh water. Strainers and valves shall be thoroughly cleaned. Prior to operating tests, air shall be removed from all water systems by operating the air vents.

3.9.2 Heating Units

Inside space heating equipment, ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for fans that are operated during construction, and new filters shall be installed after construction dirt has been removed from the building, and the ducts, plenum, casings, and other items specified have been vacuum cleaned. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.10 FUEL SYSTEM TESTS

3.10.1 Fuel Oil System Test

The fuel oil system shall be tested in accordance with Section 13202 FUEL STORAGE SYSTEMS.

3.10.2 Gas System Test

The gas fuel system shall be tested in accordance with the test procedures outlined in NFPA 54.

3.11 FIELD TRAINING

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 24 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The field instructions shall cover all of the items contained in the approved operation and maintenance instructions, as well as demonstrations of routine maintenance operations and boiler safety devices. The Contracting Officer shall be notified at least 14 days prior to date of proposed conduction of the training course.

SECTION 15620

LIQUID CHILLERS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 450 (1999) Water-Cooled Refrigerant Condensers, Remote Type

ARI 460 (2000) Remote Mechanical-Draft Air-Cooled Refrigerant Condensers

ARI 480 (1995) Refrigerant-Cooled Liquid Coolers, Remote Type

ARI 495 (1999) Refrigerant Liquid Receivers

ARI 550/590 (1998) Water-Chilling Packages Using the Vapor Compression Cycle

ARI 560 (1992) Absorption Water Chilling and Water Heating Packages

ARI 575	(1994) Method of Measuring Machinery Sound Within an Equipment Space
ARI 700	(1999) Specifications for Fluorocarbon and Other Refrigerants
ARI 740	(1998) Refrigerant Recovery/Recycling Equipment

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(1990; R 1999) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 307	(2000) Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM D 520	(2000) Zinc Dust Pigment
ASTM E 84	(2000a) Surface Burning Characteristics of Building Materials
ASTM F 104	(1995) Nonmetallic Gasket Materials

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(1994) Safety Code for Mechanical Refrigeration
ASHRAE 34	(1997) Number Designation and Safety Classification of Refrigerants
ASHRAE 64	(1995) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(1999) Safety in Welding and Cutting

ASME INTERNATIONAL (ASME)

ASME BPVC SEC IX	(1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(1998) Motors and Generators NEMA MG 2 (1989) Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators
NEMA SM 23	(1991) Steam Turbines for Mechanical Drive Service

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 37	(2002) Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 54	(1999) National Fuel Gas Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J537 (1996) Storage Batteries

UNDERWRITERS LABORATORIES (UL)

UL 1236 (1994; Rev thru Mar 1999) Battery Chargers for Charging Engine-Starter Batteries

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G

Installation; G

Drawings, at least 5 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

a. Equipment layouts which identify assembly and installation details.

b. Plans and elevations which identify clearances required for maintenance and operation.

c. Wiring diagrams which identify each component individually and all interconnected or interlocked relationships between components.

d. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations.

e. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

SD-03 Product Data

Refrigeration System; G

Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. Data shall be adequate to demonstrate compliance with contract requirements as specified within the paragraphs:

a. Liquid Chiller

b. Chiller Components

c. Accessories

If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Spare Parts

Spare parts data for each different item of equipment specified, after approval of detail drawings and not later than 1 months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Posted Instructions; G

Posted instructions, at least 2 weeks prior to construction completion, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

Verification of Dimensions

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

Factory Tests

Schedules, at least 2 weeks prior to the factory test, which identify the date, time, and location for each test.

Schedules shall be submitted for both the Chiller Performance Test and the Chiller Sound Test. The Chiller Performance Test schedule shall also allow the witnessing of the test by a Government Representative.

System Performance Tests

A schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules shall identify the proposed date, time, and location for each test.

Demonstrations

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

SD-06 Test Reports

Factory Tests; G

Six copies of the report shall be provided in bound 216 x 279 mm (8 1/2 x 11 inch) booklets. Reports shall certify the compliance with performance requirements and follow the format of the required testing standard for both the Chiller Performance Tests and the Chiller Sound Tests. Test report shall include certified calibration report of all test instrumentation. Calibration report shall include certification that all test instrumentation has been calibrated within 6 months prior to the test date, identification of all instrumentation, and certification that all instrumentation complies with requirements of the test standard. Test report shall be submitted 1 week after completion of the factory test.

System Performance Tests; G

Six copies of the report shall be provided in bound 216 x 279 (8 1/2 x 11 inch) booklets. The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information and shall be taken at least three different times at outside dry-bulb temperatures that are at least 3 degrees C (5 degrees F) apart:

a. Date and outside weather conditions.

b. The load on the system based on the following:

(1) The refrigerant used in the system.

(2) Condensing temperature and pressure.

(3) Suction temperature and pressure.

(4) For absorption units, the cooling water pressures and temperatures entering and exiting the absorber and condenser. Also the refrigerant solution pressures, concentrations, and temperatures at each measurable point within the system.

(5) Running current, voltage and proper phase sequence for each phase of all motors.

(6) The actual on-site setting of all operating and safety controls.

(7) Chilled water pressure, flow and temperature in and out of the chiller.

(8) The position of the capacity-reduction gear, gas supply control valve, and fuel oil supply valve at machine off, one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

SD-07 Certificates

Refrigeration System

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, 1 copy of proof of such compliance shall be provided. The label or listing of the specified agency shall be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above shall be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

Service Organization; G

A certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

SD-10 Operation and Maintenance Data

Operation Manuals; G

Six complete copies of an operation manual in bound 216 x 279 (81/2 x 11 inch) booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Maintenance Manuals; G

Six complete copies of maintenance manual in bound 216 x 279 (81/2 x 11 inch) booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

1.3 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.5.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including chillers, compressors, compressor drivers, condensers, liquid coolers, receivers, refrigerant leak detectors, heat exchanges, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of anodized aluminum or stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics shall be as shown, and unless otherwise indicated, all motors of 746 kW (1 hp) and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.4 SELF-CONTAINED LIQUID CHILLER

Unless necessary for delivery purposes, units shall be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site by a factory representative. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit assembly shall be completed in strict accordance with manufacturer's recommendations. Chiller shall operate within capacity range and speed recommended by the manufacturer. Parts weighing 23 kg (50 pounds) or more which must be removed for inspection, cleaning, or repair, such as motors, gear boxes, cylinder heads, casing tops, condenser, and cooler heads, shall have lifting eyes or lugs. Chiller shall include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller shall be provided with a single point wiring connection for incoming power supply. Chiller's condenser and liquid cooler shall be provided with standard water boxes with flanged or welded connections.

2.4.1 Scroll, Reciprocating, or Rotary Screw Type

Chiller shall be constructed and rated in accordance with ARI 550/590. Chiller shall be conform to ASHRAE 15. Chiller shall have a minimum full load COP (EER) rating and a part load COP (kW/ton) rating as indicated. As a minimum, chiller shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit

d. Controls package

e. Scroll, reciprocating, or rotary screw compressor

f. Compressor driver

g. Compressor driver connection

h. Liquid cooler (evaporator)

i. Air or Water-cooled condenser coil

j. Tools

2.4.2 Centrifugal or Rotary Screw Type

Chiller shall be constructed and rated in accordance with ARI 550/590. Chiller shall have a minimum full load COP (EER) rating and a part load COP (kW/ton) rating as indicated. Chiller shall conform to ASHRAE 15. As a minimum, chiller shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit

d. Controls package

e. Centrifugal or rotary screw compressor

f. Compressor driver

g. Compressor driver connection

h. Liquid cooler (evaporator)

i. Air or Water-cooled condenser coil

j. Receiver

k. Tools

2.5 SPLIT-SYSTEM LIQUID CHILLER

Total chiller system shall be constructed and rated in accordance with ARI 550/590. Individual chiller components shall be constructed and rated in accordance with the applicable ARI standards. Chiller system shall be conform to ASHRAE 15. Chiller shall have a minimum full load COP (EER) rating and a part load COP (kW/ton) rating as indicated. Chiller shall be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site in strict accordance with manufacturer's recommendations. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit assembly shall be completed in strict accordance with manufacturer's recommendations. Chiller shall operate within capacity range and speed recommended by the manufacturer. Parts weighing 23 kg (50 pounds) or more which must be removed for inspection, cleaning, or repair, shall have lifting eyes or lugs. Chiller shall include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller's condenser and liquid cooler shall be provided with standard water boxes with flanged or welded connections. As a minimum, chiller shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit

d. Controls package

e. Tools

2.5.1 Compressor-Chiller Unit

As a minimum, the compressor-chiller unit shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll, reciprocating, or rotary screw compressor

b. Compressor driver, electric motor

c. Compressor driver connection

d. Liquid cooler (evaporator)

2.5.2 Compressor Unit

As a minimum, the condensing unit shall include the following components as defined in paragraph CHILLER COMPONENTS. SECTION 15620A Page 21

a. Scroll, reciprocating, or rotary screw compressor

b. Compressor driver, electric motor

c. Compressor driver connection

2.5.3 Remote Liquid Cooler (Evaporator)

Cooler shall be constructed and rated in accordance with ARI 480. Cooler shall be of the shell-and-coil or shell-and-tube type design. Cooler's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Cooler's water side shall be designed and factory pressure tested for not less than 1,000 kPa (150 psi). Cooler shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Cooler shall be skid-mounted. Refrigerant circuit shall be complete with liquid solenoid valve and expansion device capable of modulating to the minimum step of capacity unloading.

2.5.4 Remote Air-Cooled Condenser

Condenser shall be a factory-fabricated and assembled unit, consisting of coils, fans, and electric motor drive. Condenser shall be constructed and rated in accordance with ARI 460. Unless the condenser coil is completely protected through inherent design, louvered panel coil guards shall be provided by the manufacturer to prevent physical damage to the coil. Manufacturer shall certify that the condenser and associated equipment are designed for the submitted condensing temperature. For design conditions, if matched combination catalog ratings matching remote condensers to compressors are not available, the Contractor shall furnish a crossplotting of the gross heat rejection of the condenser against the gross heat rejection of the compressor, for the design conditions to show the compatibility of the equipment furnished.

2.5.4.1 Condenser Casing

Condenser casing shall be aluminum not less than 2 mm (0.080 inch) or hot-dip galvanized steel not lighter than 1.2 mm (18 gauge). Condensers having horizontal air discharge shall be provided with discharge baffle to direct air upward, constructed of the same material and thickness as the casing.

2.5.4.2 Coil

Condenser coil shall be of the extended-surface fin-and-tube type and shall be constructed of seamless copper tubes with compatible aluminum fins. Fins shall be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils shall be circuited and sized for a minimum of 3 degrees C (5 degrees F) subcooling and full pumpdown capacity. Coil shall be factory leak and pressure tested after assembly in accordance with ASHRAE 15.

2.5.4.3 Fans

Fans shall be centrifugal or propeller type as best suited for the application. Fans shall be direct or V-belt driven. Belt drives shall be completely enclosed within the unit casing or equipped with a guard. When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment shall be provided. Sheaves shall be selected to provide the capacity indicated at the approximate midpoint of the adjustment. Fans shall be statically and dynamically balanced.

2.5.5 Remote Water-Cooled Condenser

Condenser shall be a factory-fabricated and assembled unit constructed and rated in accordance with ARI 450. Condenser shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than 1,000 kPa 150 psi. Condensers shall be complete with pressure relief valve or rupture disk, water drain connections, refrigerant charging valve, and stand or saddle. Low pressure refrigerant condenser shall be provided with a purge valve located at the highest point in the condenser to purge non-condensibles trapped in the condenser. Condenser shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable, except for the coaxial tubes. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Condenser performance shall be based on water velocities not less than 0.91 m/s (3 fps) nor more than 3.7 mm (12 fps) and a fouling factor of 0.00025. Water-cooled condensers may be used for refrigerant storage in lieu of a separate liquid receiver, if the condenser storage capacity is 20 percent in excess of the fully charged system for remote water cooled condensers.

2.5.6 Remote Evaporatively-Cooled Condenser

Condenser shall be rated and tested in accordance with the requirements of ASHRAE 64. Condenser shall include fans, water pump with suction strainer, electric motor and drive equipment, water eliminators if required, condensing coil, liquid receiver if required, water pan or sump, spray nozzles or water-distribution pan, water strainer, water make-up assembly, bleeder with flow valve of the needle valve type sized for the flow required or a fixed orifice, enclosure with suitable access doors, and air-inlet and outlet openings. No water shall carry over into the unit discharge outlet.

2.5.6.1 Condenser Casing

Enclosure shall be constructed of not lighter than 1.3 mm (18 gauge) hot-dip galvanized steel or 2.0 mm (0.080 inch) aluminum, reinforced and braced. Access doors or panels suitably sized and located shall be provided for access to water nozzles or distribution pan, coils, and valves for cleaning, repair, or removal of the item. Access doors or panels shall be gasketed with synthetic rubber, or equivalent gasket material, and locked in place with thumb screws or catches. One-half inch mesh hot-dip galvanized steel or copper air-inlet screens shall be provided on each air inlet.

2.5.6.2 Refrigerant Section

Condenser coil shall be constructed of unfinned copper or steel tubes hot-dip galvanized after fabrication. The receiver shall be welded steel and shall be fitted and tested in accordance with ARI 495. A refrigerant charging valve shall be installed in the liquid line between the receiver cut-off valve and the expansion device. Refrigerant section shall be tested in accordance with ASHRAE 15 for the refrigerant employed in the system.

2.5.6.3 Fans

Fans shall be centrifugal or propeller type as best suited for the application. Fans shall be direct or V-belt driven. Belt drives shall be completely enclosed within the unit casing or equipped with a guard. When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment shall be provided. Sheaves shall be selected to provide the capacity indicated at the approximate midpoint of the adjustment. Fans shall be statically and dynamically balanced. Fan motor shall be totally enclosed type or open dripproof and located within an enclosure to be fully protected from the weather.

2.5.6.4 Water Section

Water eliminators shall be constructed of nonferrous metal, of an approved nonmetallic material, or of not lighter than 0.6 mm (24 gauge), hot-dip galvanized after fabrication. Spray nozzles shall be brass nonclogging type designed to permit easy disassembly, and shall be arranged for easy access. Water pump shall be bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the evaporative condenser or remotely on a separate mounting pad. Pump suction shall be fully submerged and provided with screened inlet. Water pan or sump shall be constructed of not lighter than 1.8 mm (14 gauge) steel, hot-dip galvanized after fabrication, or molded acid-resistant glass-fiber-reinforced polyester. Water distribution pan shall be constructed of not lighter than 1.6 mm (16 gauge) steel, hot-dip galvanized after fabrication. Joints shall be watertight. Water pan or sump shall be provided with drain, overflow, and make-up water connection with stop valve and float valve. A bleed line with a flow valve of the needle type sized for the flow required or fixed orifice shall be provided in the pump discharge line and shall be extended to the nearest drain for continuous discharge.

2.6 CHILLER COMPONENTS

2.6.1 Refrigerant and Oil

Refrigerants shall be one of the fluorocarbon gases. Refrigerants shall have number designations and safety classifications in accordance with ASHRAE 34. Refrigerants shall meet the requirements of ARI 700 as a minimum. Refrigerants shall have an Ozone Depletion Potential (ODP) of less than or equal to 0.05.

2.6.2 Structural Base

Chiller and individual chiller components shall be provided with a factory-mounted structural steel base (welded or bolted) or support legs. Chiller and individual chiller components shall be isolated from the building structure by means of vibration isolators with published load ratings. Vibration isolators shall have isolation characteristics as recommended by the manufacturer for the unit supplied and the service intended.

2.6.3 Chiller Refrigerant Circuit

Chiller refrigerant circuit shall be completely piped and factory leak tested. For multicompressor units, not less than 2 independent refrigerant circuits shall be provided. Circuit shall include as a minimum a combination filter and drier, combination sight glass and moisture indicator, liquid-line solenoid valve for reciprocating, an electronic or thermostatic expansion valve with external equalizer, charging ports, compressor service valves for field-serviceable compressors, and superheat adjustment.

2.6.4 Controls Package

Chiller shall be provided with a complete factory-mounted or remote-mounted where indicated, prewired electric or microprocessor based control system.

Controls package shall contain as a minimum a digital display or acceptable gauges, an on-auto-off switch, motor starters, disconnect switches, power wiring, and control wiring. Controls package shall provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and EMCS interfaces as defined below.

2.6.4.1 Operating Controls

Chiller shall be provided with the following adjustable operating controls as a minimum.

a. Leaving chilled water temperature control

b. Adjustable timer or automated controls to prevent a compressor from short cycling

c. Automatic lead/lag controls (adjustable) for multi-compressor units

d. Load limiting

e. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls shall automatically re-cycle the chiller on power interruption.

f. Startup and head pressure controls to allow system operation at all ambient temperatures down to minus 29 degrees C (minus 20 degrees F).

g. Fan sequencing for air-cooled condenser

2.6.4.2 Monitoring Capabilities

During normal operations, the control system shall be capable of monitoring and displaying the following operating parameters. Access and operation of display shall not require opening or removing any panels or doors.

a. Entering and leaving chilled water temperatures

b. Self diagnostic

c. Operation status

d. Operating hours

e. Number of starts

f. Compressor status (on or off)

g. Refrigerant discharge and suction pressures

h. Oil pressure

i. Condenser water entering and leaving temperatures

2.6.4.3 Programmable Setpoints

The control system shall be capable of being reprogrammed directly at the unit. The programmable setpoints shall include the following as a minimum.

a. Leaving Chilled Water Temperature

b. Leaving Condenser Water Temperature

c. Time Clock/Calender Date

2.6.4.4 Safety Controls with Manual Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

a. Low chilled water temperature protection

b. High condenser refrigerant discharge pressure protection

c. Low evaporator pressure protection

d. Chilled water flow detection

e. High motor winding temperature protection

f. Low oil flow protection if applicable

g. Motor current overload and phase loss protection

2.6.4.5 Safety Controls with Automatic Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which provide automatic reset.

a. Over/under voltage protection

b. Chilled water flow interlock

c. Phase reversal protection

2.6.4.6 Remote Alarm

During the initiation of a safety shutdown, a chiller's control system shall be capable of activating a remote alarm bell. In coordination with the chiller, the contractor shall provide an alarm circuit (including transformer if applicable) and a minimum 100 mm (4 inch) diameter alarm bell. Alarm circuit shall activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell shall not sound for a chiller that uses low-pressure cutout as an operating control.

2.6.4.7 Energy Management Control System (EMCS) Interface

The control system shall be capable of communicating all data to a remote integrated DDC processor through a single shielded cable. The data shall include as a minimum all system operating conditions, capacity controls, and safety shutdown conditions. The control system shall also be capable of receiving at a minimum the following operating commands.

a. Remote Unit Start/Stop

b. Remote Chilled Water Reset

c. Remote Condenser Water Reset

2.6.5 Compressor(s)

2.6.5.1 Reciprocating Compressor(s)

Rotating parts shall be statically and dynamically balanced at the factory to minimize vibration. Compressors shall be capable of operating at partial-load conditions without increased vibration over the normal vibration at full load operation and shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of size 7.45 kW (10 horsepower) and above shall have an oil lubrication system of the reversible, forced-feed type with oil strainer. Shaft seal in open-type units shall be mechanical type. Piston speed for open-type compressors shall not exceed the manufacturer's recommendation or 6 m/s (1200 fpm), whichever is less. Compressors shall include:

a. Vertical, V, W, or radial cylinder design

b. Oil lubrication

c. Integrally cast block of close-grained iron or cast aluminum block with hardened steel cylinder sleeves

d. Oil-level bull's eye

e. Cast cylinder heads

f. Cast-aluminum or forged-steel connecting rods

g. Cast iron or forged-steel crankshaft

h. Main bearings of the sleeve-insert type

i. Crankcase oil heaters controlled as recommended by the manufacturer

j. Suction and discharge refrigerant service valves that are flange connected, wrench operated, with cap

k. A strainer on the suction side of the compressor

l. A hot-gas muffler to reduce vibration and noise from pulsations

2.6.5.2 Scroll Compressor(s)

Compressors shall be of the hermetically sealed design. Compressors shall be mounted on vibration isolators to minimize vibration and noise. Rotating parts shall be statically and dynamically balanced at the factory to minimize vibration. Lubrication system shall be centrifugal pump type equipped with a means for determining oil level and an oil charging valve. Crankcase oil heater shall be provided if standard or if available as an option. If provided, the crankcase oil heater shall be controlled as recommended by the manufacturer.

2.6.5.3 Rotary Screw Compressor(s)

Compressors shall operate stably for indefinite time periods at any stage of capacity reduction without hot-gas bypass. Provision shall be made to insure proper lubrication of bearings and shaft seals on shutdown with or without electric power supply. Rotary screw compressors shall include:

a. An open or hermetic, positive displacement, oil-injected design directly driven by the compressor driver. Compressor shall allow access to internal compressor components for repairs, inspection, and replacement of parts.

b. Rotors which are solid steel forging with sufficient rigidity for proper operation.

c. A maximum rotor operating speed no greater than 3600 RPM.

d. Casings of cast iron, precision machined for minimal clearance about periphery of rotors.

e. A lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

f. Shaft main bearings of the sleeve type with heavy duty bushings or rolling element type in accordance with ABMA 9 or ABMA 11. Bearings shall be conservatively loaded and rated for an L(10) life of not less than 200,000 hours.

g. A differential oil pressure or flow cutout to allow the compressor to operate only when the required oil pressure or flow is provided to the bearings.

h. A temperature- or pressure-initiated, hydraulically actuated, single-slide-valve, capacity-control system to provide minimum automatic capacity modulation from 100 percent to 15 percent.

i. An oil separator and oil return system to remove oil entrained in the refrigerant gas and automatically return the oil to the compressor.

j. Crankcase oil heaters controlled as recommended by the manufacturer.

2.6.5.4 Centrifugal Compressor(s)

Centrifugal compressors shall be single or multistage, having dynamically balanced impellers, either direct or gear driven by the compressor driver. Impellers shall be over-speed tested at 1.2 times the impeller-shaft speed. Impeller shaft shall be heat-treated alloy steel with sufficient rigidity for proper operation at any required operating speed. Centrifugal compressors shall include:

a. Shaft main bearings that are the rolling element type in accordance with ABMA 9 or ABMA 11, journal type with bronze or babbitt liners, or of the aluminum-alloy one-piece insert type. Bearings shall be rated for an L(10) life of not less than 200,000 hours.

b. Casing of cast iron, aluminum, or steel plate with split sections gasketed and bolted or clamped together.

c. Lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

d. Provisions to ensure proper lubrication of bearings and shaft seals prior to starting and upon stopping with or without electric power supply. On units providing forced-feed lubrication prior to starting, a differential oil pressure cutout interlocked with the compressor starting equipment shall allow the compressor to operate only when the required oil pressure is provided to the bearings.

e. Oil sump heaters controlled as recommended by the manufacturer.

f. Temperature-or pressure-actuated prerotation vane or suction damper to provide automatic capacity modulation from 100 percent capacity to 10 percent capacity. If operation to 10 percent capacity cannot be achieved without providing hot-gas bypass, then the Contractor shall indicate in the equipment submittal the load percent at which hot gas bypass is required.

2.6.6 Compressor Driver, Electric Motor

Motors, starters, variable speed drives, wiring, etc. shall be in accordance with paragraph ELECTRICAL WORK. Motor starter shall be unit mounted or remote mounted as indicated with starter type, wiring, and accessories coordinated with the chiller manufacturer. Starter shall be able to operate in temperatures up to 120 degrees F.

2.6.7 Compressor Driver Connections

Each compressor shall be driven by a V-belt drive or direct connected through a flexible coupling, except that flexible coupling is not required on hermetic units. V-belt drives shall be designed for not less than 150 percent of the driving motor capacity. Flexible couplings shall be of the type that does not require lubrication.

2.6.8 Liquid Cooler (Evaporator)

Cooler shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than 1,000 kPa (150 psi). Cooler shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on a water velocity not less than 0.91 m/s (3 fps) nor more than 3.7 mm (12 fps) and a fouling factor of 0.000018 m2(degrees C)/W [0.0001 h(ft2)(degrees F)/Btu].

2.6.9 Air-Cooled Condenser Coil

Condenser coil shall be of the extended-surface fin-and-tube type and shall be constructed of seamless copper tubes with compatible aluminum fins. Fins shall be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils shall be circuited and sized for a minimum of 3 degrees C (5 degrees F) subcooling and full pumpdown capacity. Coil shall be factory leak and pressure tested after assembly in accordance with ASHRAE 15.

2.6.10 Water-Cooled Condenser Coil

Condenser shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than 1,000 kPa (150 psi). Condensers shall be complete with refrigerant relief valve/rupture disc assembly, water drain connections, and refrigerant charging valve. Low pressure refrigerant condenser shall be provided with a purge valve located at the highest point in the condenser to purge non-condensibles trapped in the condenser. Condenser shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable, except for the coaxial tubes. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on water velocities not less than 0.91 m/s (3 fps) nor more than 3.7 mm (12 fps) and a fouling factor of 0.000044 m2(degrees C)/W [0.00025 h(ft2)(degrees F)/Btu]. Water-cooled condensers may be used for refrigerant storage in lieu of a separate liquid receiver, if the condenser storage capacity is 5 percent in excess of the fully charged system for single packaged systems.

2.6.11 Heat Recovery Condenser Coil

Condenser shall be of the shell-and-coil or shell-and-tube type design and shall not be a part of the standard condenser. Condenser shall be provided and installed by the chiller manufacturer. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than 1,000 kPa (150 psi). Condenser shall have performance characteristics as indicated on the drawings. Condenser shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable, except for the coaxial tubes. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on water velocities not less than 0.91 m/s (3 fps) nor more than 3.7 mm (12 fps) and a fouling factor of 0.00025.

2.6.12 Receivers

Liquid receivers not already specified herein as an integral factory-mounted part of a package, shall be designed, fitted, and rated in accordance with the recommendations of ARI 495, except as modified herein. Receiver shall bear a stamp certifying compliance with ASME BPVC SEC VIII D1 and shall meet the requirements of ASHRAE 15. Inner surfaces shall be thoroughly cleaned by sandblasting or other approved means. Each receiver shall have a storage capacity not less than 20 percent in excess of that required for the fully-charged system. Each receiver shall be equipped with inlet, outlet drop pipe, drain plug, purging valve, relief valves of capacity and setting required by ASHRAE 15, and two bull's eye liquid-level sight glasses. Sight glasses shall be in the same vertical plane, 90 degrees apart, perpendicular to the axis of the receiver, and not over 75 mm (3 inches) horizontally from the drop pipe measured along the axis of the receiver. In lieu of bull's eye sight glass, external gauge glass with metal glass guard and automatic closing stop valves may be provided.

2.6.13 Chiller Purge System

Chillers which operate at pressures below atmospheric pressure shall be provided with a purge system. Purge system shall automatically remove air, water vapor, and non-condensible gases from the chiller's refrigerant. Purge system shall condense, separate, and return all refrigerant back to the chiller. An oil separator shall be provided with the purge system if required by the manufacturer. Purge system shall not discharge to occupied areas, or create a potential hazard to personnel. Purge system shall include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system shall include lights or an alarm which indicate excessive purge or an abnormal air leakage into chiller.

2.6.14 Tools

One complete set of special tools, as recommended by the manufacturer for field maintenance of the system, shall be provided. Tools shall be mounted on a tool board in the equipment room or contained in a toolbox as directed by the Contracting Officer.

2.7 ABSORPTION LIQUID CHILLER

Chiller shall be constructed and rated in accordance with ARI 560 and shall bear the appropriate underwriter's laboratories (UL) label. Chiller shall have a minimum cooling Coefficient of Performance (COP) as indicated. Chiller shall be the single-stage or two-stage hermetic, water-cooled type design. Chiller shall be indirectly-fired with steam or hot water. Unless necessary for delivery purposes, chiller shall be assembled, leak-tested, charged, and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged, and adjusted at the job site by a factory representative. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit assembly shall be completed in strict accordance with manufacturer's recommendations. Chiller shall operate within capacity range and speed recommended by the manufacturer. Parts weighing 23 EKG (50 pounds) or more which must be removed for inspection, cleaning, or repair shall have lifting eyes or lugs. Chiller shall be provided with insulation on surfaces subject to sweating including the liquid cooler and water boxes. Chiller shall be provided from the factory with a single point wiring connection for incoming power supply. Magnetic across-the-line motor starters with overload protection shall be provided for each factory supplied pump. Chiller shall include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller shall include the following as a minimum:

a. Absorber, evaporator, and condenser

b. Generator

c. Refrigerant, absorber, and inhibitor solutions

d. Low and high temperature heat exchanger(s)

e. Self-contained, hermetically sealed, self lubricating, liquid cooled, refrigerant and solution pumps. Pumps shall be direct coupled with the motor and shall include isolation valves.

f. Automatic purge system

g. Automatic decrystallization system

h. Chiller controls package

i. Interconnecting piping and wiring

j. Flanged or connections for water boxes

k. Refrigerant spray nozzles

l. Factory-mounted structural steel base (welded or bolted) or support legs

m. Thermometers and sight glasses to allow visual inspection of unit operation. Mercury shall not be used in thermometers.

2.7.1 Component Construction

Chiller exterior surfaces shall be factory painted, finished, and insulated as applicable. Chiller shell shall be of carbon steel construction with cast iron or welded steel heads. Evaporator, absorber, condenser, generator(s), and heat exchanger(s) shall be of the shell-and-tube type construction and be in accordance with ASME BPVC SEC VIII D1. Evaporator, absorber, condenser, and heat exchanger tubes shall be shall be seamless copper or cupronickel (CuNi). Generator tubes shall be seamless cupronickel. Tubes shall be individually replaceable. Water boxes shall be provided with lifting lugs, gasketed removable covers, drains, and vents. Unit's internal waterside components shall be rated for not less than 1,000 kPA (150 psig) and factory tested at 150 percent of design working pressure. Insulation shall be provided for the refrigerant pump, all exposed chilled water piping, the absorber shell, the steam or hot water inlet piping.

2.7.2 Controls Package

Chiller shall be provided with a complete factory mounted and prewired electric or microprocessor based control system. Controls package shall be unit-mounted, or floor-mounted where indicated, which contains as a minimum a digital display or acceptable gauges, an on-auto-off switch, motor starters, power wiring, control wiring, and disconnect switches. Controls package shall provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and EMCS interfaces as defined below.

2.7.2.1 Operating Controls

Chiller shall be provided with the following adjustable operating controls as a minimum.

a. Leaving chilled water temperature control

b. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls shall automatically re-cycle the chiller on power interruption.

2.7.2.2 Monitoring Capabilities

During normal operations, the control system shall be capable of monitoring and displaying the following operating parameters. Access and operation of display shall not require opening or removing any panels or doors.

a. Entering and leaving chilled water temperatures

b. Entering and leaving condenser water temperatures

c. Refrigerant and solution temperatures

d. Generator pressures and temperatures

e. Self diagnostic

f. Operation status

g. Operating hours

h. Number of starts

i. Number of purge cycles over the last 7 days

2.7.2.3 Programmable Setpoints

The control system shall be capable of being reprogrammed directly at the unit. No parameters shall be capable of being changed without first entering a security access code. The programmable setpoints shall include the following as a minimum.

a. Leaving Chilled Water Temperature

b. Leaving Condenser Water Temperature

c. Time Clock/Calender Date

2.7.2.4 Safety Controls with Manual Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

a. Refrigerant or solution pump thermal or current overload

b. Low refrigerant temperature

c. Loss of chilled water

d. Loss of condenser water

e. High or low condenser water temperatures

f. Power failure

g. Generator high temperature or pressure

h. Low solution level

2.7.2.5 Remote Alarm

During the initiation of a safety shutdown, the control system shall be capable of activating a remote alarm bell. In coordination with the chiller, the contractor shall provide an alarm circuit (including transformer if applicable) and a minimum 100 mm (4 inch) 4 inch diameter alarm bell. Alarm circuit shall activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell shall not sound for a chiller that uses low-pressure cutout as an operating control.

2.7.2.6 Energy Management Control System (EMCS) Interface

The control system shall be capable of communicating all data to a remote integrated DDC processor through a single shielded cable. The data shall include as a minimum all system operating conditions, capacity controls, and safety shutdown conditions. The control system shall also be capable of receiving at a minimum the following operating commands.

a. Remote Unit Start/Stop

b. Remote Chilled Water Reset

c. Remote Condenser Water Reset

2.8 ACCESSORIES

2.8.1 Refrigerant Leak Detector

Detector shall be the continuously-operating, halogen-specific type. Detector shall be appropriate for the refrigerant in use. Detector shall be specifically designed for area monitoring and shall include sampling points installed where indicated. Detector design and construction shall be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector shall have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector shall be supplied factory-calibrated for the appropriate refrigerant(s). Detector shall be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant(s) in use. The detector's relay shall be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector shall be provided with a failure relay output that energizes when the monitor detects a fault in its operation. Detector shall be capable with the facility's energy management and control system (EMSS). The EMCS shall be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.

2.8.2 Refrigerant Relief Valve/Rupture Disc Assembly

The assembly shall be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly shall be in accordance with ASME BPVC SEC VIII D1 and ASHRAE 15. The assembly shall be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc shall be the non-fragmenting type.

2.8.3 Refrigerant Signs

Refrigerant signs shall be a medium-weight aluminum type with a baked enamel finish. Signs shall be suitable for indoor or outdoor service. Signs shall have a white background with red letters not less than 12 mm (0.5 inches) in height.

2.8.3.1 Installation Identification

Each new refrigerating system shall be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name.

b. Refrigerant number and amount of refrigerant.

c. The lubricant identity and amount.

d. Field test pressure applied.

2.8.3.2 Controls and Piping Identification

Refrigerant systems containing more than 50 kg (110 lb) of refrigerant shall be provided with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow, the ventilation system, and the refrigerant compressor(s).

b. Pressure limiting device(s).

2.8.4 Refrigerant Recovery/Recycle System

A manually initiated refrigerant recovery/recycle system shall be provided, consisting of a motor-driven, air- or water-cooled, reciprocating condensing unit and a receiver of sufficient capacity to store the entire refrigerant charge of the largest water-chilling system. For refrigerants with atmospheric pressure boiling temperature below 20 degrees C (68 degrees F) the receiver shall be sized so that it is no more than 80 percent full at 32 degrees C (90 degrees F). For refrigerants with atmospheric pressure boiling temperature above 20 degrees C (68 degrees F), the receiver shall be sized so that it is no more than 90 percent full at 32 degrees C (90 degrees F). The recovery/recycle system condensing unit shall be assembled as a complete unit and meet the requirements of ASHRAE 15. The system components shall be portable and shall include all valves, connections, and controls required for operation. Receiver and relief devices shall conform to the requirements of ASME BPVC SEC VIII D1. The recovery/recycle system shall be tested and listed to conform to ARI 740 for refrigerant recovery/recycle systems by a recognized national testing laboratory. For refrigerants with atmospheric pressure boiling temperature below 20 degrees C (68 degrees F), the recovery/recycle unit shall have an ARI 740 vapor refrigerant recovery rate of no less than 8.5 kg/minute (17.0 lb/minute). For refrigerants with atmospheric pressure boiling temperature above 20 degrees C (68 degrees F), the recovery/recycle unit shall have an ARI 740 vapor refrigerant recovery rate of no less than 1.0 kg/minute (2.2 lb/minute).

2.8.5 Gaskets

Gaskets shall conform to ASTM F 104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 371 degrees C (700 degrees F) service.

2.8.6 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall be in accordance with ASTM A 307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A 307.

2.9 FABRICATION

2.9.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B 117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm (1/8 inch) on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

2.9.2 Factory Applied Insulation

Chiller shall be provided with factory installed insulation on surfaces subject to sweating including the liquid cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it shall be installed to provide easy removal and replacement of heads without damage to the insulation. Where motors are the gas-cooled type, factory installed insulation shall be provided on the cold-gas inlet connection to the motor per manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E 84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E 84.

2.10 FACTORY TESTS

2.10.1 Chiller Performance Test

The Contractor and proposed chiller manufacturer shall be responsible for performing the chiller factory test to validate the specified full load capacity, full load EER, IPLV, and NPLV in accordance with ARI 550/590 except as indicated. The Contractor and chiller manufacturer shall provide to the

Government a certified chiller factory test report in accordance with ARI 550/590 to confirm that the chiller performs as specified. Tests shall be conducted in an ARI certified test facility in conformance with ARI 550/590 procedures and tolerances, except as indicated. At a minimum, chiller capacity shall be validated to meet the scheduled requirements indicated on the drawings. Tolerance or deviation shall be in strict accordance with ARI 550/590. Stable operation at minimum load of 10 percent of total capacity shall be demonstrated during the factory test.

2.10.1.1 Temperature Adjustments

Temperature adjustments shall adhere to ARI 550/590 to adjust from the design fouling factor to the clean tube condition. Test temperature adjustments shall be verified prior to testing by the manufacturer. There shall be no exceptions to conducting the test with clean tubes with the temperature adjustments per ARI 550/590. The manufacturer shall clean the tubes, if necessary, prior to testing to obtain a test fouling factor of 0.0000.

2.10.1.2 Test Instrumentation

The factory test instrumentation shall be per ARI 550/590 and the calibration shall be traceable to the National Institute of Standards and Technology.

2.10.1.3 Test Report

A certified test report of all data shall be forwarded to the Government for approval prior to project acceptance. Calibration curves and information sheets for all instrumentation shall be provided.

2.10.1.4 Equipment Adjustments

If the equipment fails to perform within allowable tolerances, the manufacturer shall be allowed to make necessary revisions to his equipment and retest as required.

2.10.2 Chiller Sound Test

Chillers shall be sound tested at the factory prior to shipment to confirm the sound pressure level specified herein. Tests and data shall be conducted and measured in strict accordance with ARI 575 at the full load system operating conditions. The chiller sound pressure level, in decibels (dB), with a reference pressure of 20 micropascals, shall not exceed 90 dB, A weighted. Ratings shall be in accordance with ARI 575. No reduction of entering condenser water temperature or raising of leaving chilled water temperature shall be allowed. A minimum of 75 percent of the sound data points shall be taken along the length of the machine, and established as the minimum percentage of total possible points used to determine sound levels. In the event that the chiller does not meet the dBA sound pressure level, the manufacturer shall, at his expense, provide sufficient attenuation to the machine to meet the specified value. This attenuation shall be applied in such a manner that it does not hinder the operation or routine maintenance procedures of the chiller. The attenuation material, adhesives, coatings, and other accessories shall have surface burning characteristics as determined by ASTM E 84.

2.11 SUPPLEMENTAL COMPONENTS/SERVICES

2.11.1 Chilled and Condenser Water Piping and Accessories

Chilled and condenser water piping and accessories shall be provided and installed in accordance with Section 15181 CHILLED AND CONDENSER WATER PIPING AND ACCESSORIES.

2.11.2 Refrigerant Piping

Refrigerant piping for split-system liquid chillers shall be provided and installed in accordance with Section 15182 REFRIGERANT PIPING.

2.11.3 Cooling Tower

Cooling towers shall be provided and installed in accordance with the US Army Corps of Engineers, Unified Facilities Guide Specifications (UFGS), Section 15645A COOLING TOWER.

2.11.4 Temperature Controls

Chiller control packages shall be fully coordinated with and integrated into the temperature control system specified in Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM and 15950 HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS, and into the existing air-conditioning system.

PART 3 EXECUTION

3.1 INSTALLATION

Work shall be performed in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. Where equipment is specified to conform to the requirements of ASME BPVC SEC VIII D1and ASME BPVC SEC IX, the design, fabrication, and installation of the system shall conform to ASME BPVC SEC VIII D1 and ASME BPVC SEC IX.

3.1.1 Refrigeration System

3.1.1.1 Equipment

Refrigeration equipment and the installation thereof shall conform to ASHRAE 15. Necessary supports shall be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, liquid coolers, and similar items. Compressors shall be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations shall be provided. Each foundation shall include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment shall be set on not less than a 150 mm (6 inch) concrete pad doweled in place. Concrete foundations for floor mounted pumps shall have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block shall be of mass not less than three times the combined pump, motor, and base weights. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Isolators shall limit vibration as indicated. Lines connected to pumps mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.1.1.2 Field Refrigerant Charging

a. Initial Charge: Upon completion of all the refrigerant pipe tests, the vacuum on the system shall be broken by adding the required charge of dry refrigerant for which the system is designed, in accordance with the manufacturer's recommendations. Contractor shall provide the complete charge of refrigerant in accordance with manufacturer's recommendations. Upon satisfactory completion of the system performance tests, any refrigerant that has been lost from the system shall be replaced. After the system is fully operational, service valve seal caps and blanks over gauge points shall be installed and tightened.

b. Refrigerant Leakage: If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant shall be pumped into the system receiver or other suitable container. The refrigerant shall not be discharged into the atmosphere.

c. Contractor's Responsibility: The Contractor shall, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 85 g (3 ounces) of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year shall be repaired in accordance with the specified requirements including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.1.1.3 Oil Charging

Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase shall be furnished. One charge shall be used during the performance testing period, and upon the satisfactory completion of the tests, the oil shall be drained and replaced with the second charge.

3.1.2 Mechanical Room Ventilation

Mechanical ventilation systems shall be in accordance with Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.1.3 Field Applied Insulation

Field installed insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.4 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09900 PAINTS AND COATINGS.

3.2 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative shall be provided for 3 days. The representative shall advise on the following:

a. Hermetic machines:

(1) Testing hermetic water-chilling unit under pressure for refrigerant leaks; evacuation and dehydration of machine to an absolute pressure of not over 300 microns.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

b. Open Machines:

(1) Erection, alignment, testing, and dehydrating.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

c. Absorption Units:

(1) Testing and evacuation.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

3.3 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions. Testing, adjusting, and balancing shall be as specified in Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.4 SYSTEM PERFORMANCE TESTS

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Tests shall cover a period of not less than 48 hours for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened. Any refrigerant lost during the system startup shall be replaced. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and the system shall be retested. Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. Field tests shall be coordinated with Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.5 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 24 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

SECTION 15700

UNITARY HEATING AND COOLING EQUIPMENT

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 210/240	(1994) Unitary Air-Conditioning and Air-Source Heat Pump Equipment
ARI 270	(1995) Sound Rating of Outdoor Unitary Equipment
ARI 310/380	(1993) Packaged Terminal Air-Conditioners and Heat Pumps

ARI 320	(1998)Water-Source Heat Pumps
ARI 325	(1998) Ground Water-Source Heat Pumps
ARI 340/360	(1993) Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
ARI 350	(1986) Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment
ARI 370	(1986) Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
ARI 410	(1991) Forced-Circulation Air-Cooling and Air-Heating Coils
ARI 460	(2000) Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ARI 490	(1998) Remote Mechanical-Draft Evaporative Refrigerant Condensers
ARI 495	(1999) Refrigerant Liquid Receivers
ARI 500	(2000) Variable Capacity Positive Displacement Refrigerant Compressors and Compressor Units for Air-Conditioning and Heat Pump Applications
ARI 700	(1999) Specifications for Fluorocarbon and Other Refrigerants

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123/A 123M	(2001) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2001) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 307	(2000) Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM B 117	(1997) Operating Salt Spray (Fog)
ASTM C 1071	(1998) Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material)
ASTM D 520	(2000) Zinc Dust Pigment
ASTM E 437	(1992; R 1997) Industrial Wire Cloth and Screens (Square Opening Series)
ASTM E 84	(2000a) Surface Burning Characteristics of Building Materials

ASTM F 104	(1995) onmetallic Gasket Materials
ASTM F 872	(1984; R 1990) Filter Units, Air Conditioning: Viscous-Impingement Type, Cleanable

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 127	(1988) Method of Testing for Rating Computer and Data Processing Room Unitary Air-Conditioners
ASHRAE 15	(1994) Safety Code for Mechanical Refrigeration
ASHRAE 34	(1997) Number Designation and Safety Classification of Refrigerants
ASHRAE 52.1	(1992) Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
ASHRAE 64	(1995) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(1999) Safety in Welding and Cutting

ASME INTERNATIONAL (ASME)

ASME BPVC SEC IX	(1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ASSOCIATION OF HOME APPLIANCE MANUFACTURERS (AHAM)

AHAM RAC-1	(1997) Directory of Certified Room Air Conditioners

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993) Industrial Control and Systems, Enclosures
NEMA MG 1	(1998) Motors and Generators
NEMA MG 2	(1989) Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(1999) National Fuel Gas Code
NFPA 70	(1999) National Electrical Code

NFPA 90A	(1999) Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 1995	(1995; Rev thru Aug 1999) Heating and Cooling Equipment
UL 207	(1993; Rev thru Oct 1997) Refrigerant-Containing Components and Accessories, Nonelectrical
UL 484	(1993; Rev thru Feb 1999) Room Air Conditioners
UL 586	(1996; Rev thru Aug 1999) High-Efficiency, Particulate, Air Filter Units
UL 900	(1994; Rev thru Nov 1999) Test Performance of Air Filter Units

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G

Drawings provided in adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

a. Equipment layouts which identify assembly and installation details.

b. Plans and elevations which identify clearances required for maintenance and operation.

c. Wiring diagrams which identify each component individually and interconnected or interlocked relationships between components.

d. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for equipment indicated or required to have concrete foundations.

e. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

f. Automatic temperature control diagrams and control sequences.

g. Installation details which includes the amount of factory set superheat and corresponding refrigerant pressure/temperature.

SD-03 Product Data

Unitary Equipment; G

Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations. Data shall be submitted for each specified component.

Spare Parts Data

Spare parts data for each different item of equipment specified, after approval of detail drawings and not later than 1 months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Posted Instructions; G

Posted instructions, at least 2 weeks prior to construction completion, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

Verification of Dimensions

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

System Performance Tests

A schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules shall identify the proposed date, time, and location for each test.

Demonstrations

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

SD-06 Test Reports

Refrigerant Tests, Charging, and Start-Up; G

Six copies of each test containing the information described below in bound 216 x 279 mm (8-1/2 x 11 inch) booklets. Individual reports shall be submitted for the refrigerant system tests.
A

a. The date the tests were performed.

b. A list of equipment used, with calibration certifications.

c. Initial test summaries.

d. Repairs/adjustments performed.

e. Final test results.

System Performance Tests; G

Six copies of the report provided in bound 216 x 279 mm (8-1/2 x 11 inch) booklets. The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information and shall be taken at least three different times at outside dry-bulb temperatures that are at least 3 degrees C (5 degrees F) apart:

a. Date and outside weather conditions.

b. The load on the system based on the following:

(1) The refrigerant used in the system.

(2) Condensing temperature and pressure.

(3) Suction temperature and pressure.

(4) Ambient, condensing and coolant temperatures.

(5) Running current, voltage and proper phase sequence for each phase of all motors.

c. The actual on-site setting of operating and safety controls.

d. Thermostatic expansion valve superheat - value as determined by field test.

e. Subcooling.

f. High and low refrigerant temperature switch set-points

g. Low oil pressure switch set-point.

h. Defrost system timer and thermostat set-points.

i. Moisture content.

j. Capacity control set-points.

k. Field data and adjustments which affect unit performance and energy consumption.

l. Field adjustments and settings which were not permanently marked as an integral part of a device.

SD-07 Certificates

Unitary Equipment;

Where the system, components, or equipment are specified to comply with requirements of ARI, ASHRAE, ASME, or UL, proof of such compliance shall be provided. The label or listing of the specified agency shall be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above shall be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

Service Organization; G

A certified list of qualified permanent service organizations, which includes their addresses and qualifications, for support of the equipment. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

SD-10 Operation and Maintenance Data

Operation Manuals; G

Six complete copies of an operation manual in bound 216 x 279 (81/2 x 11 inch) booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Maintenance Manuals; G

Six complete copies of maintenance manual in bound 216 x 279 mm (8-1/2 x 11 inch) booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

1.3 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.5.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including compressors, condensers, receivers, heat exchanges, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of anodized aluminum or stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics shall be as shown, and unless otherwise indicated, all motors of 746 kW (1 hp) and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.4 UNITARY EQUIPMENT, ROOM UNIT

2.4.1 Window or Through-the-Wall Mounted Unit

Unit shall be a window or through-the-wall mounted, appliance grade, factory assembled air-conditioner unit. Unit shall be in accordance with AHAM RAC-1 and UL 484. Units shall include a self-contained, precharged, slide-in and removable chassis-mounted, air-cooled refrigeration system. Cooling section shall be equipped with a filter-drier on the suction line. Fan and condenser motors shall have open, dripproof, totally enclosed, or explosion proof enclosures as indicated or required.

2.4.2 Packaged Terminal Unit

Unit shall be a through-the-wall mounted, heavy-duty commercial grade, factory assembled and precharged air-conditioner or heat pump unit. Unit shall be in accordance with ARI 310/380 and UL 1995. Units shall be removable from inside the building for servicing without removing the outside cabinet. Unit shall have a noise rating in accordance with ARI 350 and not exceed bels as indicated while the entire unit is operating at any fan or compressor speed. Heat pump units shall contain a reversing valve to change unit to heating cycle. An outdoor coil temperature sensor shall be provided to guard against coil freeze-up by either switching to supplemental heat only, or by cycling the compressor to defrost the coil.

2.4.3 Compressor

Compressor shall be hermetically sealed reciprocating, rotary, or scroll type. Compressor shall be fitted with permanent split capacitor motor, overload protection, and vibration isolators. Compressor shall be protected against high discharge pressure, loss of charge, low voltage, and short cycling.

2.4.4 Air-To-Refrigerant Coils

Evaporator and condenser coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. A condensate removal system shall be provided.

2.4.5 Fans

Indoor and outdoor fans shall be the centrifugal, direct driven type. Fans shall be statically and dynamically balanced. Outdoor fan shall be designed so that condensate will evaporate without drip, splash, or spray on building exterior. Indoor fan shall be provided with a minimum two-speed motor with built-in overload protection. Fan motors shall be the inherently protected, permanent split-capacitor type.

2.4.6 Air Filters

Filters shall be of the sectional or panel cleanable type and be capable of filtering the entire air supply.

2.4.7 Primary/Supplemental Heat

Primary or Supplemental heat shall be provided as specified in paragraph "Unitary Equipment Components".

2.4.8 Cabinet Construction

Cabinet shall be free of visible fasteners, sharp protuberances and edges. Enclosure sheet metal shall be a minimum of 1.2 mm (18 gauge) steel with a protective coating. Face panels shall be removable and shall provide full access to unit appurtenances. Access to controls shall be without removal of the face panel. Conditioned air shall discharge through adjustable louvers. Cabinet shall be thermally and acoustically insulated with materials which conform to NFPA 90A. Units shall be furnished with a field-wired or prewired subbase. Subbase shall have leveling screws with provisions for remote unit control. Subbase shall be of 1.3 mm (18 gauge) galvanized steel construction with a protective coating to match that of the room cabinet. Paint and finishes shall comply with the requirements specified in paragraph FACTORY COATING.

2.4.9 Wall Sleeve

Louver shall be stormproof type, constructed of anodized, stamped or extruded aluminum. Sleeve shall be a water and airtight completely insulated assembly, with weather-resistant protective coating.

2.4.10 Duct Package

Duct extension shall consist of 1.3 mm (18 gauge) minimum galvanized steel plenum extender with all necessary internal dampers and baffles to divert the supply air as indicated. Duct extension shall be painted with a protective coating that matches room cabinet.

2.4.11 Unit Controls

Controls shall include an on-off switch, high and low selector switch for the cooling mode or both the heating and cooling mode, multiple speed fan cooling or cooling and heating mode, room air fan switch, outside air damper control, and an adjustable cooling only or cooling and heating thermostat. Function and temperature controls shall be integral to unit or remotely mounted as indicated or as accepted by the Contracting Officer.

2.5 UNITARY EQUIPMENT, PACKAGE SYSTEM

Unit shall be an air-cooled, water-cooled, or evaporatively-cooled, factory assembled, weatherproof or indoor packaged unit as indicated. Unit shall be the air-conditioning or heat pump type conforming to applicable Underwriters Laboratories (UL) standards including UL 1995. Unit shall be rated in accordance with ARI 210/240, ARI 340/360, ARI 320, or ARI 325 as applicable. Unit shall be provided with equipment as specified in paragraph "Unitary Equipment Components". Evaporator or supply fans shall be double-width, double inlet, forward curved, backward inclined, or airfoil blade, centrifugal scroll type. Motors shall have open, dripproof, totally enclosed, or explosion proof enclosures as indicated or required. Condenser fans shall be manufacturer's standard for the unit specified and may be either propeller or centrifugal scroll type. Unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged with refrigerant and oil in accordance with manufacturer's recommendations. Outdoor unit shall produce a maximum ARI sound rating (bels), as indicated , in accordance with ARI 270 or ARI 370 as applicable. Interior water source piping shall be insulated as a "cold pipe" described in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Water-cooled unit shall be fitted with a strainer protected solenoid shut-off valve. The valve shall be a fully automatic, self-contained temperature regulating valve with integral thermometer.

2.5.1 Air-to-Refrigerant Coils

Air-to-refrigerant coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.5.2 Water-to-Refrigerant Coils

Coils shall be of the tube-in-tube, shell-and-coil, shell-and-tube, or concentric tube type and be provided as an integral part of the packaged unit. Water-wetted metals shall be copper or copper-nickel, except that heads may be ferrous metal in systems with chemically treated recirculating water. Coils shall be rated for not less than 2758 kPa (400 psi) refrigerant side and 862 kPa (125 psi) water side pressure service at operating temperatures. Coils shall be supplied with water as indicated. Water supply, return and control system wetted parts shall be copper, bronze or stainless steel. Water supply, return connections and piping internal to unit shall be copper with brazed or threaded copper or bronze fittings, terminating in a threaded connection. Piping arrangement shall include valved access for recirculation of acidic scale removal chemicals and isolation pressure taps to determine pressure drop and water flow. Performance shall be based on an allowable water velocity not less than 0.9 m/s (3 fps) nor more than 3 m/s (10 fps) with a fouling factor of 0.0005.

2.5.3 Evaporatively-Cooled Section

The evaporative section shall be a packaged component of the unitary equipment. Unit shall be the counter-flow blow-through design, with single-side air entry. Unit shall have fan assemblies built into the unit base, with all moving parts factory mounted and aligned. Primary construction of the pan section, the cabinet, etc. shall be not lighter than 16-gauge steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A 153/A 153M and ASTM A 123/A 123M, as applicable and a minimum coating thickness of 0.76 kg/square meter (2-1/2 ounces per square foot) of surface. Cut edges shall be given a protective coating of zinc-rich compound. After assembly, the manufacturer's standard zinc chromatized aluminum or epoxy paint finish shall be applied to the exterior of the unit.

2.5.3.1 Pan Section

The pan shall be watertight and be provided with drain, overflow, and make-up water connections. Standard pan accessories shall include circular access doors, a lift-out strainer of anti-vortexing design and a brass make-up valve with float ball.

2.5.3.2 Fan Section

Fan shall be the centrifugal or propeller] type in accordance with paragraph "Fans". Fan and fan motor shall not be located in the discharge airstream of the unit. Motors shall have open, splashproof, or totally enclosed enclosure and be suitable for the indicated service. The unit design shall prevent water from entering into the fan section.

2.5.3.3 Condensing Coil

Coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter without fins. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system.

2.5.3.4 Water Distribution System

Water shall be distributed uniformly over the condensing coil to ensure complete wetting of the coil at all times. Spray nozzles shall be brass, stainless steel, or high-impact plastic. Nozzles shall be the cleanable, nonclogging, removable type. Nozzles shall be designed to permit easy disassembly and be arranged for easy access.

2.5.3.5 Water Pump

The water pump shall be the bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the unit or remotely on a separate mounting pad. Pumps shall have cast-iron casings. Impellers shall be bronze, and shafts shall be stainless steel with bronze casing wearing rings. Shaft seals shall be the mechanical type. Pump casing shall be factory coated with epoxy paint. Pump motors shall have open, dripproof, totally enclosed, or explosion proof enclosures as indicated or required. A bleed line with a flow valve or fixed orifice shall be provided in the pump discharge line and shall be extended to the nearest drain for continuous discharge. Pump suction shall be fully submerged and provided with a galvanized steel or monel screened inlet.

2.5.3.6 Drift Eliminator

Eliminators shall be provided to limit drift loss to not over 0.005 percent of the specified water flow. Eliminators shall be constructed of zinc-coated steel or polyvinyl chloride (PVC). Eliminators shall prevent carry over into the unit's fan section.

2.5.3.7 Evaporator Controls

Unit shall be provided with modulating capacity control dampers mounted in the discharge of the fan housing. On a decrease in refrigerant discharge pressure the dampers shall modulate to reduce the airflow across the condensing coil. Controls shall include a proportional acting pressure controller, a control transformer, motor actuator with linkages and end switches to cycle fan motor on and off. Cycling of a fan motor on and off shall be in accordance with the manufacturer.

2.5.4 Compressor

Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of 35 kW (10 tons) and larger shall be provided with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors shall operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Compressors shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, thermal overloads, lubrication pump, high and low pressure safety cutoffs and protection against short cycling.

2.5.5 Refrigeration Circuit

Refrigerant containing components shall comply with ASHRAE 15 and be factory tested, cleaned, dehydrated, charged, and sealed. Refrigerant charging valves and connections, and pumpdown valves shall be provided for each circuit. Filter-drier shall be provided in each liquid line and be reversible-flow type. Refrigerant flow control devices shall be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve.

2.5.6 Unit Controls

Unit shall be internally prewired with a 24 or 120 volt control circuit powered by an internal transformer. Terminal blocks shall be provided for power wiring and external control wiring. Unit shall have cutoffs for high and low pressure, and low oil pressure for compressors with positive displacement oil pumps, supply fan failure and safety interlocks on all service panels. Head pressure controls shall sustain unit operation with ambient temperature of -29 degrees C (-20 degrees F). Adjustable-cycle timers shall prevent short-cycling. Multiple compressors shall be staged by means of a time delay. Unit shall be internally protected by fuses or a circuit breaker in accordance with UL 1995. Low cost cooling shall be made possible by means of a control circuit which will modulate dampers to provide 100 percent outside air while locking out compressors.

2.6 UNITARY EQUIPMENT, SPLIT SYSTEM

Unit shall be an air-cooled, water-cooled, or evaporatively-cooled, split system which employs a remote condenser or condensing unit, a separate indoor unit, and interconnecting refrigerant piping. Unit shall be the air-conditioning or heat pump type conforming to applicable Underwriters Laboratories (UL) standards including UL 1995. Unit shall be rated in accordance with ARI 210/240, ARI 340/360, ARI 320, or ARI 325 as applicable. Unit shall be provided with necessary fans, air filters, coil frost protection, liquid receiver, internal dampers, mixing boxes, supplemental heat, and cabinet construction as specified in paragraph "Unitary Equipment Components". The remote unit shall be as specified in paragraph REMOTE CONDENSER OR CONDENSING UNIT. Evaporator or supply fans shall be double-width, double inlet, forward curved, backward inclined, or airfoil blade, centrifugal scroll type. Condenser or outdoor fans shall be the manufacturer's standard for the unit specified and may be either propeller or centrifugal scroll type. Fan and condenser motors shall have open, dripproof, totally enclosed, or explosion proof enclosures as indicated or required.

2.6.1 Air-to-Refrigerant Coil

Coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.6.2 Compressor

Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of 35 kW (10 tons) and larger shall be provided with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors will operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Each compressor shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, thermal overloads, lubrication pump, high and low pressure safety cutoffs and protection against short cycling.

2.6.3 Refrigeration Circuit

Refrigerant-containing components shall comply with ASHRAE 15 and be factory tested, cleaned, dehydrated, charged, and sealed. Refrigerant charging valves and connections, and pumpdown valves shall be provided for each circuit. Filter-drier shall be provided in each liquid line and be reversible-flow type. Refrigerant flow control devices shall be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve. A refrigerant suction line thermostatic and water flow switch control shall be provided to prevent freeze-up in event of loss of water flow during heating cycle.

2.6.4 Unit Controls

Unit shall be internally prewired with a 24 or 120 volt control circuit powered by an internal transformer. Terminal blocks shall be provided for power wiring and external control wiring. Unit shall have cutoffs for high and low pressure, and low oil pressure for compressors with positive displacement oil pumps, supply fan failure, and safety interlocks on all service panels. Head pressure controls shall sustain unit operation with ambient temperature of -29 degrees C (-20 degrees F). Adjustable-cycle timers shall prevent short-cycling. Multiple compressors shall be staged by means of a time delay. Unit shall be internally protected by fuses or a circuit breaker in accordance with UL 1995. Low cost cooling shall be made possible by means of a control circuit which will modulate dampers to provide 100 percent outside air while locking out compressors.

2.7 REMOTE CONDENSER OR CONDENSING UNIT

Units with capacities less than 39.5 kW (135,000 Btuh) shall produce a maximum ARI sound rating of 8.6 bels when rated in accordance with ARI 270. Units with capacities 39.5 kW (135,000 Btuh) or greater shall produce a maximum ARI sound rating of 8.8 bels when rated in accordance with ARI 370. Each remote condenser coil shall be fitted with a manual isolation valve and an access valve on the coil side. Saturated refrigerant condensing temperature shall not exceed 49 degrees C (120 degrees F) at 40 degrees C (95 degrees F) ambient. Unit shall be provided with low ambient condenser controls to ensure proper operation in an ambient temperature of -29 degrees C (-20 degrees F). Fan and cabinet construction shall be provided as specified in paragraph "Unitary Equipment Components". Fan and condenser motors shall have open, dripproof, totally enclosed, or explosion proof enclosures as indicated or required.

2.7.1 Air-Cooled Condenser

Unit shall be rated in accordance with ARI 460 and conform to the requirements of UL 1995. Unit shall be factory fabricated, tested, packaged, and self-contained. Unit shall be complete with casing, propeller or centrifugal type fans, heat rejection coils, connecting piping and wiring, and all necessary appurtenances.

2.7.1.1 Connections

Interconnecting refrigeration piping, electrical power, and control wiring between the condensing unit and the indoor unit shall be provided as required and as indicated. Electrical and refrigeration piping terminal connections between condenser or condensing unit and evaporator units shall be provided.

2.7.1.2 Head Pressure Control and Liquid Subcooling

Low ambient control for multi-circuited units serving more than one evaporator coil shall provide independent condenser pressure controls for each refrigerant circuit. Controls shall be set to produce a minimum of 95 degrees F saturated refrigerant condensing temperature. Unit shall be provided with a liquid subcooling circuit which shall ensure proper liquid refrigerant flow to the expansion device over the specified application range of the condenser. Unit shall be provide with manufacturer's standard or not less than 4 degrees F liquid subcooling. Subcooling circuit shall be liquid sealed.

2.7.1.3 Condensing Coil

Coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes.

Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.7.1.4 Unit Controls

The control system shall be complete with required accessories for regulating condenser pressure by fan cycling, solid-state variable fan speed, modulating condenser coil or fan dampers, flooding the condenser, or a combination of the above. Unit mounted control panels or enclosures shall be constructed in accordance with applicable requirements of NFPA 70 and housed in NEMA ICS 6, Class 1 or 3A enclosures. Controls shall include control transformer, fan motor starters, solid-state speed control, electric heat tracing controls, time delay start-up, overload protective devices, interface with local and remote components, and intercomponent wiring to terminal block points.

2.7.2 Evaporative Condenser

Each unit shall be the counter-flow blow-through design, with single-side air entry. The unit shall have fan assemblies built into the unit base, with all moving parts factory mounted and aligned. Primary construction of the pan section, the cabinet, etc. shall be not lighter than 16-gauge steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A 153/A 153M and ASTM A 123/A 123M, as applicable and have an extra heavy coating of not less than 0.76 kg/square meter (2-1/2 ounces per square foot) of surface. Cut edges shall be given a protective coating of zinc-rich compound. After assembly, the manufacturer's standard zinc chromatized aluminum or epoxy paint finish shall be applied to the exterior of the unit. Unit shall be rated in accordance with ARI 490 and tested in accordance with the requirements of ASHRAE 64.

2.7.2.1 Pan Section

The pan shall be watertight and be provided with drain, overflow, and make-up water connections. Standard pan accessories shall include circular access doors, a lift-out strainer of anti-vortexing design and a brass make-up valve with float ball.

2.7.2.2 Fan Section

Fan shall be the centrifugal or propeller type in accordance with paragraph "Fans". Fan and fan motor shall not be located in the discharge airstream of the unit. Motors shall have open, splashproof, or totally enclosed enclosure and be suitable for the indicated service. The condensing unit design shall prevent water from entering into the fan section.

2.7.2.3 Condensing Coil

Coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter without fins. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged.

2.7.2.4 Water Distribution System

Water shall be distributed uniformly over the condensing coil to ensure complete wetting of the coil at all times. Spray nozzles shall be brass, stainless steel, or high-impact plastic. Nozzles shall be the cleanable, nonclogging, removable type. Nozzles shall be designed to permit easy disassembly and be arranged for easy access.

2.7.2.5 Water Pump

The water pump shall be the bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the evaporative condenser or remotely on a separate mounting pad. Pumps shall have cast-iron casings. Impellers shall be bronze, and shafts shall be stainless steel with bronze casing wearing rings. Shaft seals shall be the mechanical type. Pump casing shall be factory coated with epoxy paint. Pump motors shall have open, dripproof, totally enclosed, or explosion proof enclosures as indicated or required. A bleed line with a flow valve or fixed orifice shall be provided in the pump discharge line and shall be extended to the nearest drain for continuous discharge. Pump suction shall be fully submerged and provided with a galvanized steel or monel screened inlet.

2.7.2.6 Drift Eliminator

Eliminators shall be provided to limit drift loss to not over 0.005 percent of the specified water flow. Eliminators shall be constructed of zinc-coated steel or polyvinyl chloride (PVC). Eliminators shall prevent carry over into the unit's fan section.

2.7.2.7 Unit Controls

The evaporative condenser unit shall be provided with modulating capacity control dampers mounted in the discharge of the fan housing. On a decrease in refrigerant discharge pressure the dampers shall modulate to reduce the airflow through the evaporative condenser. Controls shall include a proportional acting pressure controller, a control transformer, motor actuator with linkages and end switches to cycle fan motor on and off. Cycling of a fan motor on and off shall be in accordance with the manufacturer.

2.7.3 Compressor

Unit shall be rated in accordance with ARI 500. Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Units

35 kW (120,000 Btuh) and larger shall be provided with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors will operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Each compressor shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, lubrication pump, thermal overloads, and high and low pressure safety cutoffs and protection against short cycling.

2.8 AIR-CONDITIONERS FOR ELECTRONIC DATA PROCESSING (EDP) SPACES

Unit shall be an air-cooled or water-cooled, self-contained type air-conditioning unit. Unit shall be a packaged unit with an internal water-cooled condenser or a split-system with a remote condenser or condensing unit. Unit shall be designed and constructed for automatic control of space conditions. Unit shall be in accordance with ASHRAE 127 and UL 1995. Unit shall be rated in accordance with ARI 210/240 or ARI 340/360 as applicable. ARI certification is not required. The system shall be designed and constructed for maximum reliability and ease of maintenance. Necessary redundancy, access to refrigeration circuits, means of troubleshooting, and malfunction alarms shall be provided. Unit shall be provided with necessary fans, air filters, coil frost protection, liquid receiver, internal dampers, mixing boxes, supplemental heat, and cabinet construction as specified in paragraph "Unitary Equipment Components". Evaporator or supply fans shall be double-width, double inlet, forward curved centrifugal scroll type. Condenser or outdoor fans shall be manufacturer's standard for unit specified and may be either propeller or centrifugal scroll type. Fan and condenser motors shall have open, dripproof, totally enclosed, or explosion proof enclosures as indicated or required. Remote unit shall be as specified in paragraph REMOTE CONDENSER/CONDENSING UNIT.

2.8.1 Air-to-Refrigerant Coils

Evaporator or condenser coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Units shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.8.2 Water-to-Refrigerant Coils

Unit shall be of the tube-in-tube, shell-and-coil, shell-and-tube, or concentric tube type and be provided as an integral part of the self-contained unit. Water-wetted metals shall be copper or copper-nickel, except that heads may be ferrous metal in systems with chemically treated recirculating water. Unit shall be rated for not less than 2758 kPa (400 psi) refrigerant side and 862 kPa (125 psi) water side pressure service at operating temperatures. Unit shall be supplied with water as indicated. Water supply, return and control system wetted parts shall be copper, bronze or stainless steel. Water supply, return connections and piping internal to unit shall be copper with brazed or threaded copper or bronze fittings, terminating in a threaded connection. Piping arrangement shall include valved access for recirculation of acidic scale removal chemicals and isolation pressure taps to determine pressure drop and water flow. Performance shall be based on an allowable water velocity not less than 0.9 m/s (3 fps) nor more than 3 m/s (10 fps) with a fouling factor of 0.0005. A separate condenser shall be provided for each compressor circuit. Control shall be set for refrigerant condensing temperature as indicated. Units which use a once-thru water-source shall be fitted with a strainer protected solenoid shut-off valve. The valve shall be a fully automatic, self-contained temperature regulating valve with integral thermometer. Mercury shall not be used in thermometers.

2.8.3 Compressor

Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of 26 kW (7-1/2 tons) and larger shall be provided with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors will operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Each compressor shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, lubrication pump, thermal overloads, and high and low pressure safety cutoffs and protection against short cycling.

2.8.4 Refrigeration Circuit

Refrigerant-containing components shall comply with ASHRAE 15 and be factory tested, cleaned, dehydrated, charged, and sealed. Refrigerant charging valves and connections, and pumpdown valves shall be provided for each circuit. Filter-drier shall be provided in each liquid line and be reversible-flow type. Refrigerant flow control devices shall be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve. A refrigerant suction line thermostatic and water flow switch control shall be provided to prevent freeze-up in event of loss of water flow during heating cycle.

2.8.5 Unit Controls

A unit's basic functions and space ambient conditions shall be controllable at one station. A temperature and humidity strip-chart recorder, integral or external to the unit, readable to specified control accuracy, shall be provided, complete with cartridge ink and chart supply for 1 year of operation.

2.8.5.1 Externally Accessible Controls

The following controls shall be externally accessible:

a. Start and stop total system functions.

b. Audible alarm silence.

c. Main power disconnect.

2.8.5.2 Status Indicators

The following status indicators shall be externally visible:

a. Power On.

b. System On.

c. Malfunction.

d. Provision for remote alarm status indication.

2.8.5.3 Alarmed Conditions

The following system status conditions shall be both audibly and visually alarmed:

a. Loss of air flow.

b. Dirty filters.

c. Compressor overload or lock-out (compressor high head pressure and low suction pressure).

d. High and low room temperature.

e. High relative humidity.

2.8.5.4 Space Temperature

Space temperature shall be controlled within plus or minus 1 degrees C (1-1/2 degrees F) of the set point over a range of 16 to 32 degrees C (60 to 90 degrees F) with a set point as indicated. Space relative humidity shall be controlled within plus or minus 5 percent of the set point over a range of 20 to 80 percent with a set point as indicated.

2.8.5.5 Safety Controls

Safety controls shall include the following:

a. Fused, unfused or line-break circuit breaker disconnects, as indicated or required.

b. Automatic pump-out or pump-down liquid flooding controls.

c. High refrigerant pressure cutout.

d. Low refrigerant pressure cutout where automatic pump-down is not provided.

e. Accessible hermetic and open compressor low oil pressure cutout.

f. Elapsed time meter for each compressor where load equalization is not incorporated.

g. Lead and lag compressor selector switch, when compatible with system.

2.8.6 Cabinet Construction

Cabinet shall be totally enclosed. Enclosure surfaces shall be pulsation free, with hinged and removable doors and panels for vertical side or front access to unit components. Routine maintenance access to compressor and system control components shall be possible without unit shut-down. Enclosure surfaces shall be thermally and acoustically insulated. Interior baffle and compartment surfaces shall be galvanized steel. Drain pans shall collect all condensate and be steel with external insulation as required. Surface mounting steel pads and vibration isolating pads shall be provided. Enclosure surfaces shall be prepared, primed and finished. Paint and finishes shall comply with the requirements specified in paragraph FACTORY COATING. Cabinets shall be fitted with integral or separable, adjustable and lockable jacks to support the units from the structural slab at the raised-floor elevation.

2.9 EQUIPMENT EFFICIENCY

Unit shall have an efficiency as indicated on the drawings.

2.10 UNITARY EQUIPMENT COMPONENTS

2.10.1 Refrigerant and Oil

Refrigerant shall be one of the fluorocarbon gases. Refrigerants shall have number designations and safety classifications in accordance with ASHRAE 34. Refrigerants shall meet the requirements of ARI 700 as a minimum. Refrigerants shall have an Ozone Depletion Potential (ODP) of less than or equal to 0.05. Contractor shall provide and install a complete charge of refrigerant for the installed system as recommended by the manufacturer. Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase shall be furnished. One charge shall be used during the system performance testing period. Following the satisfactory completion of the performance testing, the oil shall be drained and replaced with a second charge. Lubricating oil shall be of a type and grade recommended by the manufacturer for each compressor. Where color leak indicator dye is incorporated, charge shall be in accordance with manufacturer's recommendation.

2.10.2 Fans

Fan wheel shafts shall be supported by either maintenance-accessible lubricated antifriction block-type bearings, or permanently lubricated ball bearings. Unit fans shall be selected to produce the cfm required at the fan total pressure. Motor starters, if applicable, shall be magnetic across-the-line type with a open, dripproof, totally enclosed, or explosion proof enclosure as indicated or required. Thermal overload protection shall be of the manual or automatic-reset type. Fan wheels or propellers shall be constructed of aluminum or galvanized steel. Centrifugal fan wheel housings shall be of galvanized steel, and both centrifugal and propeller fan casings shall be constructed of aluminum or galvanized steel. Steel elements of fans, except fan shafts, shall be hot-dipped galvanized after fabrication or fabricated of mill galvanized steel. Mill-galvanized steel surfaces and edges damaged or cut during fabrication by forming, punching, drilling, welding, or cutting shall be recoated with an approved zinc-rich compound. Fan wheels or propellers shall be statically and dynamically balanced. Direct-drive fan motors shall be of the multiple-speed variety. Belt-driven fans shall have adjustable sheaves to provide not less than 20 percent fan-speed adjustment. The sheave size shall be selected so that the fan speed at the approximate midpoint of the sheave adjustment will produce the specified air quantity. Centrifugal scroll-type fans shall be provided with streamlined orifice inlet and V-belt drive. Each drive will be independent of any other drive. Propeller fans shall be direct-drive or V-belt drive type with adjustable or fixed pitch blades as indicated. V-belt driven fans shall be mounted on a corrosion protected drive shaft supported by either maintenance-accessible lubricated antifriction block-type bearings, or permanently lubricated ball bearings. Each drive will be independent of any other drive. Drive bearings shall be protected with water slingers or shields. V-belt drives shall be fitted with guards where exposed to contact by personnel and fixed pitch or adjustable pitch sheaves as indicated.

2.10.3 Primary/Supplemental Heating

2.10.3.1 Water Coil

Coil shall conform to the provisions of ARI 410. Coil shall be fin-and-tube type constructed of seamless copper tubes and aluminum fins mechanically bonded or soldered to tubes. Headers shall be constructed of cast iron, welded steel or copper. Coil shall be constructed to float within the casing to allow free expansion and contraction of tubing. Casing and tube support sheets shall not be lighter than 1.6 mm (16 gauge) galvanized steel formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. Coil shall be circuited for suitable water velocity without excessive pressure drop and properly pitched for drainage where required or indicated. Each coil shall be tested at the factory under water at not less than 2000 kPa (300 psi) air pressure, tested hydrostatically after assembly of the unit and proved tight under a gauge pressure of 1400 kPa (200 psi). Coil shall be suitable for use with water up to 120 degrees C (250 degrees F). Coil shall allow complete coil drainage with a pitch of not less than 10 mm per meter 1/8 inch per foot slope to drain.

2.10.3.2 Steam Coil

Coil shall conform to the provisions of ARI 410. Coil shall be constructed of cast semi-steel, welded steel, or copper headers, red-brass or copper tubes, and copper or aluminum fins mechanically bonded or soldered. Tubes shall be rolled and bushed and brazed or welded into headers. Coil casings and tube support sheets, with collars of ample width, shall be not lighter than 1.6 mm (16 gauge) 16 gauge galvanized steel, formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag.

The fin tube and header section shall float within the casing to allow free expansion of tubing for coils subject to high pressure-steam service. Coils shall be factory pressure tested and capable of withstanding 1700 kPa (250 psi) hydrostatic test pressure or 1700 kPa (250 psi) air pressure, and be for 700 kPa (100 psi) steam working pressure. Preheat coils shall be steam-distributing tube type. Condensing tubes shall be not less than 15 mm (5/8 inch) outside diameter. Distribution tubes shall be not less than 10 mm (3/8 inch) outside diameter, and be equipped with orifices to discharge steam to condensing tubes. Distribution tubes shall be installed concentrically inside of condenser tubes and be held securely in alignment. The maximum length of a single coil shall be limited to 120 times the diameter of the outside tube. Other heating coils shall be minimum 12 mm (1/2 inch) outside diameter single-tube type. Supply headers shall distribute steam evenly to all tubes at the indicated steam pressure. Coil shall allow complete coil drainage with a pitch of not less than 10 mm per meter (1/8 inch per foot) slope to drain.

2.10.3.3 Electric Heating Coil

Coil shall be an electric duct heater in accordance with UL 1995 and NFPA 70. Coil shall be duct- or unit-mounted. Coil shall be of nickel chromium resistor, single stage, strip or stainless steel, fin tubular type. Coil shall be provided with a built-in or surface-mounted high-limit thermostat interlocked electrically so that the coil cannot be energized unless the fan is energized. Coil casing and support brackets shall be of galvanized steel or aluminum. Coil shall be mounted to eliminate noise from expansion and contraction and be completely accessible for service.

2.10.3.4 Gas-Fired Heating Section

Gas-fired heat exchanger shall be constructed of aluminized steel, ceramic coated cold-rolled steel or stainless steel suitable for natural gas fuel supply. Burner shall have direct spark or hot surface ignition. Valve shall include a pressure regulator. Combustion air shall be supplied with a centrifugal combustion air blower. Safety controls shall include a flame sensor and air pressure switch. Heater section shall be mounted to eliminate noise from expansion and contraction and shall be completely accessible for service. Gas equipment shall bear the AGA label for the type of service involved. Burner shall be in accordance with NFPA 54.

2.10.4 Air Filters

Air filters shall be listed in accordance with requirements of UL 900, except high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test Method shall be as listed under the label service and shall meet the requirements of UL 586.

2.10.4.1 Extended Surface Pleated Panel Filters

Filters shall be 50 mm (2 inch) depth sectional type of the size indicated and shall have an average efficiency of 25 to 30 percent when tested in accordance with ASHRAE 52.1. Initial resistance at 2.54 m/s (500 feet per minute) will not exceed 90 Pa (0.36 inches water gauge). Filters shall be UL Class 2. Media shall be nonwoven cotton and synthetic fiber mat. A wire support grid bonded to the media shall be attached to a moisture resistant fiberboard frame.

Four edges of the filter media shall be bonded to the inside of the frame to prevent air bypass and increase rigidity.

2.10.4.2 Replaceable Media Filters

Replaceable media filters shall be the dry-media or viscous adhesive type, of the size required to suit the application. Filtering media shall be not less than 50 mm (2 inches) thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Pad shall be enclosed in a holding frame of not less than 1.6 mm (16 gauge) galvanized steel, and equipped with quick-opening mechanism for changing filter media. The air flow capacity of the filter shall be based on net filter face velocity not exceeding 1.52 m/s (300 feet per minute), with initial resistance of 32 Pa (0.13 inches water gauge). Average efficiency shall be not less than 80 percent when tested in accordance with ASHRAE 52.1.

2.10.4.3 Sectional Cleanable Filters

Cleanable filters shall conform to ASTM F 872, and be 25 or 50 mm (1 or 2 inches thick. Viscous adhesive shall be provided in 18.9 L (5 gallon) containers in sufficient quantity for 12 cleaning operations and not less than 1 L (one quart) for each filter section. Initial pressure drop for clean filters shall not exceed the applicable values listed in ASTM F 872. One washing and charging tank shall be provided for every 100 filter sections or fraction thereof. Each washing and charging unit shall consist of a tank and single or double drain rack mounted on legs. Drain rack shall be provided with dividers and partitions to properly support the filters in the draining position.

2.10.5 Coil Frost Protection

Each circuit shall be provided with a coil frost protection system which is a manufacturer's standard. The coil frost protection system shall use a temperature sensor in the suction line of the compressor to shut the compressor off when coil frosting occurs. Timers shall be used to prevent the compressor from rapid cycling.

2.10.6 Pressure Vessels

Pressure vessels shall conform to ASME BPVC SEC VIII D1 or UL 207, as applicable for maximum and minimum pressure or temperature encountered. Where referenced publications do not apply, pressure components shall be tested at 1-1/2 times design working pressure. Refrigerant wetted carbon steel surfaces shall be pickled or abrasive blasted free of mill scale, cleaned, dried, charged, and sealed.

2.10.6.1 Hot Gas Muffler

Unit shall be selected by the manufacturer for maximum noise attenuation. Units rated for 100 kW (30 tons) capacity and under may be field tunable type.

2.10.6.2 Liquid Receiver

A liquid receiver shall be provided when a system's condenser or compressor does not contain a refrigerant storage capacity of at least 20 percent in excess of a fully charged system. Receiver shall be designed, filled, and rated in accordance with the recommendations of ARI 495, except as modified herein. Receiver shall be fitted to include an inlet connection; an outlet drop pipe with oil seal and oil drain where necessary; two bull's-eye liquid level sight glass in same vertical plane, 90 degrees apart and perpendicular to axis of receiver or external gauge glass with metal guard and automatic stop valves; thermal well for thermostat; float switch column; external float switches; and purge, charge, equalizing, pressurizing, plugged drain and service valves on the inlet and outlet connections. Receiver shall be provided with a relief valve of capacity and setting in accordance with ASHRAE 15.

2.10.6.3 Oil Separator

Separator shall be the high efficiency type and be provided with removable flanged head for ease in removing float assembly and removable screen cartridge assembly. Pressure drop through a separator shall not exceed 70 kPa (10 psi) during the removal of hot gas entrained oil. Connections to compressor shall be as recommended by the compressor manufacturer. Separator shall be provided with an oil float valve assembly or needle valve and orifice assembly, drain line shutoff valve, sight glass, filter for removal of all particulate sized 10 microns and larger, thermometer and low temperature thermostat fitted to thermal well, immersion heater, external float valve fitted with three-valve bypass, and strainer.

2.10.6.4 Oil Reservoir

Reservoir capacity shall equal one charge of all connected compressors. Reservoir shall be provided with an external liquid gauge glass, plugged drain, and isolation valves. Vent piping between the reservoir and the suction header shall be provided with a 35 kPa (5 psi) pressure differential relief valve. Reservoir shall be provided with the manufacturer's standard filter on the oil return line to the oil level regulators.

2.10.7 Internal Dampers

Dampers shall be parallel blade type with renewable blade seals and be integral to the unitary unit. Damper provisions shall be provided for each outside air intake, exhaust, economizer, and mixing boxes. Dampers shall have manual or automatic modulation as indicated and operate as specified.

2.10.8 Mixing Boxes

Mixing boxes shall match the base unit in physical size and shall include equally-sized flanged openings, each capable of full air flow. Arrangement shall be as indicated.

2.10.9 Cabinet Construction

Casings for the specified unitary equipment shall be constructed of galvanized steel or aluminum sheet metal and galvanized or aluminum structural members. Minimum thickness of single wall exterior surfaces shall be 1.3 mm (18 gauge) galvanized steel or 1.8 mm (0.071 inch) thick aluminum on units with a capacity above 70 kW (20 tons) and 1.0 mm (20 gauge) galvanized steel or 1.6 mm (0.064 inch) thick aluminum on units with a capacity less than 70 kW (20 tons). Casing shall be fitted with lifting provisions, access panels or doors, fan vibration isolators, electrical control panel, corrosion-resistant components, structural support members, insulated condensate drip pan and drain, and internal insulation in the cold section of the casing. Where double-wall insulated construction is proposed, minimum exterior galvanized sheet metal thickness shall be 1.0 mm (20 gauge). Provisions to permit replacement of major unit components shall be incorporated. Penetrations of cabinet surfaces, including the floor, shall be sealed. Unit shall be fitted with a drain pan which extends under all areas where water may accumulate. Drain pan shall be fabricated from Type 300 stainless steel, galvanized steel with protective coating as required, or an approved plastic material. Pan insulation shall be water impervious. Extent and effectiveness of the insulation of unit air containment surfaces shall prevent, within limits of the specified insulation, heat transfer between the unit exterior and ambient air, heat transfer between the two conditioned air streams, and condensation on surfaces. Insulation shall conform to ASTM C 1071. Paint and finishes shall comply with the requirements specified in paragraph FACTORY COATING.

2.10.9.1 Indoor Cabinet

Indoor cabinets shall be suitable for the specified indoor service and enclose all unit components.

2.10.9.2 Outdoor Cabinet

Outdoor cabinets shall be suitable for outdoor service with a weathertight, insulated and corrosion-protected structure. Cabinets constructed exclusively for indoor service which have been modified for outdoor service are not acceptable.

2.11 ACCESSORIES

2.11.1 Dry-Cooler, Glycol Solution

Unit shall be factory fabricated and tested, packaged, self-contained, complete with casing, propeller or centrifugal type fans, heat rejection coils, appurtenances, and intercomponent piping and wiring. Unit shall be certified by the manufacturer or an independent test laboratory that the unit's ratings meet ARI 410 the indicated conditions. Unit shall be designed for outdoor or indoor installation and comply with the requirements of UL 1995. Unit shall compatible with the solution specified in paragraph "Glycol Solution". Unit shall be fitted with recirculating pump, expansion tank, Type L copper intercomponent piping, system accessories and controls. Factory assembled piping shall be Type L copper. Cabinet construction shall be in accordance with paragraph "Unitary Equipment Components".

2.11.1.1 Coil

Coils shall have nonferrous tubes of 10 mm (3/8 inch) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.11.1.2 Fan Section

Fan shall be the centrifugal or propeller type in accordance with paragraph "Fans". Motors shall have open, dripproof, totally enclosed, or explosion proof enclosures and be suitable for the indicated service.

2.11.1.3 Pump

Pump and controls shall be mounted within a lockable sheet metal enclosure supported from dry cooler structure. Pump shall be of the end-suction type with an open, dripproof, totally enclosed, or explosion proof motor as indicated or required. Pump construction shall be as specified in paragraph "Pumps". Seals shall be mechanical type suitable for ethylene glycol solution up to a 60 percent concentration of glycol, and be rated for 82 degrees C (180 degrees F) service.

2.11.1.4 Controls

The control system shall be complete with all required accessories for regulating glycol temperature by fan cycling, solid-state variable fan speed, modulating glycol 3-way mixing valve or modulating fan dampers. Unit-mounted control panels or enclosures shall be constructed in accordance with applicable requirements of NFPA 70 and housed in NEMA ICS 6, Class 1 or 3A enclosures. Controls shall include a control transformer, fan motor starters, solid-state speed control, pump motor starters, electric heat tracing controls, time delay start-up, overload protective devices, interface with local and remote components, and intercomponent wiring to terminal block points.

2.11.2 Humidifier

2.11.2.1 Steam Spray Type

Steam spray humidifiers shall inject steam directly into the surrounding air or air stream. Single grid humidifiers shall consist of a single copper distribution grid with pipe connection on one end and cap on the other end. Automatic steam control valves and condenser traps shall be field-installed. Enclosed grid shall be housed in a copper enclosure with a built-in condensate drain connection. Exposed grid shall be wick wrapped. Package type steam spray humidifiers shall be equipped to trap out and to evaporate condensate and to supply dry steam to a single distribution grid. Grid shall be steam jacketed and condensate drained. Unit shall trap excess condensate to return system. Package type steam spray humidifiers shall have modulating electric, electronic, or pneumatic steam control valve, as indicated. Steam spray humidifiers shall be rated for humidifying capacity in pounds of steam per hour and at steam pressure as indicated.

2.11.2.2 Steam-Diffuser Type

Diffuser units shall be of a design that will separate any condensate from steam supply and provide positive drain of condensate to waste and supply dry steam only to air stream. Humidifiers may be installed on single or multiple units. Materials shall be noncorrosive materials or Type 300 stainless steel.

2.11.3 Purge System

Refrigeration systems which operate at pressures below atmospheric pressure shall be provided with a purge system. Purge systems shall automatically remove air, water vapor, and non-condensible gases from the system's refrigerant. Purge systems shall condense, separate, and return all refrigerant back to the system. An oil separator shall be provided with the purge system if required by the manufacturer. Purge system shall not discharge to occupied areas, or create a potential hazard to personnel. Purge system shall include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system shall include lights or an alarm which indicate excessive purge or an abnormal air leakage into the system.

2.11.4 Refrigerant Leak Detector

Detector shall be the continuously-operating, halogen-specific type. Detector shall be appropriate for the refrigerant in use. Detector shall be specifically designed for area monitoring and shall include single or multiple sampling points installed where indicated. Detector design and construction shall be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector shall have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector shall be supplied factory-calibrated for the appropriate refrigerant(s). Detector shall be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant in use. The detector's relay shall be capable of initiating corresponding alarms and ventilation system as indicated on the drawings. Detector shall be provided with a failure relay output that energizes when the monitor detects a fault in its operation. Detector shall be compatible with the facility's energy management and control system (EMCS). The EMCS shall be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.

2.11.5 Refrigerant Relief Valve/Rupture Disc Assembly

The assembly shall be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly shall be in accordance with ASME BPVC SEC VIII D1 and ASHRAE 15. The assembly shall be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc shall be the non-fragmenting type.

2.11.6 Refrigerant Signs Refrigerant signs shall be a medium-weight aluminum type with a baked enamel finish. Signs shall be suitable for indoor or outdoor service. Signs shall have a white background with red letters not less than 12 mm (0.5 inches) in height.

2.11.6.1 Installation Identification

Each new refrigeration system shall be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name

b. Refrigerant number and amount of refrigerant.

c. The lubricant identity and amount.

d. Field test pressure applied.

2.11.6.2 Controls and Piping Identification

Refrigerant systems containing more than 50 kg (110 lb) of refrigerant shall be provided with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow, the ventilation system, and the refrigerant compressor.

b. Pressure limiting device(s).

2.11.7 Heat Recovery Devices

2.11.7.1 Hot Air Reclaim

Unit shall be a heat recovery, factory-fabricated, draw-through, central station type air conditioner in accordance with Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.11.7.2 Hot Water Reclaim

Unit shall be a double-wall, tube-within-tube heat exchanger type, complete with thermostatic control. Unit shall be constructed and refrigerant pressure/temperature rated in accordance with ASHRAE 15. Heat exchanger coil shall consist of an external refrigerant containing carbon steel tube and an internal, double-wall-in-metallic contact, convoluted, potable water containing copper tube. Cabinet shall be fabricated of zinc-protected steel and be internally insulated in coil space. The recovery device shall be provided with a refrigerant compressor head pressure control and a interlocked, potable water circulating pump. Pump and motor assembly shall be close-coupled, manufacturer's standard type with indicated head and capacity characteristics, and with brass, bronze, copper or stainless steel wetted parts. Pump shall be mounted remotely or integral to the exchanger and be rated for 115 or 208 volt ac power supply.

2.11.8 Gaskets

Gaskets shall conform to ASTM F 104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 370 degrees C (700 degrees F) service.

2.11.9 Bolts and Nuts

Bolts and nuts shall be in accordance with ASTM A 307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A 307.

2.11.10 Bird Screen

Screen shall be in accordance with ASTM E 437, Type 1, Class 1, 2 by 2 mesh, 1.6 mm (0.063 inch) diameter aluminum wire or 0.79 mm (0.031 inch) diameter stainless steel wire.

2.12 FABRICATION

2.12.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B 117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm (1/8 inch) on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

2.12.2 Factory Applied Insulation

Refrigeration equipment shall be provided with factory installed insulation on surfaces subject to sweating including the suction line piping. Where motors are the gas-cooled type, factory installed insulation shall be provided on the cold-gas inlet connection to the motor per manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E 84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E 84.

2.13 SUPPLEMENTAL COMPONENTS/SERVICES

2.13.1 Condenser Water Piping and Accessories

Condenser water piping and accessories shall be provided and installed in accordance with Section 15181 CHILLED AND CONDENSER WATER PIPING AND ACCESSORIES.

2.13.2 Refrigerant Piping

Refrigerant piping for split-system unitary equipment shall be provided and installed in accordance with Section 15182 REFRIGERANT PIPING.

2.13.3 Cooling Tower

Cooling towers shall be provided and installed in accordance with the US Army Corps of Engineers, Unified Facilities Guide Specifications (UFGS), Section 15645A COOLING TOWER.

2.13.4 Ductwork

Ductwork shall be provided and installed in accordance with Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.13.5 Temperature Controls

Temperature controls shall be in accordance with Section 15950 HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS and fully coordinated with and integrated into the existing air-conditioning system.

PART 3 EXECUTION

3.1 INSTALLATION

Work shall be performed in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. Where equipment is specified to conform to the requirements of ASME BPVC SEC VIII D1and ASME BPVC SEC IX, the design, fabrication, and installation of the system shall conform to ASME BPVC SEC VIII D1 and ASME BPVC SEC IX.

3.1.1 Equipment

Refrigeration equipment and the installation thereof shall conform to ASHRAE 15. Necessary supports shall be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, and similar items. Compressors shall be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations shall be provided. Each foundation shall include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment shall be set on not less than a 150 mm (6 inch) concrete pad doweled in place. Concrete foundations for floor mounted pumps shall have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block shall be of mass not less than three times the combined pump, motor, and base weights. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Lines connected to pumps mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.1.2 Mechanical Room Ventilation

Mechanical ventilation systems shall be in accordance with Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.1.3 Field Applied Insulation

Field applied insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.4 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09900 PAINTING, GENERAL.

3.2 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions. Testing, adjusting, and balancing shall be as specified in Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.3 REFRIGERANT TESTS, CHARGING, AND START-UP

Split-system refrigerant piping systems shall be tested and charged as specified in Section 15182 REFRIGERANT PIPING. Packaged refrigerant systems which are factory charged shall be checked for refrigerant and oil capacity to verify proper refrigerant levels per manufacturer's recommendations. Following charging, packaged systems shall be tested for leaks with a halide torch or an electronic leak detector.

3.3.1 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. Under no circumstances shall the refrigerant be discharged into the atmosphere.

3.3.2 Contractor's Responsibility

The Contractor shall, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 85 g (3 ounces) of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year shall be repaired in accordance with the requirements herein at no cost to the Government including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.4 SYSTEM PERFORMANCE TESTS

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Tests shall cover a period of not less than 48 hours for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened. Any refrigerant lost during the system startup shall be replaced. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and the system shall be retested. Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. Field tests shall be coordinated with Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.5 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 24 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

SECTION 15895

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 260	(2001) Sound Rating of Ducted Air Moving and Conditioning Equipment
ARI 350	(2000) Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment

ARI 410	(1991) Forced-Circulation Air-Cooling and Air-Heating Coils
ARI 430	(1999) Central-Station Air-Handling Units
ARI 440	(1998) Room Fan-Coils
ARI 445	(1987; R 1993) Room Air-Induction Units
ARI 880	(1998) Air Terminals
ARI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

AIR CONDITIONING CONTRACTORS OF AMERICA (ACCA)

ACCA Manual 4	(2001) Installation Techniques for Perimeter Heating & Cooling; 11th Edition

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 210	(1999) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(1996) Reverberant Room Method for Sound Testing of Fans

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(1990; R 1999) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S12.32	(1990; R 2001) Precision Methods for the Determination of Sound Power Levels of Discrete-Frequency and Narrow-Band Noise Sources in Reverberation Rooms

ASTM INTERNATIONAL (ASTM)

ASTM A 123/ A 123M	(2001a) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 167	(1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 924/ A 924M	(1999) General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM C 916	(1985; R 1996el) Adhesives for Duct Thermal Insulation

ASTM C 1071	(2000) Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D 520	(2000) Zinc Dust Pigment
ASTM D 1654	(1992; R 2000) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 1785	(1999) Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2466	(2001) Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2564	(1996a) Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D 2855	(1996) Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D 3359	(1997) Measuring Adhesion by Tape Test
ASTM E 84	(2001) Surface Burning Characteristics of Building Materials
ASTM E 437	(1992; R 1997) Industrial Wire Cloth and Screens (Square Opening Series)
ASTM F 872	(1984; R 1990) Filter Units, Air-Conditioning: Viscous-Impingement Type, Cleanable

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(2001) Safety Standard for Refrigeration Systems
ASHRAE 52.1	(1992) Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
ASHRAE 68	(1997) Laboratory Method of Testing to Determine the Sound Power in a Duct
ASHRAE 70	(1991) Method of Testing for Rating the Performance of Air Outlets and Inlets
ASHRAE 84	(1991) Method of Testing Air-to-Air Heat Exchangers

U.S. GENERL SERVICES ADMINISTRATION (GSA)

CID A-A-1419	(Rev D; Canc. Notice 1) Filter Element, Air Conditioning (Viscous-Impingement and Dry Types, Replaceable)

INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY(IEST)

IEST RP-CC-001.3	(1997) HEPA and ULPA Filters

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(1998) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2002) National Electrical Code
NFPA 90A	(1999) Installation of Air Conditioning and Ventilating Systems
NFPA 96	(2001) Ventilation Control and Fire Protection of Commercial Cooking Equipment

NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION (NAIMA)

NAIMA AH115	(2001) Fibrous Glass Duct Construction Standards

SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA HVAC Duct Const Stds	(1995; Addenda Nov 1997; 6th Printing 2001) HVAC Duct Construction Standards - Metal and Flexible
SMACNA Industry Practice	(1975; 8th Printing 1997) Accepted Industry Practice for Industrial Duct Construction
SMACNA Install Fire Damp HVAC	(1992; 2th Printing 1996) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
SMACNA Leakage Test Manual	(1985; 6th Printing 1997) HVAC Air Duct Leakage Test Manual

UNDERWRITERS LABORATORIES (UL)

UL 94	(1996; Rev thru May 2001) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 181	(1996; Rev thru Dec 1998) Factory-Made Air Ducts and Air Connectors
UL 214	(1997; Rev thru Aug 2001) Tests for Flame-Propagation of Fabrics and Films
UL 555	(1999; Rev thru Jan 2002) Fire Dampers
UL 586	(1996; Rev thru Apr 2000) High-Efficiency, Particulate, Air Filter Units
UL 705	(1994; Rev thru Feb 1999) Power Ventilators
UL 723	(1996; Rev thru Sep 2001) Test for Surface Burning

Characteristics of Building Materials

UL 900	(1994; Rev thru Oct 1999) Air Filter Units
UL 1995	(1995; Rev thru Aug 1999) Heating and Cooling Equipment
UL Bld Mat Dir	(1999) Building Materials Directory
UL Elec Const Dir	(2001) Electrical Construction Equipment Directory
UL Fire Resist Dir	(2001) Fire Resistance Directory (2 Vol.)

KOREAN INDUSTRIAL STANDARDS (KS)

KS D 3506	(2001) Hot-Dip Zinc-Coated Steel Sheets and Coils
KS D 3562	(1989) Carbon Steel Pipes for Pressure Service
KS D 7016	(1984) Woven Wire Cloth

1.2 COORDINATION OF TRADES

Ductwork, piping offsets, fittings, and accessories shall be furnished as required to provide a complete installation and to eliminate interference with other construction.

1.3 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall either be capped or plugged until installed.

1.4 FIELD MEASUREMENTS

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G
Installation; G

Drawings showing equipment layout, including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of all guides and anchors, the load imposed on each support or anchor, and typical support details. Drawings shall include any information required to demonstrate that the system has been coordinated and will properly function as a unit and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance.

SD-03 Product Data

Components and Equipment; G

Manufacturer's catalog data included with the detail drawings for the following items. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with contract requirements for the following:

a. Piping Components

b. Ductwork Components

c. Air Systems Equipment

d. Air Handling Units

e. Energy Recovery Devices

f. Terminal Units

Test Procedures

Proposed test procedures for piping hydrostatic test, ductwork leak test, and performance tests of systems, at least 2 weeks prior to the start of related testing.

Welding Procedures

A copy of qualified welding procedures, at least 2 weeks prior to the start of welding operations.

Diagrams; G

Proposed diagrams, at least 2 weeks prior to start of related testing. System diagrams that show the layout of equipment, piping, and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

Manufacturer's Experience

Statement demonstrating successful completion of similar services on at least 5 projects of similar size and scope, at least 2 weeks prior to submittal of other items required by this section.

Welded Joints

A list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations.

Performance Tests

Proposed test schedules for hydrostatic test of piping, ductwork leak test, and performance tests, at least 2 weeks prior to the start of related testing.

Field Training

Proposed schedule for field training, at least 2 weeks prior to the start of related training.

SD-06 Test Reports

Performance Tests; G

Testing, Adjusting, and Balancing; G

Test reports for the piping hydrostatic test, ductwork leak test, and performance tests in booklet form, upon completion of testing. Reports shall document phases of tests performed including initial test summary, repairs/adjustments made, and final test results.

SD-07 Certificates

Bolts

Written certification from the bolt manufacturer that the bolts furnished comply with the requirements of this specification. The certification shall include illustrations of product markings, and the number of each type of bolt to be furnished.

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions; G

Six manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Components and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years before bid opening. The 2-year manufacturer's experience shall include applications of components and equipment under similar circumstances and of similar size. The 2 years must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization.

2.2 ASBESTOS PROHIBITION

Asbestos and asbestos-containing products shall not be used.

2.3 NAMEPLATES

Equipment shall have a nameplate installed by the manufacturer that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.4 EQUIPMENT GUARDS AND ACCESS

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded according to OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. Catwalks, operating platforms, ladders, and guardrails shall be provided where shown and shall be constructed according to Section 05500 MISCELLANEOUS METAL.

2.5 PIPING COMPONENTS

Piping components shall be as specified in Section 15181 CHILLED, CONDENSER, OR DUAL SERVICE WATER PIPING.

2.6 ELECTRICAL WORK

Electrical motor-driven equipment specified shall be provided complete with motor, motor starter, and controls. Unless otherwise specified, electric equipment, including wiring and motor efficiencies, shall be according to Section 16415 ELECTRICAL WORK, INTERIOR. Electrical characteristics and enclosure type shall be as shown. Unless otherwise indicated, motors of 745 W (1 hp) and above shall be high efficiency type. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary. Each motor shall be according to NEMA MG 1 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Solid-state variable-speed controllers shall be utilized for motors rated 7.45 kW (10 hp) or less. Adjustable frequency drives shall be used for larger motors.

2.7 CONTROLS

Controls shall be provided as specified in Section 15950 HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS.

2.8 DUCTWORK COMPONENTS

2.8.1 Metal Ductwork

All aspects of metal ductwork construction, including all fittings and components, shall comply with SMACNA HVAC Duct Const Stds unless otherwise specified. Elbows shall be radius type with a centerline radius of 1.5 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes may be used. Static pressure Class 125, 250, and 500 Pa (1/2, 1, and 2 inch w.g.) ductwork shall meet the requirements of Seal Class C. Class 750 through 2500 Pa (3 through 10 inch w.g.) shall meet the requirements of Seal Class A. All ductwork in VAV systems upstream of the VAV boxes shall meet the requirements of Seal Class A.

Sealants shall conform to fire hazard classification specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS and shall be suitable for the range of air distribution and ambient temperatures that it will be exposed to. Pressure sensitive tape shall not be used as a sealant. Spiral lock seam duct, and flat oval shall be made with duct sealant and locked with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA HVAC Duct Const Stds. The sealant shall be applied to the exposed male part of the fitting collar so that the sealer will be on the inside of the joint and fully protected by the metal of the duct fitting. One brush coat of the sealant shall be applied over the outside of the joint to at least 50 mm (2 inch) band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar will not be acceptable. Outdoor air intake ducts and plenums shall be fabricated with watertight soldered or brazed joints and seams.

2.8.1.1 Transitions

Diverging air flow transitions shall be made with each side pitched out a maximum of 15 degrees, for an included angle of 30 degrees. Transitions for converging air flow shall be made with each side pitched in a maximum of 30 degrees, for an included angle of 60 degrees, or shall be as indicated. Factory-fabricated reducing fittings for systems using round duct sections when formed to the shape of the ASME short flow nozzle, need not comply with the maximum angles specified.

2.8.1.2 Metallic Flexible Duct

Metallic type duct shall be single-ply galvanized steel, Type 316 stainless steel, or two-ply aluminum, self supporting to 2.4 m (8 foot) spans. Duct shall be of corrugated/interlocked, folded and knurled type seam construction, bendable without damage through 180 degrees with a throat radius equal to 0.5 duct diameter. Duct shall conform to UL 181 and shall be rated for positive or negative working pressure of 3.75 kPa (15 inches water gauge) at 177 degrees C (350 degrees F) when duct is aluminum, and 343 degrees C (650 degrees F) when duct is galvanized steel or stainless steel.

2.8.1.3 Insulated Nonmetallic Flexible Duct Runouts

Flexible duct runouts shall be used only where indicated. Runout length shall be as shown on the drawings, but shall in no case exceed 3 m (10 feet). Runouts shall be preinsulated, factory fabricated, and shall comply with NFPA 90A and UL 181. Either field or factory applied vapor barrier shall be provided. Where coil induction or high velocity units are supplied with vertical air inlets, a streamlined and vaned and mitered elbow transition piece shall be provided for connection to the flexible duct or hose. The last elbow to these units, other than the vertical air inlet type, shall be a die-stamped elbow and not a flexible connector. Insulated flexible connectors may be used as runouts. The insulated material and vapor barrier shall conform to the requirements of Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation material surface shall not be exposed to the air stream.

2.8.1.4 General Service Duct Connectors

A flexible duct connector approximately 150 mm (6 inches) in width shall be provided where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, the flexible material shall be secured by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, the flexible material locked to metal collars shall be installed using normal duct construction methods. The composite connector system shall comply with UL 214 and be classified as "flame-retarded fabrics" in UL Bld Mat Dir.

2.8.1.5 High Temperature Service Duct Connections

Material shall be approximately 2.38 mm (3/32 inch) thick, 1.2 to 1.36 kg per square meter (35 to 40-ounce per square yard) weight, plain weave fibrous glass cloth with, nickel/chrome wire reinforcement for service in excess of 650 degrees (C1200 degrees F).

2.8.2 Fibrous Glass Ductwork

Fibrous glass ductwork may be provided in lieu of sheet metal ductwork except that fibrous glass ductwork will not be allowed in fan and equipment rooms, where subject to traffic or weather damage, for outside air intakes, for risers of more than two stories, in kitchen or fume exhaust ducts, to convey solids or corrosive gases, in concrete, for burial below grade, as casings or housings, or in systems used for life support systems. Fibrous glass ductwork, including all components, shall be fabricated according to NAIMA AH115 where the velocity and the static pressure are within its scope. Where the velocity or static pressure exceeds these limits, the ductwork manufacturer shall certify that the ductwork is intended for the velocities and pressures to be encountered, and that the proposed installation meets all performance criteria specified herein for metal ductwork. Fibrous glass ductwork shall have the thermal equivalent of the insulation specified for metal ductwork in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Field or factory fabricated fibrous glass ductwork shall conform to UL 181, Class 1. Duct wall penetrations, transverse joints and longitudinal seams shall be sealed as instructed by the manufacturer by one of the methods prescribed by NAIMA AH115, where applicable, except that pressure sensitive tape shall not be used as a sealant. All items necessary for a complete installation shall be provided as specified for sheet metal duct systems.

2.8.3 Ductwork Accessories

2.8.3.1 Duct Access Doors

Access doors shall be provided in ductwork and plenums where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system, and unless otherwise shown, shall conform to SMACNA HVAC Duct Const Stds. Access doors shall be provided upstream and downstream of air flow measuring primaries and heating and cooling coils. Doors shall be minimum 375 x 450 mm (15 x 18 inches), unless otherwise shown. Where duct size will not accommodate this size door, the doors shall be made as large as practicable. Doors 600 x 600 mm (24 x 24 inches) or larger shall be provided with fasteners operable from both sides. Doors in insulated ducts shall be the insulated type.

2.8.3.2 Fire Dampers

Fire dampers shall be 1.5 hour fire rated unless otherwise indicated. Fire dampers shall conform to the requirements of NFPA 90A and UL 555. The Contractor shall perform the fire damper test as outlined in NFPA 90A. A pressure relief damper shall be provided upstream of the fire damper. If the ductwork connected to the fire damper is to be insulated then this pressure relief damper shall be factory insulated. Fire dampers shall be automatic operating type and shall have a dynamic rating suitable for the maximum air velocity and pressure differential to which it will be subjected. Fire dampers shall be approved for the specific application, and shall be installed according to their listing. Fire dampers shall be equipped with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, will not impair the operation of the damper. Sleeves or frames shall be equipped with perimeter mounting angles attached on both sides of the wall or floor opening. Ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies shall be constructed in conformance with UL Fire Resist Dir. Fire dampers shall be curtain type with damper blades out of the air stream, single blade type, or multi-blade type. Dampers shall not reduce the duct or the air transfer opening cross-sectional area. Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness. Unless otherwise indicated, the installation details given in SMACNA Install Fire Damp HVAC and in manufacturer's instructions for fire dampers shall be followed. Acceptance testing of fire dampers shall be performed per paragraph Fire Damper Acceptance Test and NFPA 90A.

2.8.3.3 Splitters and Manual Balancing Dampers

Splitters and manual balancing dampers shall be furnished with accessible operating mechanisms. Where operators occur in finished portions of the building, operators shall be chromium plated with all exposed edges rounded. Splitters shall be operated by quadrant operators or 5 mm (3/16 inch) rod brought through the side of the duct with locking setscrew and bushing. Two rods are required on splitters over 200 mm (8 inches). Manual volume control dampers shall be operated by locking-type quadrant operators. Dampers and splitters shall be 2 gauges heavier than the duct in which installed. Unless otherwise indicated, multileaf dampers shall be opposed blade type with maximum blade width of 300 mm (12 inches). Access doors or panels shall be provided for all concealed damper operators and locking setscrews. Unless otherwise indicated, the locking-type quadrant operators for dampers, when installed on ducts to be thermally insulated, shall be provided with stand-off mounting brackets, bases, or adapters to provide clearance between the duct surface and the operator not less than the thickness of the insulation. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer. Volume dampers shall be provided where indicated.

2.8.3.4 Air Deflectors and Branch Connections

Air deflectors shall be provided at duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections may be used in lieu of deflectors or extractors for branch connections. All air deflectors, except those installed in 90 degree elbows, shall be provided with an approved means of adjustment. Adjustment shall be made from easily accessible means inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, external adjustments shall be provided with stand-off mounting brackets, integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Air deflectors shall be factory-fabricated units consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Air deflectors shall be factory or field assembled. Blade air deflectors, also called blade air extractors, shall be approved factory fabricated units consisting of equalizing grid and adjustable blade and lock. Adjustment shall be easily made from the face of the diffuser or by position adjustment and lock external to the duct. Stand-off brackets shall be provided on insulated ducts and are described herein. Fixed air deflectors, also called turning vanes, shall be provided in 90 degree elbows.

2.8.4 Duct Sleeves, Framed Prepared Openings, Closure Collars

2.8.4.1 Duct Sleeves

Duct sleeves shall be provided for round ducts 375 mm (15 inches) in diameter or less passing through floors, walls, ceilings, or roof, and installed during construction of the floor, wall, ceiling, or roof. Round ducts larger than 375 mm (15 inches) in diameter and square, rectangular, and oval ducts passing through floors, walls, ceilings, or roof shall be installed through framed prepared openings. The Contractor shall be responsible for the proper size and location of sleeves and prepared openings. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Framed prepared openings shall be fabricated from 1.0 mm (20 gauge) 20 gauge galvanized steel, unless otherwise indicated. Where sleeves are installed in bearing walls or partitions, black steel pipe, KS D 3562, Schedule 20 shall be used. Sleeve shall provide 25 mm (1 inch) clearance between the duct and the sleeve or 25 mm (1 inch) clearance between the insulation and the sleeve for insulated ducts.

2.8.4.2 Framed Prepared Openings

Openings shall have 25 mm (1 inch) clearance between the duct and the opening or 25 mm (1 inch) clearance between the insulation and the opening for insulated ducts.

2.8.4.3 Closure Collars

Collars shall be fabricated of galvanized sheet metal not less than 100 mm (4 inches) wide, unless otherwise indicated, and shall be installed on exposed ducts on each side of walls or floors where sleeves or prepared openings are provided. Collars shall be installed tight against surfaces. Collars shall fit snugly around the duct or insulation. Sharp edges of the collar around insulated duct shall be ground smooth to preclude tearing or puncturing the insulation covering or vapor barrier. Collars for round ducts 375 mm (15 inches) in diameter or less shall be fabricated from 1.0 mm (20 gauge) galvanized steel. Collars for round ducts larger than 375 mm (15 inches) and square, and rectangular ducts shall be fabricated from 1.3 mm (18 gauge) galvanized steel. Collars shall be installed with fasteners on maximum 150 mm (6 inch) centers, except that not less than 4 fasteners shall be used.

2.8.5 Plenums and Casings for Field-Fabricated Units

2.8.5.1 Plenum and Casings

Plenums and casings shall be fabricated and erected as shown in SMACNA HVAC Duct Const Stds, as applicable. Unless otherwise indicated, system casing shall be constructed of not less than 1.6 mm (16 gauge) galvanized sheet steel. Cooling coil drain pans with 25 mm (1 inch) threaded outlet shall be provided to collect condensation from the cooling coils. Drain pans shall be fabricated of not lighter than 1.6 mm (16 gauge) steel, galvanized after fabrication or of 1.3 mm (18 gauge) corrosion-resisting sheet steel conforming to ASTM A 167 or KS D 3698, Type 304, welded and stiffened. Drain pans exposed to the atmosphere shall be thermally insulated to prevent condensation. Insulation shall be coated with a flame resistant waterproofing material. Separate drain pans shall be provided for each vertical coil section, and a separate drain line shall be provided for each pan. Pans shall be generously sized to ensure capture of entrained moisture on the downstream-air side of the coil. Openings in the casing, such as for piping connections, shall be sealed and covered to prevent air leakage. Water seal for the drain shall provide at least 500 Pa (2 inch) water gauge greater than the maximum negative pressure in the coil space.

2.8.5.2 Casing

Casings shall be terminated at the curb line and anchored by the use of galvanized angle iron sealed and bolted to the curb, as indicated in SMACNA HVAC Duct Const Stds.

2.8.5.3 Access Doors

Access doors shall be provided in each section of the casing. Door frames shall be welded in place, and each door shall be neoprene gasketed, hinged with minimum of two brass hinges, and fastened with a minimum of two brass tension fasteners operable from inside and outside of the casing. Where possible, doors shall be 900 x 450 mm (36 x 18 inches) located 450 mm (18 inches) above the floor. Where the space available will not accommodate doors of this size, doors as large as the space will accommodate shall be provided. Doors shall swing so that fan suction or pressure holds door in closed position, and shall be airtight. A push-button station to stop the supply fan shall be located inside the casing where indicated.

2.8.5.4 Factory-Fabricated Insulated Sheet Metal Panels

Factory-fabricated components may be used for field-assembled units, provided all requirements specified for field-fabricated plenums and casings are met. Panels shall be of modular design, pretested for structural strength, thermal control, condensation control, and acoustical control. Panel joints shall be sealed and insulated access doors shall be provided and gasketed to prevent air leakage. Panel construction shall be not less than 1.0 mm (20 gauge) galvanized sheet steel and shall be assembled with fasteners treated against corrosion. Standard length panels shall deflect not more than 13 mm (1/2 inch) under operation. Details of construction, including joint sealing, not specifically covered shall be as indicated in SMACNA HVAC Duct Const Stds. The plenums and casings shall be constructed to withstand the specified internal pressure of the air systems.

2.8.5.5 Duct Liner

Unless otherwise specified, duct liner shall conform to ASTM C 1071, Type I or II.

2.8.6 Sound Attenuation Equipment

a. Systems With Total Pressure Above 1 kPa (4 Inches Water Gauge):

Sound attenuators shall be provided on the discharge duct of each fan operating at a total pressure above 1 kPa (4 inch water gauge), and, when indicated, at the intake of each fan system. Sound attenuators shall be provided elsewhere as indicated. The sound attenuators shall be factory fabricated and shall be tested by an independent laboratory for sound and performance characteristics. Net sound reduction shall be as indicated. Maximum permissible pressure drop shall not exceed 157 Pa (0.63 inch water gauge). Traps shall be constructed to be airtight when operating under an internal static pressure of 2.5 kPa (10 inch water gauge). Air-side surface shall be capable of withstanding air velocity of 50 m/s (10,000 fpm). The Contractor shall certify that the sound reduction values specified will be obtained after the equipment is installed in the system and coordinated with the sound information of the system fan to be provided. Sound absorbing material shall conform to ASTM C 1071, Type I or II. Sound absorbing material shall meet the fire hazard rating requirements for insulation specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. A duct transition section shall be provided for connection to ductwork. Factory fabricated double-walled internally insulated spiral lock seam and round duct and fittings designed for high pressure air system may be provided in lieu of factory fabricated sound attenuators, and shall comply with requirements specified for factory fabricated sound attenuators. The double-walled duct and fittings shall be constructed of an outer metal pressure shell of zinc-coated steel sheet, 25 mm 1 inch thick acoustical blanket insulation, and an internal perforated zinc-coated metal liner. Sufficient length of run shall be provided to obtain the noise reduction coefficient specified. The Contractor shall certify that the sound reduction value specified will be obtained within the length of duct run provided. The outer sheet metal of the double-walled duct shall have welded, or spiral lock, seams to prevent water vapor penetration. The outer sheet of the duct and fittings shall conform to the metal thickness of high pressure spiral and round ducts and fittings shown in SMACNA HVAC Duct Const Stds. The acoustical insulation shall have a thermal conductivity "k" of not more than 0.0389 W/m-K (0.27 Btu/inch/square foot/hour/degree F) at 24 degrees C (75 degrees F) mean temperature. The internal perforated zinc-coated metal liner shall be not less than 0.7 mm (24 gauge) 24 gauge with perforations not larger than 6.35 mm (1/4 inch) in diameter providing a net open area not less than 10 percent of the surface.

b. System With Total Pressure of 1000 Pa (4 Inch Water Gauge) and Lower:

Sound attenuators shall be provided only where indicated, or in lieu of lined ducts. Factory fabricated sound attenuators shall be constructed of galvanized steel sheets. Outer casing shall be not less than 0.85 mm (22 gauge). Acoustical fill shall be fibrous glass. Net sound reduction shall be as indicated. Values shall be obtained on a test unit not less than 600 by 600 mm (24 by 24 inches) outside dimensions made by a certified nationally recognized independent acoustical laboratory. Air flow capacity shall be as indicated or required. Pressure drop through the attenuator shall not exceed the value indicated, or shall not be in excess of 15 percent of the total external static pressure of the air handling system, whichever is less. Sound attenuators shall be acoustically tested with metal duct inlet and outlet sections while under the rated air flow conditions. Noise reduction data shall include the effects of flanking paths and vibration transmission. Sound attenuators shall be constructed to be airtight when operating at the internal static pressure indicated or specified for the duct system, but in no case less than 500 Pa (2 inch water gauge).

c. Acoustical Duct Liner:

Acoustical duct lining shall be fibrous glass designed exclusively for lining ductwork and shall conform to the requirements of ASTM C 1071, Type I and II. Liner composition may be uniform density, graduated density, or dual density, as standard with the manufacturer. Lining shall be coated, not less than 25 mm (1 inch thick). Where acoustical duct liner is used, liner or combination of liner and insulation applied to the exterior of the ductwork shall be the thermal equivalent of the insulation specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Duct sizes shown shall be increased to compensate for the thickness of the lining used. In lieu of sheet metal duct with field-applied acoustical lining, acoustically equivalent lengths of fibrous glass duct or factory fabricated double-walled internally insulated duct with perforated liner may be provided. Net insertion loss value, static pressure drop, and air flow velocity capacity data shall be certified by a nationally recognized independent acoustical laboratory.

2.8.7 Diffusers, Registers, and Grilles

Units shall be factory-fabricated of steel, corrosion-resistant steel, or aluminum and shall distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 0.25 m/s (50 fpm) in occupied zone, or dead spots anywhere in the conditioned area. Outlets for diffusion, spread, throw, and noise level shall be as required for specified performance. Performance shall be certified according to ASHRAE 70. Inlets and outlets shall be sound rated and certified according to ASHRAE 70. Sound power level shall be as indicated. Diffusers and registers shall be provided with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device will be acceptable. Volume dampers shall be opposed blade type for all diffusers and registers, except linear slot diffusers. Linear slot diffusers shall be provided with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 2 m 7 feet above the floor, they shall be protected by a grille or screen according to NFPA 90A.

2.8.7.1 Diffusers

Diffuser types shall be as indicated. Ceiling mounted units shall be furnished with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Diffusers shall be provided with air deflectors of the type indicated. Air handling troffers or combination light and ceiling diffusers shall conform to the requirements of UL Elec Const Dir for the interchangeable use as cooled or heated air supply diffusers or return air units. Ceiling mounted units shall be installed with rims tight against ceiling. Sponge rubber gaskets shall be provided between ceiling and surface mounted diffusers for air leakage control. Suitable trim shall be provided for flush mounted diffusers. Duct collar connecting the duct to diffuser shall be airtight and shall not interfere with volume controller. Return or exhaust units shall be similar to supply diffusers.

2.8.7.2 Registers and Grilles

Units shall be four-way directional-control type, except that return and exhaust registers may be fixed horizontal or vertical louver type similar in appearance to the supply register face. Registers shall be provided with sponge-rubber gasket between flanges and wall or ceiling. Wall supply registers shall be installed at least 150 mm (6 inches) below the ceiling unless otherwise indicated. Return and exhaust registers shall be located 150 mm (6 inches) above the floor unless otherwise indicated. Four-way directional control may be achieved by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Grilles shall be as specified for registers, without volume control damper.

2.8.8 Louvers

Louvers for installation in exterior walls which are associated with the air supply and distribution system shall be as specified in Section 07600 SHEET METALWORK, GENERAL.

2.8.9 Air Vents, Penthouses, and Goosenecks

Air vents, penthouses, and goosenecks shall be fabricated from galvanized steel or aluminum sheets with galvanized or aluminum structural shapes. Sheet metal thickness, reinforcement, and fabrication shall conform to SMACNA HVAC Duct Const Stds. Louver blades shall be accurately fitted and secured to frames. Edges of louver blades shall be folded or beaded for rigidity and baffled to exclude driving rain. Air vents, penthouses, and goosenecks shall be provided with bird screen.

2.8.10 Bird Screens and Frames

Bird screens shall conform to ASTM E 437 or KS D 7016, No. 2 mesh, aluminum or stainless steel. Aluminum screens shall be rated "medium-light". Stainless steel screens shall be rated "light". Frames shall be removable type, or stainless steel or extruded aluminum.

2.8.11 Radon Exhaust Ductwork

Radon exhaust ductwork installed in or beneath slabs shall be fabricated from Schedule 40 PVC pipe that conforms to ASTM D 1785. Fittings shall conform to ASTM D 2466. Solvent cement used to make joints shall conform to ASTM D 2564. Otherwise radon exhaust ductwork shall be metal as specified herein.

2.9 AIR SYSTEMS EQUIPMENT

2.9.1 Fans

Fans shall be tested and rated according to AMCA 210. Fans may be connected to the motors either directly or indirectly with V-belt drive. V-belt drives shall be designed for not less than 150 percent of the connected driving capacity. Motor sheaves shall be variable pitch for 11 kW (15 hp) and below and fixed pitch as defined by ARI Guideline D. Variable pitch sheaves shall be selected to drive the fan at a speed which will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, a replaceable sheave shall be provided when needed to achieve system air balance. Motors for V-belt drives shall be provided with adjustable rails or bases. Removable metal guards shall be provided for all exposed V-belt drives, and speed-test openings shall be provided at the center of all rotating shafts. Fans shall be provided with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Fan and motor assemblies shall be provided with vibration-isolation supports or mountings as indicated. Vibration-isolation units shall be standard products with published loading ratings. Each fan shall be selected to produce the capacity required at the fan static pressure indicated. Sound power level shall be as indicated. The sound power level values shall be obtained according to AMCA 300. Standard AMCA arrangement, rotation, and discharge shall be as indicated.

2.9.1.1 Centrifugal Fans

Centrifugal fans shall be fully enclosed, single-width single-inlet, or double-width double-inlet, AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Impeller wheels shall be rigidly constructed, accurately balanced both statically and dynamically. Fan blades may be forward curved or backward-inclined airfoil design in wheel sizes up to 750 mm (30 inches). Fan blades for wheels over 750 mm (30 inches) in diameter shall be backward-inclined airfoil design. Fan wheels over 900 mm (36 inches) in diameter shall have overhung pulleys and a bearing on each side of the wheel. Fan wheels 900 mm (36 inches) or less in diameter may have one or more extra long bearings between the fan wheel and the drive. Bearings shall be sleeve type, self-aligning and self-oiling with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Grease fittings shall be connected to tubing and serviceable from a single accessible point. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Fan shafts shall be steel, accurately finished, and shall be provided with key seats and keys for impeller hubs and fan pulleys. Each fan outlet shall be of ample proportions and shall be designed for the attachment of angles and bolts for attaching flexible connections. Motors, unless otherwise indicated, shall not exceed 1800 rpm and shall have open, dripproof, totally enclosed, or explosion-proof enclosures as indicated or requied. Motor starters shall be manual, magnetic, across-the-line, or reduced-voltage-start type with general-purpose, weather-resistant, or watertight enclosure as indicated or required. Remote manual switch with pilot indicating light shall be provided where indicated.

2.9.1.2 In-Line Centrifugal Fans

In-line fans shall have centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Fans shall be mounted in a welded tubular casing. Air shall enter and leave the fan axially. Inlets shall be streamlined with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Fan bearings and drive shafts shall be enclosed and isolated from the air stream. Fan bearings shall be sealed against dust and dirt and shall be permanently lubricated, and shall be precision self aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Motors shall have open, dripproof, totally enclosed, or explosion-proof enclosure as indicated. Motor starters shall be manual or magnetic across-the-line with general-purpose, weather-resistant, explosion-proof enclosures as indicated or required. Remote manual switch with pilot indicating light shall be provided where indicated.

2.9.1.3 Axial Flow Fans

Axial flow fans shall be complete with drive components and belt guard, and shall have a steel housing, cast fan wheel, cast or welded steel diffusers, fan shaft, bearings, and mounting frame as a factory-assembled unit. Fan wheels shall have radially projecting blades of airfoil cross section and shall be dynamically balanced and keyed to the fan shaft. Fan bearings and drive shafts shall be enclosed and isolated from the air stream. Fan bearings shall be sealed against dust and dirt, shall be permanently lubricated or with accessible grease fittings, and shall be precision self-aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours of operation as defined by ABMA 9 and ABMA 11. Fan inlets shall be provided with an aerodynamically shaped bell and an inlet cone. Diffuser or straightening vanes shall be provided at the fan discharge to minimize turbulence and provide smooth discharge air flow. Fan unit shall be provided with inlet and outlet flanges, inlet screen, duct equalizer section, and manual or automatic operation adjustable inlet vanes as indicated. Unless otherwise indicated, motors shall not exceed 1800 rpm and shall have open, dripproof, totally enclosed, or explosion-proof enclosure as indicated. Motor starters shall be manual or magnetic across-the-line with general-purpose, weather-resistant, explosion-proof enclosures as indicated or required. Remote manual switch with pilot indicating light shall be provided where indicated.

2.9.1.4 Panel Type Power Wall Ventilators

Fans shall be propeller type, assembled on a reinforced metal panel with venturi opening spun into panel. Fans with wheels less than 600 mm (24 inches) in diameter shall be direct or V-belt driven and fans with wheels 600 mm (24 inches) diameter and larger shall be V-belt drive type. Fans shall be furnished with wall mounting collar. Lubricated bearings shall be provided. Fans shall be fitted with wheel and motor side metal or wire guards which have a corrosion-resistant finish. Motor enclosure shall be dripproof, totally enclosed fan cooled, or explosion-proof type as indicated or required. Gravity or Motor operated backdraft dampers shall be provided where indicated.

2.9.1.5 Centrifugal Type Power Wall Ventilators

Fans shall be direct or V-belt driven centrifugal type with backward inclined, non-overloading wheel. Motor housing shall be removable and weatherproof. Unit housing shall be designed for sealing to building surface and for discharge and condensate drippage away from building surface. Housing shall be constructed of heavy gauge aluminum. Unit shall be fitted with an aluminum or plated steel wire discharge bird screen, anodized aluminum or stainless steel wall grille, manufacturer's standard gravity or motor-operated damper, an airtight and liquid-tight metallic wall sleeve. Motor enclosure shall be totally enclosed fan cooled, dripproof, or explosion-proof type. Lubricated bearings shall be provided.

2.9.1.6 Centrifugal Type Power Roof Ventilators

Fans shall be direct or V-belt driven with backward inclined, non-overloading wheel. Motor compartment housing shall be hinged or removable and weatherproof, constructed of heavy gauge aluminum. Fans shall be provided with birdscreen, disconnect switch, gravity or motorized dampers, sound curb, roof curb, and extended base. Motors enclosure shall be dripproof or explosion-proof type as indicated or required. Grease-laden kitchen exhaust fans shall be centrifugal type according to UL 705 and fitted with V-belt drive, round hood, and windband upblast discharge configuration, integral residue trough and collection device, motor and power transmission components located in outside positively air ventilated compartment. Lubricated bearings shall be provided.

2.9.1.7 Propeller Type Power Roof Ventilators

Fans shall be direct or V-belt driven. Fan housing shall be hinged or removable weathertight, fitted with framed rectangular base constructed of aluminum or galvanized steel. Motors shall be totally enclosed fan cooled or explosion-proof type as indicated or required. Motors shall be provided with nonfusible, horsepower rated, manual disconnect mount on unit. Fans shall be provided with gravity or motor operated dampers, birdscreen, sound curb, roof curb. Lubricated bearings shall be provided.

2.9.1.8 Air-Curtain Fans

Air curtains shall be provided with a weatherproof housing constructed of high impact plastic or minimum 1.3 mm (18 gauge) rigid welded steel. Fan wheels shall be backward curved, non-overloading, centrifugal type and accurately balanced statically and dynamically. Motors shall have totally enclosed fan cooled enclosures. Motor starters shall be remote manual type with weather-resistant enclosure actuated when the doorway served is open. The air curtains shall attain the air velocities specified within 2 seconds following activation. Air intake and discharge openings shall be protected by bird screens. Air curtain unit or a multiple unit installation shall be at least as wide as the opening to be protected. The air discharge openings shall be so designed and equipped as to permit outward adjustment of the discharge air. Adjustment and installation placement shall be according to the manufacturer's written recommendation. Directional controls on air curtains for service windows shall be designed to be easily cleanable or readily removable. Air curtains shall be designed to prevent the adjustment of the air velocities specified. The interior surfaces of the air curtain units shall be accessible for cleaning. Certified test data indicating that the fan will provide the air velocities required when fan is mounted as indicated shall be furnished. Air curtains designed as fly fans shall be provided where indicated. Air curtains designed for use in service entranceways shall develop an air curtain not less than 75 mm (3 inches) thick at the discharge nozzle. The air velocity shall be not less than 8 m/s (1600 fpm) across the entire entryway when measured 900 mm (3 feet) above the floor. Air curtains designed for use on customer entranceways shall develop an air curtain not less than 200 mm (8 inches) thick at the discharge opening. The velocity shall be not less than 3 m/s (600 fpm) across the entire entryway when measured 900 mm (3 feet) above the floor. Recirculating type air curtains shall be equipped with readily removable filters, or the filters shall be designed for in-position cleaning. The air capture compartment shall be readily accessible and easily cleanable or designed for in-position cleaning. Air curtains designed for use on service windows shall develop an air curtain not less than 200 mm (8 inches) thick at the discharge opening. The air velocity shall be not less than 3 m/s (600 fpm) across the entire opening of the service window measured 900 mm (3 feet) below the air discharge opening.

2.9.1.9 Ceiling Exhaust Fans

Suspended cabinet-type ceiling exhaust fans shall be centrifugal type, direct-driven. Fans shall have acoustically insulated housing. Integral backdraft damper shall be chatter-proof. The integral face grille shall be of egg-crate design or louver design. Fan motors shall be mounted on vibration isolators. Unit shall be provided with mounting flange for hanging unit from above. Fans shall be U.L. listed.

2.9.2 Coils

Coils shall be fin-and-tube type constructed of seamless copper tubes and aluminum fins mechanically bonded or soldered to the tubes. Copper tube wall thickness shall be a minimum of 0.6096 mm (0.024 inches). Aluminum fins shall be 0.19 mm (0.0075 inch) minimum thickness. Casing and tube support sheets shall be not lighter than 1.6 mm (16 gauge) galvanized steel, formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. Each coil shall be tested at the factory under water at not less than 2.76 MPa (400 psi) air pressure and shall be suitable for 1.38 MPa (200 psi) working pressure. Coils shall be mounted for counterflow service. Coils shall be rated and certified according to ARI 410.

2.9.2.1 Direct-Expansion Coils

Direct-expansion coils shall be suitable for the refrigerant involved. Suction headers shall be seamless copper tubing or seamless or resistance welded steel tube with copper connections. Supply headers shall consist of a distributor which shall distribute the refrigerant through seamless copper tubing equally to all circuits in the coil. Tubes shall be circuited to ensure minimum pressure drop and maximum heat transfer. Circuiting shall permit refrigerant flow from inlet to suction outlet without causing oil slugging or restricting refrigerant flow in coil. Each coil to be field installed shall be completely dehydrated and sealed at the factory upon completion of pressure tests.

2.9.2.2 Water Coils

Water coils shall be installed with a pitch of not less than 10 mm per meter (1/8 inch per foot) of the tube length toward the drain end. Headers shall be constructed of cast iron, welded steel or copper. Each coil shall be provided with a plugged vent and drain connection extending through the unit casing.

2.9.2.3 Steam Heating Coils

Steam coils shall be constructed of cast semisteel, welded steel or copper headers, and copper tubes. Headers shall be constructed of cast iron, welded steel or copper. Fin tube and header section shall float within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Each coil shall be provided with a field or factory installed vacuum breaker. Coils shall be single-tube type with tubes not less than 12 mm (1/2 inch) outside diameter, except for steam preheat coils. Supply headers shall distribute steam evenly to all tubes at the indicated steam pressure. Coils shall be factory tested to ensure that, when supplied with a uniform face velocity, temperature across the leaving side will be uniform with a maximum variation of no more than 5 percent.

2.9.2.4 Steam Preheat (Nonfreeze) Coils

Steam (nonfreeze) coils shall be steam-distribution-tube type with condensing tubes not less than 25 mm (1 inch) outside diameter for tube lengths 1.5 m (60 inches) and over and 12 mm (1/2 inch) outside diameter for tube lengths under 1.5 m (60 inches). Headers shall be constructed of cast iron, welded steel, or copper. Distribution tubes shall be not less than 15 mm (5/8 inch) outside diameter for tube lengths 1.5 m (60 inches) and over and 10 mm (3/8 inch) outside diameter for tube lengths under 1.5 m (60 inches) with orifices to discharge steam to condensing tubes. Distribution tubes shall be installed concentric inside of condensing tubes and shall be held securely in alignment. Maximum length of a single coil shall be limited to 3.66 m (144 inches). Coils shall be factory tested to ensure that, when supplied with a uniform face velocity, temperature across the leaving side will be uniform with a maximum variation of no more than 5 percent.

2.9.3 Air Filters

Air filters shall be listed according to requirements of UL 900, except high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method shall be as listed under the Label Service and shall meet the requirements of UL 586.

2.9.3.1 Extended Surface Pleated Panel Filters

Filters shall be 50 mm (2 inch) depth, sectional, disposable type of the size indicated and shall have an average efficiency of 25 to 30 percent when tested according to ASHRAE 52.1. Initial resistance at 2.54 m/s (500 feet per minute) shall not exceed 9 mm (0.36 inches) water gauge. Filters shall be UL Class 2. Media shall be nonwoven cotton and synthetic fiber mat. A wire support grid bonded to the media shall be attached to a moisture resistant fiberboard frame. All four edges of the filter media shall be bonded to the inside of the frame to prevent air bypass and increase rigidity.

2.9.3.2 Extended Surface Nonsupported Pocket Filters

Filters shall be 750 mm (30 inch) depth, sectional, replaceable dry media type of the size indicated and shall have an average efficiency of 80 to 85 percent when tested according to ASHRAE 52.1. Initial resistance at 2.54 m/s (500 feet per minute) shall not exceed 11 mm (0.45 inches) water gauge. Filters shall be UL Class 1. Media shall be fibrous glass, supported in the air stream by a wire or non-woven synthetic backing and secured to a galvanized steel metal header. Pockets shall not sag or flap at anticipated air flows. Each filter shall be installed with an extended surface pleated panel filter as a prefilter in a factory preassembled, side access housing or a factory-made sectional frame bank, as indicated.

2.9.3.3 Cartridge Type Filters

Filters shall be 305 mm (12 inch) depth, sectional, replaceable dry media type of the size indicated and shall have an average efficiency of 80 to 85 percent when tested according to ASHRAE 52.1. Initial resistance at 2.54 m/s (500 feet per minute) shall not exceed 14 mm (0.56 inches), water gauge. Filters shall be UL class 1. Media shall be pleated microglass paper media with corrugated aluminum separators, sealed inside the filter cell to form a totally rigid filter assembly. Fluctuations in filter face velocity or turbulent airflow will have no effect on filter integrity or performance. Each filter shall be installed with an extended surface pleated media panel filter as a prefilter in a factory preassembled side access housing, or a factory-made sectional frame bank, as indicated.

2.9.3.4 Sectional Cleanable Filters

Cleanable filters shall conform to ASTM F 872, and shall be 25 or 50 mm (1 or 2 inches) thick as indicated. Viscous adhesive shall be provided in 20 liter (5 gallon) containers in sufficient quantity for 12 cleaning operations and not less than one liter one quart for each filter section. One washing and charging tank shall be provided for every 100 filter sections or fraction thereof. Each washing and charging unit shall consist of a tank and single or double drain rack mounted on legs. Drain rack shall be provided with dividers and partitions to properly support the filters in the draining position. Initial pressure drop for clean filters shall not exceed the applicable values listed in ASTM F 872.

2.9.3.5 Replaceable Media Filters

Replaceable media filters shall be the dry-media or viscous adhesive type, of the size required to suit the application. Filtering media shall be not less than 50 mm (2 inches) thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Pad shall be enclosed in a holding frame of not less than 1.6 mm (16 gauge) galvanized steel, and equipped with quick-opening mechanism for changing filter media. The air flow capacity of the filter shall be based on net filter face velocity not exceeding 1.5 m/s (300 feet per minute), with initial resistance of 32 Pa (0.13 inches water gauge). Average efficiency shall be not less than 80 percent when tested according to ASHRAE 52.1.

2.9.3.6 Automatic Renewable Media Filters

Automatic, renewable media filters shall consist of a horizontal or vertical traveling curtain of adhesive-coated bonded fibrous glass supplied in convenient roll form. Operation and maintenance requirements of the filter shall not require water supply, sewer connections, adhesive reservoir, or sprinkler equipment. Basic frame shall be fabricated of not less than 2 mm (14 gauge) galvanized steel. Filters shall be sectional design with each section of each filter fully factory assembled, requiring no field assembly other than setting in place next to any adjacent sections and the installation of media in roll form. Each filter shall be complete with initial loading of filter media drive motor adequate to handle the number of sections involved, and painted steel or stainless steel control box containing a warning light to indicate media runout, a runout switch, and a Hand-Off-Auto selector switch. Media feed across the filter face shall be in full-face increments or increments automatically controlled as determined by filter pressure differential, time interval control, time interval control with pressure override, or photo electric control to provide substantially constant operating resistance to airflow and varying not more than plus or minus 10 percent. Media shall be rolled or enclosed in such a way that collected particulates will not re-entrain. Rolls of clean media, no less than 19.8 m 65 feet long, shall be rerolled on disposable spools in the rewind section of the filter after the media has accumulated its design dirt load. Rewind section shall be equipped with a compression panel to tightly rewind used media for ease of handling. Media shall be of continuous, bonded fibrous glass material, shall be UL Class 2, and shall not compress more than 6 mm (1/4 inch) when subjected to air flow at 2.54 m/s (500 fpm). Media shall be factory charged with an odorless and flame retardant adhesive which shall not flow while in storage nor when subjected to temperatures up to 79.4 degrees C (175 degrees F). Media shall be supported on both the leaving and entering air faces. The initial resistance of the clean media shall not exceed 45 Pa (0.18 inch water gauge) at its rated velocity of 2.54 m/s (500 fpm). Control shall be set so that the resistance to air flow is between 100 and 125 Pa (0.40 and 0.50 inch water gauge) unless otherwise indicated. Dust holding capacity under these operating conditions, when operating at a steady state with an upper operating resistance of 125 Pa (0.50 inch water gauge), shall be at least 592 (55) grams of ASHRAE Standard Test Dust per square meter (foot) of media area, when tested according to the dynamic testing provisions of ASHRAE 52.1. Average arrestance under these conditions shall be 80 percent. When used in conjunction with factory fabricated air handling units, the horizontal type automatic renewable media filters shall be dimensionally compatible with the connecting air handling units. Horizontal type filter housings shall have all exposed surfaces factory insulated internally with 25 mm (1 inch), 24 kg per cubic meter (1-1/2 pound) density neoprene coated fibrous glass with thermal conductivity not greater than 0.04 W/m-K (0.27 Btu/hour/degree F/square foot/inch of thickness. Access doors for horizontal filters shall be of double wall construction as specified for plenums and casings for field-fabricated units in paragraph DUCTWORK COMPONENTS.

2.9.3.7 Electrostatic Filters

Electrostatic filters shall be the combination dry agglomerator/extended surface nonsupported pocket filter or the combination dry agglomerator/automatic renewable media (roll) type, as indicated (except as modified). Each dry agglomerator electrostatic air filter shall be supplied with the correct quantity of fully housed power packs and equipped with silicon rectifiers, manual reset circuit breakers, low voltage safety cutout, relays for field wiring to remote indication of primary and secondary voltages, and lamps mounted in the cover to indicate these functions locally. Power pack enclosure shall be equipped with external mounting brackets, and low and high voltage terminals shall be fully exposed with access cover removed for ease of installation. Interlock safety switches shall be furnished for each access door and access panel which permits access to either side of the filter, so that the filter will be de-energized in the event that a door or panel is opened. Ozone generation within the filter shall not exceed five parts per one hundred million parts of air. High voltage insulators shall be located outside the moving air stream or on the clean air side of the unit and shall be serviceable. Ionizer wire supports shall be fully exposed and ionizer wires shall be furnished precut to size and with formed loops at each end to facilitate ionizer wire replacement. Agglomerator cell plates shall allow proper air stream entrainment of agglomerates and prevent excessive residual dust build-up. Cells shall be open at the top and bottom to prevent accumulation of agglomerates which settle by gravity. Where the dry agglomerator electrostatic filter is indicated to be the automatic renewable media type, the storage section shall utilize a horizontal or vertical travelling curtain of adhesive-coated bonded fibrous glass for dry agglomerator storage section service and supplied in 19.8 m (65 foot) lengths in convenient roll form. Storage section construction and roll media characteristics shall otherwise be as specified for automatic renewable media filters. Initial air flow resistance of the dry agglomerator/renewable media combination, after installation of clean media, shall not exceed 62.3 Pa (0.25 inch water gauge) at 2.54 m/s (500 fpm) face velocity. Minimum atmospheric air dust spot efficiency of the combination shall be not less than 90 percent when tested according to ASHRAE 52.1 at an average operating resistance of 125 Pa (0.50 inch water gauge). Where the dry agglomerator electrostatic filter is indicated to be of the extended surface nonsupported pocket filter type, the storage section shall be as specified for extended surface non-supported pocket filters, with sectional holding frames or side access housings as indicated. Initial air flow resistance of the dry agglomerator/extended surface nonsupported pocket filter section combination, after installation of clean filters, shall not exceed 162 Pa (0.65 inch water gauge) at 2.54 m/s (500 fpm) face velocity. Minimum atmospheric air dust spot efficiency of the combination shall be not less than 95 percent when tested according to ASHRAE 52.1. Front access filters shall be furnished with full height air distribution baffles and upper and lower mounting tracks to permit the baffles to be moved for agglomerator cell inspection and service. When used in conjunction with factory fabricated air handling units, side access housings shall be supplied which have dimensional compatibility.

2.9.3.8 High-Efficiency Particulate Air (HEPA) Filters

HEPA filters shall meet the requirements of IEST RP-CC-001.3 and shall be individually tested and certified to have an efficiency of not less than 99.97 percent. Initial resistance shall not exceed as indicated. Filters shall be constructed by pleating a continuous sheet of filter medium into closely spaced pleats separated by corrugated aluminum or mineral-fiber inserts, strips of filter medium, or by honeycomb construction of the pleated filter medium. Interlocking, dovetailed, molded neoprene rubber gaskets of 5-10 durometer shall be cemented to the perimeter of the upstream or downstream face of the filter cell sides. Adhesive sealer shall be of self-extinguishing rubber-base type or other materials conforming to fire hazard classification specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Filter cell sides shall be 18 mm (3/4 inch) thick exterior grade fire-retardant plywood, cadmium plated steel, or galvanized steel assembled in a rigid manner. Overall cell side dimensions shall be correct to 2.0 mm (1/16 inch), and squareness shall be maintained to within 3.2 mm (1/8 inch). Each holding frame shall use spring loaded fasteners or other devices to seal the filter tightly within it and to prevent any bypass leakage around the filter during its installed life. Air capacity and the nominal depth of the filter shall be as indicated. Each filter shall be installed in a factory preassembled side access housing or a factory-made sectional supporting frame as indicated. Prefilters of the type, construction and efficiency indicated, shall be provided.

2.9.3.9 Range and Griddle Hood Service

Filter shall be sectional, permanent, washable, all metallic media type, nominal 50 mm (2 inches) thick, with suitable metal frames, designed for extraction of grease from grease-laden air. Clean filter static pressure drop shall not exceed as indicated.

2.9.3.10 Holding Frames

Frames shall be fabricated from not lighter than 1.6 mm (16 gauge) sheet steel with rust-inhibitor coating. Each holding frame shall be equipped with suitable filter holding devices. Holding frame seats shall be gasketed. All joints shall be airtight.

2.9.3.11 Filter Gauges

Filter gauges shall be dial type, diaphragm actuated draft and shall be provided for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Gauges shall be at least 98 mm (3-7/8 inches) in diameter, shall have white dials with black figures, and shall be graduated in 0.0025 kPa mm (0.01 inch of water), and shall have a minimum range of 0.25 kPa (1 inch of water) beyond the specified final resistance for the filter bank on which each gauge is applied. Each gauge shall incorporate a screw operated zero adjustment and shall be furnished complete with two static pressure tips with integral compression fittings, two molded plastic vent valves, two 1.5 m (5 foot) minimum lengths of 6.35 mm (1/4 inch) diameter aluminum or vinyl tubing, and all hardware and accessories for gauge mounting.

2.10 AIR HANDLING UNITS

2.9.1 Field-Fabricated Air Handling Units

Built-up units shall be as specified in paragraph DUCTWORK COMPONENTS. Fans, coils spray-coil dehumidifiers, and air filters shall be as specified in paragraph AIR SYSTEMS EQUIPMENT for types indicated.

2.10.2 Factory-Fabricated Air Handling Units

Units shall be single-zone draw-through type, single-zone blow-through type, multizone blow-through type, blow-through double-deck type, or blow-through triple deck type as indicated. Units shall include fans, coils, airtight insulated casing, prefilters, secondary filter sections and diffuser sections where indicated, air blender adjustable V-belt drives, belt guards for externally mounted motors, access sections where indicated, mixing box or combination sectional filter-mixing box, pan or drysteam or spray type humidifier, vibration-isolators, and appurtenances required for specified operation. Vibration isolators shall be as indicated. Each air handling unit shall have physical dimensions suitable to fit space allotted to the unit and shall have the capacity indicated. Air handling unit shall have published ratings based on tests performed according to ARI 430.

2.10.2.1 Casings

Casing sections shall be single or 50 mm (2 inch) double wall type as indicated, constructed of a minimum 1.3 mm (18 gauge) galvanized steel, or 1.3 mm (18 gauge) steel outer casing protected with a corrosion resistant paint finish according to paragraph FACTORY PAINTING. Inner casing of double-wall units shall be minimum 1.0 mm (20 gauge) solid galvanized steel. Casing shall be designed and constructed with an integral insulated structural steel frame such that exterior panels are non-load bearing. Exterior panels shall be individually removable. Removal shall not affect the structural integrity of the unit. Casings shall be provided with inspection doors, access sections, and access doors as indicated. Inspection and access doors shall be insulated, fully gasketed, double-wall type, of a minimum 1.3 mm (18 gauge) outer and 1.0 mm (20 gauge) inner panels. Doors shall be rigid and provided with heavy duty hinges and latches. Inspection doors shall be a minimum 300 mm (12 inches) wide by 300 mm (12 inches) high. Access doors shall be minimum 600 mm (24 inches) wide and shall be the full height of the unit casing or a minimum of 1800 mm (6 foot), whichever is less. Access Sections shall be according to paragraph AIR HANDLING UNITS. Drain pan shall be double-wall insulated type constructed of 1.4 mm (16 gauge) galvanized steel or stainless steel, pitched to the drain connection. Drain pans shall be constructed water tight, treated to prevent corrosion, and designed for positive condensate drainage. When 2 or more cooling coils are used, with one stacked above the other, condensate from the upper coils shall not flow across the face of lower coils. Intermediate drain pans or condensate collection channels and downspouts shall be provided, as required to carry condensate to the unit drain pan out of the air stream and without moisture carryover. Drain pan shall be constructed so that the pan may be visually inspected easily including underneath the coil without removal of the coil and so that the pan may be physically cleaned completely and easily underneath the coil without removal of the coil. Casing insulation shall conform to NFPA 90A. Single-wall casing sections handling conditioned air shall be insulated with not less than 25 mm (1 inch) thick, 24 kg per cubic meter (1-1/2 pound density) coated fibrous glass material having a thermal conductivity not greater than 0.033 W/m-K (0.23 Btu/hr-sf-F). Double-wall casing sections handling conditioned air shall be insulated with not less than 50 mm (2 inches) of the same insulation specified for single-wall casings. Foil-faced insulation shall not be an acceptable substitute for use with double wall casing. Double wall insulation must be completely sealed by inner and outer panels. Factory applied fibrous glass insulation shall conform to ASTM C 1071, except that the minimum thickness and density requirements do not apply, and shall meet the requirements of NFPA 90A. Air handling unit casing insulation shall be uniform over the entire casing. Foil-faced insulation shall not be an acceptable substitute for use on double-wall access doors, inspections doors, and casing sections. Duct liner material, coating, and adhesive shall conform to fire-hazard requirements specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Exposed insulation edges and joints where insulation panels are butted together shall be protected with a metal nosing strip or shall be coated to conform to meet erosion resistance requirements of ASTM C 1071. A latched and hinged inspection door, shall be provided in the fan and coil sections. Additional inspection doors, access doors and access sections shall be provided where indicated or required.

2.10.2.2 Heating and Cooling Coils

Coils shall be provided as specified in paragraph AIR SYSTEMS EQUIPMENT, for types indicated.

2.10.2.3 Cooling Coils, Spray Type

Cooling coils shall be of the copper finned direct expansion or water type as specified in paragraph AIR SYSTEMS EQUIPMENT furnished complete with water sprays. All horizontal units and vertical units with coil face velocities of 2.5 m per second (550 fpm) or above, shall be provided with moisture eliminators. Sprays shall have all bronze, brass, or stainless steel centrifugal type nozzles, with removable caps designed and arranged for uniform wetting of the entire coil face area. Nozzles shall be supplied by standard weight galvanized steel piping and a centrifugal type circulating pump furnished as an integral part of the unit. Eliminators shall be not lighter than 0.7 mm (24 gauge) corrosion-resistant steel, removable for maintenance and coil inspection. No water shall carry over into the fan section or supply ducts from the air handling unit provided with or without eliminators.

2.10.2.4 Air Filters

Air filters shall be as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

2.10.2.5 Fans

Fans shall be double-inlet, centrifugal type with each fan in a separate scroll. Fans and shafts shall be dynamically balanced prior to installation into air handling unit, then the entire fan assembly shall be statically and dynamically balanced at the factory after it has been installed in the air handling unit. Fans shall be mounted on steel shafts accurately ground and finished. Fan bearings shall be sealed against dust and dirt and shall be precision self-aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Bearings shall be permanently lubricated or lubricated type with lubrication fittings readily accessible at the drive side of the unit. Bearings shall be supported by structural shapes, or die formed sheet structural members, or support plates securely attached to the unit casing. Bearings may not be fastened directly to the unit sheet metal casing. Fans and scrolls shall be furnished with coating indicated. Fans shall be driven by a unit-mounted or a floor-mounted motor connected to fans by V-belt drive complete with belt guard for externally mounted motors. Belt guards shall be the three sided enclosed type with solid or expanded metal face. Belt drives shall be designed for not less than a 1.3 service factor based on motor nameplate rating. Motor sheaves shall be variable pitch for 20 kW (25 hp) and below and fixed pitch above 20 kW (25 hp) as defined by ARI Guideline D. Where fixed sheaves are required, variable pitch sheaves may be used during air balance, but shall be replaced with an appropriate fixed sheave after air balance is completed. Variable pitch sheaves shall be selected to drive the fan at a speed that will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. Motors for V-belt drives shall be provided with adjustable bases. Fan motors shall have open, splashproof, or totally enclosed enclosures as indicated or required. Motor starters shall be manual or magnetic across-the-line or reduced-voltage-start type with general-purpose, weather-resistant, or watertight enclosure as indicated or required. Unit fan or fans shall be selected to produce the required capacity at the fan static pressure. Sound power level shall be as indicated. The sound power level values shall be obtained according to AMCA 300, ASHRAE 68, or ARI 260.

2.10.2.6 Access Sections and Filter/Mixing Boxes

Access sections shall be provided where indicated and shall be furnished with access doors as shown. Access sections and filter/mixing boxes shall be constructed in a manner identical to the remainder of the unit casing and shall be equipped with access doors. Mixing boxes shall be designed to minimize air stratification and to promote thorough mixing of the air streams.

2.10.2.7 Diffuser Sections

Diffuser sections shall be furnished between the discharge of all housed supply fans and cooling coils of blow-through single zone units and filter sections of those units with high efficiency filters located immediately downstream of the air handling unit fan section. Diffuser sections shall be fabricated by the unit manufacturer in a manner identical to the remainder of the unit casing, shall be designed to be airtight under positive static pressures up to 2 kPa (8 inches water gauge) and shall have an access door on each side for inspection purposes. Diffuser section shall contain a perforated diffusion plate, fabricated of galvanized steel, Type 316 stainless steel, aluminum, or steel treated for corrosion with manufacturer's standard corrosion-resisting finish. The diffusion plate shall be designed to accomplish uniform air flow across the down-stream coil and filters while reducing the higher fan outlet velocity to within plus or minus 5 percent of the required face velocity of the downstream component.

2.10.2.8 Dampers

Dampers shall be as specified in paragraph CONTROLS.

2.11 TERMINAL UNITS

2.11.1 Room Fan-Coil Units

Base units shall include galvanized coil casing, coil assembly drain pan, valve and piping package, outside air damper, wall intake box, air filter, fans, motor, fan drive, and motor switch, plus an enclosure for cabinet models and casing for concealed models. Leveling devices integral with the unit shall be provided for vertical type units. Sound power levels shall be as indicated. Sound power level data or values for these units shall be obtained according to test procedures based on ARI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles. Values obtained for the standard cabinet models will be acceptable for concealed models without separate test provided there is no variation between models as to the coil configuration, blowers, motor speeds, or relative arrangement of parts. Automatic valves and controls shall be provided as specified in paragraph CONTROLS. Each unit shall be fastened securely to the building structure. Capacity of the units shall be as indicated. Room fan-coil units shall be certified as complying with ARI 440, and shall meet the requirements of UL 1995.

2.11.1.1 Enclosures

Enclosures shall be fabricated of not lighter than 1.3 mm (18 gauge) steel, reinforced and braced. Front panels of enclosures shall be removable and provided with 7 mm (1/4 inch) closed cell insulation or 13 mm (1/2 inch) thick dual density foil faced fibrous glass insulation. The exposed side shall be high density, erosion-proof material suitable for use in air streams with velocities up to 23 m/s (4,500 fpm). Discharge grille shall be adjustable or fixed and shall be of such design as to properly distribute air throughout the conditioned space. Plastic discharge and return grilles are acceptable provided the plastic material is certified by the manufacturer to be classified as flame resistant according to UL 94 and the material shall comply with the heat deflection criteria specified in UL 1995. Ferrous metal surfaces shall be galvanized or factory finished with corrosion resistant enamel. Access doors or removable panels shall be provided for piping and control compartments. Duct discharge collar shall be provided for concealed models. Enclosures shall have easy access for filter replacement.

2.11.1.2 Fans

Fans shall be galvanized steel or aluminum, multiblade, centrifugal type. In lieu of metal, fans and scrolls may be non-metallic materials of suitably reinforced compounds. Fans shall be dynamically and statically balanced. Surfaces shall be smooth. Assemblies shall be accessible for maintenance. Disassembly and re-assembly shall be by means of mechanical fastening devices and not by epoxies or cements.

2.11.1.3 Coils

Coils shall be constructed of not less than 10 mm (3/8 inch) outside diameter seamless copper tubing, with copper or aluminum fins mechanically bonded or soldered to the tubes. Coils shall be provided with not less than 12 mm (1/2 inch) outside diameter flare or sweat connectors, accessory piping package with thermal connections suitable for connection to the type of control valve supplied, and manual air vent. Coils shall be tested hydrostatically at 2000 kPa (300 psi) or under water at 1700 kPa (250 psi) air pressure and suitable for 1400 kPa (200 psi) working pressure. Provisions shall be made for coil removal.

2.11.1.4 Drain Pans Drain and drip pans shall be sized and located to collect all water condensed on and dripping from any item within the unit enclosure or casing. Condensate drain pans shall be designed for self-drainage to preclude the buildup of microbial slime and shall be thermally insulated to prevent condensation and constructed of not lighter than 0.9 mm (21 gauge) type 304 stainless steel or noncorrosive ABS plastic. Insulation shall have a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and shall be of a waterproof type or coated with a waterproofing material. Drain pans shall be pitched to drain and shall be designed so as to allow no standing water. Minimum 20 mm (3/4 inch) NPT or 15 mm (5/8 inch) OD drain connection shall be provided in drain pan. Auxiliary drain pans to catch drips from control and piping packages, eliminating insulation of the packages, may be plastic; if metal, the auxiliary pans shall comply with the requirements specified above. Insulation at control and piping connections thereto shall extend 25 mm (1 inch) minimum over the auxiliary drain pan.

2.11.1.5 Manually Operated Outside Air Dampers

Manually operated outside air dampers shall be provided according to the arrangement indicated. Dampers shall be parallel airfoil type and of galvanized construction. Blades shall rotate on stainless steel or nylon sleeve bearings.

2.11.1.6 Filters

Filters shall be of the fiberglass disposable type, 25 mm (1 inch) thick, conforming to CID A-A-1419. Filters in each unit shall be removable without the use of tools.

2.11.1.7 Motors

Motors shall be of the permanent split-capacitor type with built-in thermal overload protection, directly connected to unit fans. Motor switch shall be two or three speeds and off, manually operated, and shall be mounted on an identified plate inside the unit below or behind an access door or adjacent to the room thermostat as indicated. In lieu of the above fan speed control, a solid-state variable-speed controller having a minimum speed reduction of 50 percent may be provided. Motors shall have permanently-lubricated or oilable sleeve-type or combination ball and sleeve-type bearings with vibration isolating mountings suitable for continuous duty. Motor power consumption, shown in watts, at the fan operating speed selected to meet the specified capacity shall not exceed the following values:

Free Discharge Motors

Unit Capacity,L/S (cfm)	Maximum Power Consumption (Watts)	
	115V	230V
94 (200)	70	110
142 (300)	100	110
189 (400)	170	150
283 (600)	180	210
378 (800)	240	240
472 (1000)	310	250
566 (1200)	440	400

High Static Motors

Unit Capacity, L/S (cfm)	Maximum Power Consumption (Watts)
94 (200)	145
142 (300)	145
189 (400)	210
283 (600)	320
378 (800)	320

472 (1000)	530
566 (1200)	530

2.11.2 Coil Induction Units

Base unit shall include air plenums, air-discharge nozzles, air discharge grilles, recirculation grilles, water coil assembly, valve and piping package, condensate drain pan, and adjustable air-balancing dampers, plus an enclosure for cabinet models and casing for concealed models. Each unit shall be selected to produce not less than the capacity indicated without exceeding the indicated static pressure. The sound power level shall be as indicated. Sound power level data or values for these units shall be based on tests conducted according to ANSI S12.32. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles. The values obtained for the standard cabinet models will be acceptable for concealed models without separate tests, provided there is no variation between models as to coil configuration, air discharge nozzles, air balancing dampers, or relative arrangement of parts. Automatic valves and controls shall be provided as specified in paragraph CONTROLS. Each unit shall be secured to the building structure. Capacity of the units shall be as indicated. The induction units shall conform to the provisions of ARI 445.

2.11.2.1 Enclosures

Enclosures shall be fabricated of not lighter than 1.2 mm (18 gauge) steel, reinforced and braced. Front panel of enclosure shall be removable and insulated when required acoustically and to prevent condensation. Discharge grilles shall be adjustable or integrally stamped and shall properly distribute air throughout the conditioned space. Plastic discharge and return grilles are not acceptable. Access doors shall be provided for all piping and control compartments.

2.11.2.2 Air Plenums

Plenums shall be fabricated of galvanized steel with interior acoustically baffled and lined with sound absorbing material that will attenuate the sound power from the primary air supply to the room. Heat-resistant nozzles shall be integral with or attached airtight to the plenum. Where coil induction units are supplied with vertical runouts, a streamlined, vaned, mitered elbow transition piece shall be provided for connection between the unit and ductwork. An adjustable air-balancing damper shall be provided in each unit.

2.11.2.3 Coils

Coils shall be constructed of not less than 10 mm (3/8 inch) outside diameter seamless copper tubing, with copper or aluminum fins, mechanically bonded or soldered to the tubes. Coil connections shall be provided with not less than 13 mm (1/2 inch) outside diameter flare or sweat connectors, accessory piping package with terminal connections suitable for connection to the type of control valve supplied, and manual air vent. Coils shall be tested hydrostatically at 2000 kPa (300 psi) or under water at 1700 kPa (250 psi) air pressure and shall be suitable for 1400 kPa (200 psi) working pressure.

2.11.2.4 Screens

Lint screens or throwaway filters shall be provided for each unit and shall be easily accessible.

2.11.2.5 Drain Pan

Drain and drip pans shall be sized and located to collect condensed water dripping from any item within the unit enclosure. Drain pans shall be constructed of not lighter than 0.9 mm (21 gauge) steel, galvanized after fabrication, and thermally insulated to prevent condensation. Insulation shall have a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and be of a waterproof type or coated with a waterproofing material. In lieu of the above, drain pans may be constructed of die-formed 0.8 mm (22 gauge) steel, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 0.9 mm (21 gauge) steel material or of die-formed 0.9 mm (21 gauge) type 304 stainless steel insulated as specified above. Drain pans shall be pitched to drain. Drain connection shall be provided when a condensate drain system is indicated. Connection shall be minimum 20 mm (3/4 inch) NPT or 15 mm (5/8 inch) OD.

2.11.3 Variable Air Volume (VAV) and Dual Duct Terminal Units

VAV and dual duct terminal units shall be the type, size, and capacity shown and shall be mounted in the ceiling or wall cavity and shall be suitable for single or dual duct system applications. Actuators and controls shall be as specified in paragraph CONTROLS. Unit enclosures shall be constructed of galvanized steel not lighter than 0.85 mm (22 gauge) or aluminum sheet not lighter than 1.3 mm (18 gauge). Single or multiple discharge outlets shall be provided as required. Units with flow limiters are not acceptable. Unit air volume shall be factory preset and readily field adjustable without special tools. Reheat coils shall be provided as indicated. A flow chart shall be attached to each unit. Acoustic performance of the terminal units shall be based upon units tested according to ARI 880. Sound power level shall be as indicated. Discharge sound power shall be shown for minimum and 375 Pa (1-1/2 inches) water gauge inlet static pressure. Acoustical lining shall be according to NFPA 90A.

2.11.3.1 Constant Volume, Single Duct

Constant volume, single duct, terminal units shall contain within the casing, a mechanical or pneumatic constant volume regulator. Volume regulators shall control air delivery to within plus or minus 5 percent of specified air flow subjected to inlet pressure from 200 to 1500 Pa (3/4 to 6 inch water gauge).

2.11.3.2 Variable Volume, Single Duct

Variable volume, single duct, terminal units shall be provided with a calibrated air volume sensing device, air valve or damper, actuator, and accessory relays. Units shall control air volume to within plus or minus 5 percent of each air set point volume as determined by the thermostat with variations in inlet pressures from 200 to 1500 Pa (3/4 to 6 inch water gauge). Internal resistance of units shall not exceed 100 Pa (0.4 inch water gauge) at maximum flow range. External differential pressure taps separate from the control pressure taps shall be provided for air flow measurement with a 0 to 250 Pa (0 to 1 inch water gauge range). Unit volume controller shall be normally open or closed upon loss of pneumatic pressure.

2.11.3.3 Variable Volume, Single Duct, Fan-Powered

Variable volume, single duct, fan-powered terminal units shall be provided with a calibrated air volume sensing device, air valve or damper, actuator, fan and motor, and accessory relays. Units shall control primary air volume to within plus or minus 5 percent of each air set point as determined by the thermostat with variations in inlet pressure from 200 to 1500 Pa (3/4 to 6 inch water gauge). Unit fan shall be centrifugal, direct-driven, double-inlet type with forward curved blades. Fan motor shall be either single speed with speed controller or three-speed, permanently lubricated, permanent split-capacitor type. Fan/motor assembly shall be isolated from the casing to minimize vibration transmission. Fan control shall be factory furnished and wired into the unit control system. A factory-mounted pressure switch shall be furnished to operate the unit fan whenever pressure exists at the unit primary air inlet or when the control system fan operates.

2.11.3.4 Dual Duct Terminal Units

Dual duct terminal units shall be provided with hot and cold inlet valve or dampers. Dampers shall be controlled in unison by single or dual actuators. Actuator shall be as specified in paragraph CONTROLS. Unit shall control delivered air volumes within plus or minus 5 percent with inlet air variations from 250 to 2000 Pa (1 to 8 inch water gauge) in either duct. Mixing baffles shall be included with the unit casing. Cabinet and closed duct leakage shall not exceed 2 percent of maximum rated air volume. Internal resistance of units shall not exceed as indicated at maximum flow range.

2.11.3.5 Ceiling Induction Unit

Ceiling induction unit shall be provided with a calibrated primary air volume sensing device, primary air valve, induced air damper, and insulated induction tube. Unit shall be arranged to induce air from the ceiling plenum to maintain a maximum total flow circulated to the conditioned space. Primary air shall be varied upon demand of the room thermostat. Upon a demand for maximum cooling, the unit shall deliver 100 percent primary air and, at minimum cooling, shall deliver 25 percent primary air. Terminal unit shall be capable of closing to full shut off without additional actuators or linkage changes. Terminals shall reset primary air volume within plus or minus 5 percent determined by the thermostat regardless of upstream changes in the static pressure. Minimum inlet static pressure shall not exceed 250 Pa (1 inch water gauge), including a maximum of 75 Pa (0.3 inch water gauge) downstream static pressure. External differential pressure taps separate from control pressure taps shall be provided for primary air flow measurement with 0 to 250 Pa (0 to 1 inch water gauge) range.

2.11.3.6 Reheat Units

a. Hot Water Coils: Hot-water coils shall be fin-and-tube type constructed of seamless copper tubes and copper or aluminum fins mechanically bonded or soldered to the tubes. Headers shall be constructed of cast iron, welded steel or copper. Casing and tube support sheets shall be 1.6 mm (16 gauge), galvanized steel, formed to provide structural strength. Tubes shall be correctly circuited for proper water velocity without excessive pressure drop and they shall be drainable where required or indicated. At the factory, each coil shall be tested at not less than 1700 kPa (250 psi) air pressure and shall be suitable for 1400 kPa (200 psi) working pressure. Drainable coils shall be installed in the air handling units with a pitch of not less than 10 mm per m (1/8 inch per foot) of tube length toward the drain end. Coils shall conform to the provisions of ARI 410.

b. Steam Coils: Steam coils shall be constructed of cast semisteel, welded steel, or copper headers, red-brass or copper tubes, and copper or aluminum fins mechanically bonded or soldered to the tubes. Tubes shall be rolled and bushed, brazed or welded into headers. Coil casings and tube support sheets, with collars of ample width, shall be not lighter than 1.6 mm (16 gauge) galvanized steel formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. The fin tube and header section shall float within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Coils shall be factory pressure tested and capable of withstanding 1700 kPa (250 psi) hydrostatic test pressure or 1700 kPa (250 psi) air pressure, and shall be for 1400 kPa (200 psi) steam working pressure. Preheat coils shall be steam-distribution tube type with condensing tubes having not less than 15 mm (5/8 inch) outside diameters. Distribution tubes shall have not less than 10 mm (3/8 inch) outside diameter, with orifices to discharge steam to condensing tubes. Distribution tubes shall be installed concentric inside of condensing tubes and shall be held securely in alignment. The maximum length of a single coil shall be limited to 120 times the diameter of the outside tube. Other heating coils shall be single tube type with not less than 12 mm (1/2 inch) outside diameter. Supply headers shall distribute steam evenly to all tubes at the indicated steam pressure. Coils shall conform to the provisions of ARI 410.

c. Electric Resistance Heaters: Electric resistance heaters shall be of the duct-mounting type consisting of a nickel-chromium resistor mounted on refractory material and a steel or aluminum frame for attachment to ductwork. Electric duct heater shall meet the requirement of Underwriters Laboratories and NFPA 70 and shall be provided with a built-in or surface-mounted high-limit thermostat. Electric duct heaters shall be interlocked electrically so that heaters cannot be energized unless the fan is running.

2.11.4 Unit Ventilators

Unit ventilators shall include an enclosure, galvanized casing or cold-rolled steel casing with corrosion resistant coating, coil assembly, resistance heating coil assembly, valve and piping package, drain pan, air filters, fan assembly, fan drive, motor, motor controller, dampers, and damper operators. Sound power level shall be as indicated. Sound power level data or values for these units shall be obtained according to test procedures based on ARI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles, when handling standard flow for which the unit air capacity is rated. Each unit shall be secured to the building structure. Capacity of the unit ventilators shall be as indicated. Unit ventilators shall be of the year-round classroom type with automatic controls arranged to properly heat, cool, and ventilate the room. Automatic valves and controls shall be provided as specified in paragraph CONTROLS. Sequence of control shall be any one of the standard ANSI cycles specified in paragraph CONTROLS.

2.11.4.1 Enclosures

Enclosures shall be fabricated of not lighter than 1.6 mm (16 gauge) galvanized steel, reinforced and braced, or all welded framework with panels to provide equivalent strength. The casing shall be acoustically and thermally insulated internally with not less than 13 mm (1/2 inch) thick dual density fibrous glass insulation. The exposed side shall be high density, erosion-proof material suitable for use in air streams with velocities up to 246 m/s (4500 fpm). The insulation shall be fastened with waterproof, fire-resistant adhesive. Front panel shall be designed for easy removal by one person. Discharge grilles shall have adjustable grilles or grilles with adjustable vanes and shall properly distribute air throughout the conditioned space. Return grilles shall be removable where front panel does not provide access to interior components. Plastic discharge or return grilles are not acceptable. Removable panels or access doors shall be provided for all piping and control compartments. Fan switch shall be key operated or accessible through a locked access panel. Gaskets shall be provided at the back and bottom of the unit for effective air seal, as required.

2.11.4.2 Electric Resistance Heating Elements

Electric resistance heating elements shall be of the sheathed, finned, tubular type, or of the open resistance type designed for direct exposure to the air stream. Heating element electrical characteristics shall be as indicated. Where fan motor or control voltage is lower than required for the electric resistance heating element, a fused factory mounted and wired transformer shall be provided.

2.11.4.3 Fans

Fans shall be of the galvanized steel or aluminum, multiblade, centrifugal type, dynamically and statically balanced. Fan housings shall be provided with resilient mounted, self-aligning permanently lubricated ball bearings, sleeve bearings, or combination ball and sleeve bearings, capable of not less than 2000 hours of operation on one oiling. Fans shall be direct-connected.

2.11.4.4 Coils

Coils shall be circuited for a maximum water velocity of 2.4 m/s (8 fps) without excessive pressure drop and shall otherwise be as specified for hot water coils in paragraph TERMINAL UNITS.

2.11.4.5 Drain Pans

Drain and drip pans shall be sized and located to collect all condensed water dripping from any item within the unit enclosure. Drain pans shall be constructed of not lighter than 1.2 mm (18 gauge) steel, galvanized after fabrication, and thermally insulated to prevent condensation. Insulation shall be coated with a fire-resistant waterproofing material. In lieu of the above, drain pans may be constructed of die-formed 1.0 mm (20 gauge) steel, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 1.3 mm (18 gauge) steel material, or of die-formed 1.3 mm (18 gauge) type 304 stainless steel insulated as specified above. Drain pans shall be pitched to drain. Drain connection shall be provided when a condensate drain system is indicated. Connection shall be minimum 20 mm (3/4 inch) NDT or 18 mm (5/8 inch) OD.

2.11.4.6 Filters

Fiberglass disposable type, 25 mm (1 inch) thick, conforming to CID A-A-1419, installed upstream of coil.

2.11.4.7 Dampers

An outside air proportioning damper shall be provided on each unit. In addition, a vane shall be provided to prevent excessive outside air from entering unit and to prevent blow-through of outside air through the return air grille under high wind pressures. Where outside air and recirculated air proportioning dampers are provided on the unit, an additional vane will not be required. Face and bypass dampers shall be provided for each unit to ensure constant air volume at all positions of the dampers. Each unit shall be provided with a factory installed control cam assembly, pneumatic motor, or electric motor to operate the face and bypass dampers and outside air damper or outside air and recirculated air dampers in the sequence as specified in paragraph CONTROLS.

2.11.4.8 Motors

Motors shall be of the permanent split-capacitor type with built-in thermal overload protection and automatic reset. Motor shall be mounted on a resilient mounting, isolated from the casing and shall be suitable for operation on electric service available. A manually operated motor switch shall provide for 2 or 3 speeds and off and shall be mounted on an identified plate inside the unit below or behind an access door or adjacent to the room thermostat as indicated. In lieu of speed control, a solid state variable speed controller having minimum speed reduction of 50 percent may be provided.

2.11.4.9 Outside Air Intakes

Outside air intakes shall be the manufacturer's standard design and provided with 13 mm (1/2 inch) mesh bird screen or louvers on 13 mm (1/2 inch) centers.

2.12 ENERGY RECOVERY DEVICES

2.12.1 Rotary Wheel

Unit shall be a factory fabricated and tested assembly for air-to-air energy recovery by transfer of sensible heat from exhaust air to supply air stream. Device performance shall be according to ASHRAE 84. Device shall deliver an energy transfer effectiveness of not less than 70 percent with cross-contamination not in excess of 0.1 percent of exhaust airflow rate at system design differential pressure, including purging sector if provided with wheel. Exchange media shall be chemically inert, moisture-resistant, fire-retardant, laminated, nonmetallic material which complies with NFPA 90A. Exhaust and supply streams shall be isolated by seals which are static, field adjustable, and replaceable. Chain drive mechanisms shall be fitted with ratcheting torque limiter or slip-clutch protective device. Enclosure shall be fabricated from galvanized steel and shall include maintenance access provisions. Recovery control and rotation failure provisions shall be as indicated.

2.12.2 Run-Around-Coil

Assembly shall be factory fabricated and tested air-to-liquid-to-air energy recovery system for transfer of sensible heat from exhaust air to supply air stream. System shall deliver an energy transfer effectiveness not less than that indicated without cross-contamination with maximum energy recovery at minimum life cycle cost. Components shall be computer optimized for capacity, effectiveness, number of coil fins per inch, number of coil rows, flow rate, heat transfer rate as indicated, and frost control. Coils shall conform to paragraph AIR HANDLING UNITS. Related pumps, and piping specialties shall conform to requirements in the US Army Corps of Engineers, Unified Facilities Guide Specifications (UFGS), Section 15652A COLD STORAGE REFRIGERATION SYSTEMS and Section 15556A FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS.

2.12.3 Heat Pipe

Device shall be a factory fabricated, assembled and tested, counterflow arrangement, air-to-air heat exchanger for transfer of sensible heat between exhaust and supply streams. Device shall deliver an energy transfer effectiveness not less than that indicated without cross-contamination. Heat exchanger tube core shall be 15, 18 or 25 mm (1/2, 5/8 or 1 inch) nominal diameter, seamless aluminum or copper tube with extended surfaces, utilizing wrought aluminum Alloy 3003 or Alloy 5052, temper to suit. Maximum fins per unit length and number of tube rows shall be as indicated. Tubes shall be fitted with internal capillary wick, filled with an ASHRAE 15, Group 1 refrigerant working fluid, selected for system design temperature range, and hermetically sealed. Heat exchanger frame shall be constructed of not less than 1.6 mm (16 gauge) galvanized steel and fitted with intermediate tube supports, and flange connections. Tube end-covers and a partition of galvanized steel to separate exhaust and supply air streams without cross-contamination and in required area ratio shall be provided. A drain pan constructed of welded Type 300 series stainless steel shall be provided. Heat recovery regulation shall be provided by system face and bypass dampers and related control system as indicated or interfacing with manufacturer's standard tilt-control mechanism for summer/winter operation, regulating the supply air temperature and frost prevention on weather face of exhaust side at temperature indicated. Coil shall be fitted with pleated flexible connectors.

2.13 FACTORY PAINTING

Units which are not of galvanized construction according to ASTM A 123/A 123M or ASTM A 924/A 924M shall be factory painted with a corrosion resisting paint finish. Internal and external ferrous metal surfaces shall be cleaned, phosphatized and coated with a paint finish which has been tested according to ASTM B 117, ASTM D 1654, and ASTM D 3359. Evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors shall be submitted. Rating of failure at the scribe mark shall be not less than 6, average creepage not greater than 3 mm (1/8 inch). Rating of the inscribed area shall not be less than 10, no failure. On units constructed of galvanized steel which have been welded, exterior surfaces of welds or welds that have burned through from the interior shall receive a final shop docket of zinc-rich protective paint according to ASTM D 520 Type I.

PART 3 EXECUTION

3.1 INSTALLATION

Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.

3.1.1 Piping

Pipe and fitting installation shall conform to the requirements of Section 15181 CHILLED, CONDENSER, OR DUAL SERVICE WATER PIPING.

3.1.2 Condensate Drain Lines

Water seals shall be provided in the condensate drain from all units except room fan-coil units and coil-induction units. The depth of each seal shall be 50 mm (2 inches) plus 0.1 mm for each Pa (the number of inches), measured in water gauge, of the total static pressure rating of the unit to which the drain is connected. Water seals shall be constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Pipe cap or plug cleanouts shall be provided where indicated. Drains indicated to connect to the sanitary waste system shall be connected by an indirect waste fitting. Air conditioner drain lines shall be insulated as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.1.3 Equipment and Installation

Frames and supports shall be provided for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Air handling units shall be floor mounted or ceiling hung, as indicated. The method of anchoring and fastening shall be as detailed. Floor-mounted equipment, unless otherwise indicated, shall be set on not less than 150 mm (6 inch) concrete pads or curbs doweled in place. Concrete foundations for circulating pumps shall be heavy enough to minimize the intensity of the vibrations transmitted to the piping and the surrounding structure, as recommended in writing by the pump manufacturer. In lieu of a concrete pad foundation, a concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. The concrete foundation or concrete pedestal block shall be of a mass not less than three times the weight of the components to be supported. Lines connected to the pump mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.1.4 Access Panels

Access panels shall be provided for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05500 MISCELLANEOUS METALS.

3.1.5 Flexible Connectors

Pre-insulated flexible connectors and flexible duct shall be attached to other components in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the connector or duct manufacturer and shall be provided at the intervals recommended.

3.1.6 Sleeved and Framed Openings

Space between the sleeved or framed opening and the duct or the duct insulation shall be packed as specified in Section 07840 FIRESTOPPING for fire rated penetrations. For non-fire rated penetrations, the space shall be packed as specified in Section 07900 JOINT SEALING.

3.1.7 Metal Ductwork

Installation shall be according to SMACNA HVAC Duct Const Stds unless otherwise indicated. Duct supports for sheet metal ductwork shall be according to SMACNA HVAC Duct Const Stds, unless otherwise specified. Friction beam clamps indicated in SMACNA HVAC Duct Const Stds shall not be used. Risers on high velocity ducts shall be anchored in the center of the vertical run to allow ends of riser to move due to thermal expansion. Supports on the risers shall allow free vertical movement of the duct. Supports shall be attached only to structural framing members and concrete slabs. Supports shall not be anchored to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, suitable intermediate metal framing shall be provided. Where C-clamps are used, retainer clips shall be provided.

3.1.7.1 Underground Ductwork

Underground ductwork shall be PVC plastisol coated galvanized steel with coating on interior and exterior surfaces and watertight joints. Ductwork shall be installed as indicated, according to ACCA Manual 4 and manufacturer's instructions. Maximum burial depth shall be 2 m (6 feet).

3.1.7.2 Radon Exhaust Ductwork

Subslab suction piping shall be perforated where indicated. PVC joints shall be installed as specified in ASTM D 2855.

3.1.7.3 Light Duty Corrosive Exhaust Ductwork

Light duty corrosive exhaust ductwork shall be PVC plastisol coated galvanized steel with PVC coating on interior and exterior surfaces or PVC coating on interior and epoxy wash primer coating on exterior surfaces.

3.1.8 Fibrous Glass Ductwork

Installation shall be according to the manufacturer's written recommendations unless otherwise required in NAIMA AH115. Duct supports for fibrous glass ductwork shall conform to NAIMA AH115. In those cases not covered in NAIMA AH115, the written recommendation of the fibrous duct manufacturer shall be followed.

3.1.9 FRP Ductwork

Fibrous glass reinforced plastic ducting and related structures shall conform to SMACNA Industry Practice. Flanged joints shall be provided where indicated. Crevice-free butt lay-up joints are acceptable where flanged joints are not indicated. When ambient temperatures are lower than 10 degrees C (50 degrees F), joints shall be heat cured by exothermic reaction heat packs.

3.1.10 Kitchen Exhaust Ductwork

3.1.10.1 Ducts Conveying Smoke and Grease Laden Vapors

Ducts conveying smoke and grease laden vapors shall conform to requirements of NFPA 96. Seams, joints, penetrations, and duct-to-hood collar connections shall have a liquid tight continuous external weld. Duct material shall be minimum 1.3 mm (18 gauge), Type 304L or 316L, stainless steel.

3.1.10.2 Exposed Ductwork

Exposed ductwork shall be fabricated from minimum 1.3 mm (18 gauge), Type 304L or 316L, stainless steel with continuously welded joints and seams. Ducts shall be pitched to drain at hoods and low points indicated. Surface finish shall match hoods.

3.1.10.3 Concealed Ducts Conveying Moisture Laden Air

Concealed ducts conveying moisture laden air shall be fabricated from minimum 1.3 mm (18 gauge), Type 300 series, stainless steel. Joints shall be continuously welded, brazed, or soldered to be liquid tight. Duct shall be pitched to drain at points indicated. Transitions to other metals shall be liquid tight, companion angle bolted and gasketed.

3.1.11 Acoustical Duct Lining

Lining shall be applied in cut-to-size pieces attached to the interior of the duct with nonflammable fire resistant adhesive conforming to ASTM C 916, Type I, NFPA 90A, UL 723, and ASTM E 84. Top and bottom pieces shall lap the side pieces and shall be secured with welded pins, adhered clips of metal, nylon, or high impact plastic, and speed washers or welding cup-head pins installed according to SMACNA HVAC Duct Const Stds. Welded pins, cup-head pins, or adhered clips shall not distort the duct, burn through, nor mar the finish or the surface of the duct. Pins and washers shall be flush with the surfaces of the duct liner and all breaks and punctures of the duct liner coating shall be sealed with the nonflammable, fire resistant adhesive. Exposed edges of the liner at the duct ends and at other joints where the lining will be subject to erosion shall be coated with a heavy brush coat of the nonflammable, fire resistant adhesive, to prevent delamination of glass fibers. Duct liner may be applied to flat sheet metal prior to forming duct through the sheet metal brake. Lining at the top and bottom surfaces of the duct shall be additionally secured by welded pins or adhered clips as specified for cut-to-size pieces. Other methods indicated in SMACNA HVAC Duct Const Stds to obtain proper installation of duct liners in sheet metal ducts, including adhesives and fasteners, will be acceptable.

3.1.12 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, temporary dust control protection shall be provided. The distribution system (supply and return) shall be protected with temporary seal-offs at all inlets and outlets at the end of each day's work. Temporary protection shall remain in place until system is ready for startup.

3.1.13 Insulation

Thickness and application of insulation materials for ductwork, piping, and equipment shall be according to Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Outdoor air intake ducts and plenums shall be externally insulated up to the point where the outdoor air reaches the conditioning unit or up to the point where the outdoor air mixes with the outside air stream.

3.1.14 Duct Test Holes

Holes with closures or threaded holes with plugs shall be provided in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Extensions, complete with cap or plug, shall be provided where the ducts are insulated.

3.1.15 Power Roof Ventilator Mounting

Foamed 13 mm (1/2 inch) thick, closed-cell, flexible elastomer insulation shall cover width of roof curb mounting flange. Where wood nailers are used, holes shall be pre-drilled for fasteners.

3.1.16 Power Transmission Components Adjustment

V-belts and sheaves shall be tested for proper alignment and tension prior to operation and after 72 hours of operation at final speed. Belts on drive side shall be uniformly loaded, not bouncing. Alignment of direct driven couplings shall be to within 50 percent of manufacturer's maximum allowable range of misalignment.

3.2 FIELD PAINTING AND IDENTIFICATION SYSTEMS

3.2.1 Identification Tags

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number shall be installed on all valves and dampers. Tags shall be 35 mm (1-3/8 inch) minimum diameter and marking shall be stamped or engraved. Indentations shall be black for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.2.2 Finish Painting and Pipe Color Code Marking

Finish painting of items only primed at the factory, surfaces not specifically noted otherwise, and color code marking for piping shall be as specified in Section 09900 PAINTS AND COATINGS.

3.2.3 Color Coding Scheme for Locating Hidden Utility Components

Scheme shall be provided in buildings having suspended grid ceilings. The color coding scheme shall identify points of access for maintenance and operation of components and equipment that are not visible from the finished space and are accessible from the ceiling grid. The color coding scheme shall consist of a color code board and colored metal disks. Each colored metal disk shall be approximately 12 mm (3/8 inch) diameter and secured to removable ceiling panels with fasteners. Each fastener shall be inserted into the ceiling panel so as to be concealed from view. The fasteners shall be manually removable without the use of tools and shall not separate from the ceiling panels when the panels are dropped from ceiling height. Installation of colored metal disks shall follow completion of the finished surface on which the disks are to be fastened. The color code board shall be approximately 1 m (3 foot) wide, 750 mm (30 inches) high, and 12 mm (1/2 inches) thick. The board shall be made of wood fiberboard and framed under glass or 1.6 mm (1/16 inch) transparent plastic cover. The color code symbols shall be approximately 20 mm (3/4 inch) in diameter and the related lettering in 12 mm (1/2 inch) high capital letters. The color code board shall be mounted where indicated or in the mechanical or equipment room. The color code system shall be as indicated below:

Color	System	Item	Location
[_____]	[_____]	[_____]	[_____]

3.3 PIPING HYDROSTATIC TEST

After cleaning, water piping shall be hydrostatically tested at a pressure equal to 150 percent of the total system operating pressure for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Leaks shall be repaired and piping retested until test is successful. No loss of pressure will be allowed. Leaks shall be repaired by re-welding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before covering or concealing.

3.4 DUCTWORK LEAK TEST

Ductwork leak test shall be performed for the entire air distribution and exhaust system, including fans, coils, filters, etc. designated as static pressure Class 750 Pa (3 inch water gauge) through Class 2500 Pa (10 inch water gauge). Test procedure, apparatus, and report shall conform to SMACNA Leakage Test Mnl. The maximum allowable leakage rate shall not exceed cfm as indicated. Ductwork leak test shall be completed with satisfactory results prior to applying insulation to ductwork exterior.

3.5 DAMPER ACCEPTANCE TEST

All fire dampers and smoke dampers shall be operated under normal operating conditions, prior to the occupancy of a building to determine that they function properly. Fire dampers equipped with fusible links shall be tested by having the fusible link cut in place. Dynamic fire dampers shall be tested with the air handling and distribution system running. All fire dampers shall be reset with the fusible links replaced after acceptance testing. To ensure optimum operation and performance, the damper must be installed so it is square and free from racking.

3.6 TESTING, ADJUSTING, AND BALANCING

Testing, adjusting, and balancing shall be as specified in Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Testing, adjusting, and balancing shall begin only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.7 PERFORMANCE TESTS

After testing, adjusting, and balancing has been completed as specified, each system shall be tested as a whole to see that all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Corrections and adjustments shall be made as necessary to produce the conditions indicated or specified. Capacity tests and general operating tests shall be conducted by an experienced engineer. Tests shall cover a period of not less than 2 days for each system and shall demonstrate that the entire system is functioning according to the specifications. Coincidental chart recordings shall be made at points indicated on the drawings for the duration of the time period and shall record the temperature at space thermostats or space sensors, the humidity at space humidistats or space sensors and the ambient temperature and humidity in a shaded and weather protected area.

3.8 CLEANING AND ADJUSTING

Pipes shall be cleaned free of scale and thoroughly flushed of foreign matter. A temporary bypass shall be provided for water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented. Inside of room fan-coil units, coil-induction units, air terminal units, unit ventilators, ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then shall be vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided prior to startup of all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.9 FIELD TRAINING

The Contractor shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of 24 hours of normal working time and shall start after the system is functionally complete but prior to the performance tests. The field instruction shall cover all of the items contained in the approved Operating and Maintenance Instructions.

SECTION 15950

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 500-D (1997) Laboratory Methods of Testing Dampers for Rating

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 269	(2000) Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM B 88	(1999) Seamless Copper Water Tube
ASTM D 1693	(2000) Environmental Stress-Cracking of Ethylene Plastics
ASTM D 635	(1998) Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position

ASME INTERNATIONAL (ASME)

ASME B16.34	(1997) Valves - Flanged, Threaded, and Welding End
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type Elastic Element
ASME BPVC SEC VIII D1 (1998)	Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 Basic Coverage

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits

ISA - THE INSTRUMENTATION, SYSTEMS AND AUTOMATION SOCIETY (ISA)

ISA S7.0.01	(1996) Quality Standard for Instrument Air

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1997) Enclosures for Electrical Equipment (1000 Volts Maximum) NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
NFPA 70	(1999) National Electrical Code
NFPA 90A	(1999) Installation of Air Conditioning and Ventilating Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 268A	(1998) Smoke Detectors for Duct Application
UL 508	(1999) Industrial Control Equipment
UL 555S	(1999) Safety for Smoke Dampers
UL 916	(1998) Energy Management Equipment

UL 94 (1996; Rev thru Jul 1998) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The fol lowing shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G

Drawings on A1 841 by 594 mm (34 by 22 inch) sheets in the form and arrangement shown. The drawings shall use the same abbreviations, symbols, nomenclature and device identifiers shown. Each control-system element on a drawing shall have a unique identifier as shown. All HVAC control system drawings shall be delivered together as a complete submittal. Drawings shall be submitted for each HVAC system.

a. HVAC control system drawings shall include the following: Sheet One: Drawing index, HVAC control system legend. Sheet Two: Valve schedule, damper schedule. Sheet Three: Compressed air station schematic. Sheet Four: HVAC control system schematic and equipment schedule. Sheet Five: HVAC control system sequence of operation and ladder diagram. Sheet Six: HVAC control panel arrangement, control panel cross-section, and control panel inner door layout. Sheet Seven: HVAC control panel back-panel layout. Sheet Eight: Control loop wiring diagrams. Sheet Nine: Motor starter and relay wiring diagram. Note: Repeat sheets four through nine for each AHU system.

b. An HVAC control system drawing index showing the name and number of the building, military site, State or other similar designation, and Country. The drawing index shall list all HVAC control system drawings, including the drawing number, sheet number, drawing title, and computer filename when used.

c. An HVAC control system legend showing generic symbols and the name of devices shown on the HVAC control system drawings.

d. A valve schedule showing each valve's unique identifier, size, flow coefficient (Cv), pressure drop at specified flow rate, actuator size, close-off pressure data, dimensions, and access and clearance requirements data.

e. A damper schedule showing each damper and actuator's identifier, nominal and actual sizes, orientation of axis and frame, direction of blade rotation, operation rate, locations of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. The damper schedule shall include the maximum leakage rate at the operating static-pressure differential. The damper schedule shall contain actuator selection data supported by calculations of the torque required to move and seal the dampers, access and clearance requirements.

f. An HVAC control system equipment schedule showing the control loop, device unique identifier, device function, setpoint, input range, and additional important parameters (i.e. output range).

g. An HVAC control system sequence of operation.

h. An HVAC control system ladder diagram showing all relays, contacts, pilot lights, switches, fuses and starters connected to the control system.

i. HVAC control panel arrangement drawings showing both side and front views of the panel. The drawing shall show panel and mounting dimensions.

j. HVAC control panel cross-section drawings showing mounting rails and standoffs for devices.

k. HVAC control panel inner door layout drawings showing both front and rear views of the inner door. The drawings shall show device locations, labels, nameplate legends, and fabrication details.

l. HVAC control panel back-panel layout drawings showing device locations, labels, nameplate legends, terminal block layout, fabrication details, and enclosure operating temperature-rise calculations.

m. HVAC control system wiring diagrams showing functional wiring diagrams of the interconnection of conductors and cables to HVAC control panel terminal blocks and to the identified terminals of devices, starters and package equipment. The wiring diagrams shall show all necessary jumpers and ground connections. The wiring diagrams shall show the labels of all conductors. Sources of power required for HVAC control systems and for packaged-equipment control systems shall be identified back to the panel-board circuit breaker number, HVAC system control panel, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not integral to a controller, starter, or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown.

SD-03 Product Data

HVAC Control System; G
Service Organizations; G

Six copies of a list of service organizations qualified to service the HVAC control system. The list shall include the service organization name, address, technical point of contact and telephone number, and contractual point of contact and telephone number.

Equipment Compliance Booklet; G

An HVAC control system equipment compliance booklet (ECB) in indexed booklet form with numbered tabs separating the information on each device. It shall consist of, but not be limited to, data sheets and catalog cuts which document compliance of all devices and components with the specifications. The ECB shall be indexed in alphabetical order by the unique identifiers. Devices and components which do not have unique identifiers shall follow the devices and components with unique identifiers and shall be indexed in alphabetical order according to their functional name. The ECB shall include a bill of materials for each HVAC control system. The bill of materials shall function as the table of contents for the ECB and shall include the device's unique identifier, device function, manufacturer, model/part/catalog number used for ordering, and tab number where the device information is located in the ECB.

Commissioning Procedures; G

a. Six copies of the HVAC control system commissioning procedures, in indexed booklet form, 30 days prior to the scheduled start of commissioning. Commissioning procedures shall be provided for each HVAC control system, and for each type of terminal-unit control system. The commissioning procedures shall reflect the format and language of this specification, and refer to devices by their unique identifiers as shown. The commissioning procedures shall be specific for each HVAC system, and shall give detailed step-by-step procedures for commissioning of the system.

b. Commissioning procedures documenting detailed, product-specific set-up procedures, configuration procedures, adjustment procedures, and calibration procedures for each device. Where the detailed product-specific commissioning procedures are included in manufacturer supplied manuals, reference may be made in the HVAC control system commissioning procedures to the manuals.

c. Commissioning procedures documenting controller configuration checksheets for each controller listing all configuration parameters, dip switch and jumper settings, and initial recommended P, I and D values. The configuration parameters shall be listed in the order in which they appear during the configuration process. Each configuration parameter shall be noted as being: set per specs with no field adjustment required, set per specs but field adjustable, or not applicable.

d. Commissioning procedures showing a time clock configuration checksheet listing all parameters, and switch settings. The parameters shall be listed in the order which they appear during the setup process.

e. An HVAC control system commissioning procedures equipment list that lists the equipment to be used to accomplish commissioning. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Performance Verification Test Procedures; G

Six copies of the HVAC control system performance verification test procedures, in indexed booklet form, 60 days before the Contractor's scheduled test dates. The performance verification test procedures shall refer to the devices by their unique identifiers as shown, shall explain, step-by-step, the actions and expected results that will demonstrate that the HVAC control system performs in accordance with the sequences of operation. An HVAC control system performance verification test equipment list shall be included that lists the equipment to be used during performance verification testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Training Course Requirements; G

Six copies of HVAC control system training course material 30 days prior to the scheduled start of the training course. The training course material shall include the operation manual, maintenance and repair manual, and paper copies of overheads used in the course. An HVAC control system training course, in outline form, with a proposed time schedule. Approval of the planned training schedule shall be obtained from the Government at least 30 days prior to the start of the training.

SD-06 Test Reports

Commissioning Report; G

Six copies of the HVAC control system commissioning report, in indexed booklet form, within 30 days after completion of the system commissioning. The commissioning report shall include data collected during the HVAC control system commissioning and shall follow the format of the commissioning procedures. The commissioning report shall include all controller and time clock checksheets with final values listed for all parameters, setpoints, P, I, D setting constants, calibration data for all devices, and results of adjustments.

Performance Verification Test; G

Six copies of the HVAC control system performance verification test report, in indexed booklet form, within 30 days after completion of the test. The HVAC control system performance verification test report shall include data collected during the HVAC control system performance verification test. The original copies of data gathered during the performance verification test shall be turned over to the Government after Government approval of the test results.

SD-10 Operation and Maintenance Data

Operation Manual; G
Maintenance and Repair Manual; G

Six copies of the HVAC control system operation manual and HVAC control system maintenance and repair manual for each HVAC control system 30 days before the date scheduled for the training course.

1.3 GENERAL REQUIREMENTS

1.3.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

1.3.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, shall arrange such work accordingly, and shall furnish all work necessary to meet such conditions.

1.4 DELIVERY AND STORAGE

Products shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants, within the storage-condition limits published by the equipment manufacturer. Dampers shall be stored so that seal integrity, blade alignment and frame alignment are maintained.

1.5 OPERATION MANUAL

An HVAC control system operation manual for each HVAC control system, in indexed booklet form, shall be provided. The operation manual shall include the HVAC control system sequence of operation, and procedures for the HVAC system start-up, operation and shut-down. The operation manual shall include as-built HVAC control system detail drawings. The operation manual shall include the as-built controller configuration checksheets, the as-built time clock configuration checksheet, the HVAC control system front panel description, the procedures for changing HVAC system controller SECTION 15950A Page 17 setpoints, the procedures for gaining manual control of processes, the time clock manufacturer's manual control of processes, the time clock manufacturer's operation manual, and the controller manufacturer's operation manual.

a. The HVAC control system front panel description shall explain the meaning and use of the lights, switches, gauges, and controller displays located in the front panel. Each light, switch, gauge, and display described shall be numbered and referenced to a drawing of the front panel.

b. The procedures for changing HVAC system controller setpoints shall describe the step-by-step procedures required to change: the process variable setpoints of controllers, the alarm setpoints of controllers, the controller bias settings, and controller setpoint reset schedules.

c. The procedures for gaining manual control of processes shall describe step-by-step procedures required to gain manual control of devices and manually adjust their positions.

1.6 MAINTENANCE AND REPAIR MANUAL

An HVAC control system maintenance and repair manual for each HVAC control system, in indexed booklet form in hardback binders, shall be provided. The maintenance and repair manual shall include the routine maintenance checklist, a recommended repair methods list, a list of recommended maintenance and repair tools, the qualified service organization list, the as-built commissioning procedures and report, the as-built performance verification test procedures and report, and the as-built equipment data booklet (EDB).

a. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all devices listed in the equipment compliance booklet (ECB), the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

b. The recommended repair methods list shall be arranged in a columnar format and shall list all devices in the equipment compliance booklet (ECB) and state the guidance on recommended repair methods, either field repair, factory repair, or whole-item replacement.

c. The as-built equipment data booklet (EDB) shall include the equipment compliance booklet (ECB) and all manufacturer supplied user manuals and information.

d. If the operation manual and the maintenance and repair manual are provided in a common volume, they shall be clearly differentiated and separately indexed.

PART 2 PRODUCTS

2.1 MATERIAL AND EQUIPMENT

Material and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization. The Contractor shall submit a certified list of qualified permanent service organizations and qualifications. These service organizations shall be reasonably convenient to the equipment on a regular and emergency basis during the warranty period.

2.2 GENERAL EQUIPMENT REQUIREMENTS

2.2.1 Electrical and Electronic Devices

All electrical, electronic, and electro-pneumatic devices not located within an HVAC control panel shall have a NEMA Type 1 enclosure in accordance with NEMA 250 unless otherwise shown.

2.2.2 Standard Signals

The output of all analog transmitters and the analog input and output of all single-loop controllers and function modules shall be 4-to-20 mAdc signals. The signal shall originate from current-sourcing devices and shall be received by current-sinking devices.

2.2.3 Ambient Temperature Limits

Ambient Temperature Actuators and transmitters shall operate within temperature limit ratings of 5 to 60 degrees C (40 to 140 degrees F). All panel-mounted instruments shall operate within limit ratings of 2 to 50 degrees C (35 to 120 degrees F) and 10 percent to 95 percent relative humidity, noncondensing. All devices installed outdoors shall operate within limit ratings of minus 40 to plus 65 degrees C (minus 40 to plus 150 degrees F).

2.2.4 Nameplates, Lens Caps, and Tag Nameplates

Nameplates, lens caps, and lens caps bearing legends as shown and tags bearing device-unique identifiers as shown shall have engraved or stamped characters. A plastic or metal tag shall be mechanically attached directly to each device or attached by a metal chain or wire. Each air flow measurement station shall have a tag showing flow rate range for signal output range, duct size, and identifier as shown.

2.2.5 Year 2000 Compliance

All equipment shall be Year 2000 compliant and shall be able to accurately process date/time data (including, but not limited to, calculating, comparing, and sequencing) from, into, and between the twentieth and twenty-first centuries, including leap year calculations, when used in accordance with the product documentation provided by the contractor, provided that all products (e.g. hardware, software, firmware) used in combination with other information technology, shall accurately process date/time data if other information technology properly exchanges date/time data with it.

2.3 WIRING

2.3.1 Terminal Blocks

Terminal blocks shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

2.3.2 Control Wiring for 24-Volt Circuits

Control wiring for 24-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 300-volt service.

2.3.3 Wiring for 120-Volt Circuits

Wiring for 120-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 600-volt service.

2.3.4 Analog Signal Wiring Circuits

Analog signal wiring circuits within control panels shall not be less than 20 AWG and shall be rated for 300-volt service.

2.3.5 Instrumentation Cable

Instrumentation cable shall be 18 AWG, stranded copper, single or multiple-twisted, minimum 51 mm 2 inch lay of twist, 100 percent shielded pairs, and shall have a 300-volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.3.6 Nonconducting Wiring Duct

Nonconducting wiring duct in control panels shall have wiring duct in control panels shall have slotted sides, snap-on duct covers, have slotted sides, snap-on duct covers, fittings for connecting ducts, mounting clips for securing ducts, and wire-retaining clips.

2.3.7 Transformers

Step-down transformers shall be utilized where control equipment operates at lower than line circuit voltage. Transformers, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Transformers shall be sized so that the connected load is 80 percent of the rated capacity or less. Transformers shall conform to UL 508.

2.4 ACTUATORS

Actuators shall be electric or electronic as shown and shall be provided with mounting and connecting hardware. Electric or electronic actuators shall be used for variable air volume (VAV) air terminal units. Actuators shall fail to their spring-return positions on signal or power failure,except that VAV terminal unit actuators may be of the floating type. The actuator stroke shall be limited in the direction of power stroke by an adjustable stop. Actuators shall smoothly open or close the devices to which they are applied and shall have a full stroke response time of 90 seconds or less. Electric actuators shall have an oil-immersed gear train. Electric or electronic actuators operating in series shall have an auxiliary actuator driver. Electric or electronic actuators used in sequencing applications shall have an adjustable operating range and start point. Valve actuators shall be selected to provide a minimum of 125 percent of the motive power necessary to operate the valve over its full range of operation.

2.5 AUTOMATIC CONTROL VALVES

2.5.1 Valve Assembly

Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Unless otherwise stated, valves shall have globe style bodies. Valve bodies shall be designed for not less than 862 kPa (125 psig) working pressure or 150 percent of the system operating pressure, whichever is greater. Valve leakage rating shall be 0.01 percent of rated Cv.

2.5.2 Butterfly-Valve Assembly

Butterfly valves shall be threaded lug type suitable for dead-end service, and for modulation to the fully-closed position, with carbon-steel bodies and noncorrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from minus 29 to plus 120 degrees C (minus 20 to plus 250 degrees F). Valves shall have a manual means of operation independent of the actuator. The rated Cv for butterfly valves shall be the valve Cv at 70% open (60 degrees open).

2.5.3 Two-Way Valves

Two-way modulating valves shall have equal-percentage characteristics.

2.5.4 Three-Way Valves

Three-way valves shall provide linear flow control with constant total flow throughout full plug travel.

2.5.5 Duct-Coil and Terminal-Unit-Coil Valves

Control valves with either flare-type or solder-type ends shall be provided for duct or terminal-unit coils. Flare nuts shall be furnished for each flare-type end valve.

2.5.6 Valves for Chilled-Water, Condenser-Water, and Glycol Service

Bodies for valves 40 mm (1-1/2 inches) and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 50 to 80 mm (2 to 3 inches) inclusive shall be of brass, bronze or iron. Bodies for 50 mm (2 inch) valves shall have threaded ends. Bodies for valves from 65 to 80 mm (2-1/2 to 3 inches) shall have flanged-end connections. Valve Cv shall be within 100 percent to 125 percent of the Cv shown. Internal valve trim shall be brass or bronze except that valve stems may be type 316 stainless steel. Valves 100 mm (4 inches) and larger shall be butterfly valves.

2.5.7 Valves for Hot-Water Service

Valves for hot-water service below 121 degrees C (250 Degrees F) shall be as follows: Bodies for valves 40 mm (1-1/2 inches) and smaller shall be brass or bronze, with threaded or union ends. Bodies for 50 mm (2 inches) valves shall have threaded ends. Bodies for valves from 50 to 80 mm (2 to 3 inches) inclusive shall be of brass, bronze, or iron. Bodies for valves 100 mm (4 inches) and larger shall be iron. Bodies for valves 65 mm (2-1/2 inches) and larger shall be provided with flanged-end connections. Valve Cv shall be within 100 percent to 125 percent of the Cv shown. Internal trim (including seats, seat rings, modulating plugs, and springs) of valves controlling water hotter than 99 degrees C (210 degrees F) shall be Type 316 stainless steel. Internal trim for valves controlling water 99 degrees C (210 degrees F) or less shall be brass or bronze. Nonmetallic parts of hot-water control valves shall be suitable for a minimum continuous operating temperature of 121 degrees C 250 degrees F or 10 degrees C (50 degrees F) above the system design temperature, whichever is higher. Valves 100 mm (4 inches) is higher. Valves 100 mm (4 inches) and larger shall be butterfly valves.

2.5.8 Valves for Steam Service

Bodies for valves 40 mm (1-1/2 inches) and smaller shall be all brass or bronze, with threaded or union ends. Bodies for valves from 50 to 80 mm (2 to 3 inches) inclusive shall be of brass, bronze, or iron. Bodies for valves 100 mm (4 inches) and larger shall be iron. Bodies for 50 mm (2 inches) valves shall have threaded ends. Bodies for valves 65 mm (2-1/2 inches) inches and larger shall be provided with flanged-end connections. Valve Cv shall be not less than shown nor greater than the Cv of the manufacturer's next larger size. Internal valve trim shall be Type 316 stainless steel.

2.5.9 Valves for High-Temperature Hot-Water Service

Valves for high-temperature hot-water service above 121 degrees C (250 Degrees F) shall be as follows: Valve bodies shall be rated Class 300, in accordance with ASME B16.34. Valve and actuator combination shall be normally closed. Bodies shall be carbon steel, globe type with welded ends on valves 25 mm (1 inch) and larger. Valves smaller than 25 mm (1 inch) shall have socket-weld ends. Packing shall be virgin polytetrafluoroethylene (PTFE). Valve Cv shall be within 100 percent to 125 percent of the Cv shown. Internal valve trim shall be Type 316 stainless steel.

2.6 DAMPERS

2.6.1 Damper Assembly

A single damper section shall have blades no longer than 1.2 m (48 inches) and shall be no higher than 1.8 m (72 inches). Maximum damper blade width shall be 203 mm (8 inches). Larger sizes shall be made from a combination of sections. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. All blade-operating linkages shall be within the frame so that blade-connecting devices within the same damper section will not be located directly in the air stream. Damper axles shall be 13 mm (0.5 inch) (minimum) plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed 10 Pa (0.04 inch water gauge) at 5 m/s (1,000 fpm) in the wide-open position. Frames shall not be less than 50 mm (2 inches) in width. Dampers shall be tested in accordance with AMCA 500-D.

2.6.1.1 Operating Links

Operating links external to dampers (such as crankarms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers) shall withstand a load equal to at least twice the maximum required damper-operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crankarms shall control the open and closed positions of dampers.

2.6.1.2 Damper Types

Dampers shall be parallel blade type.

2.6.2 Outside-Air, Return-Air, and Relief-Air Dampers

The dampers shall be provided where shown. Blades shall have interlocking edges and shall be provided with compressible seals at points of contact. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Dampers shall not leak in excess of 102 L/s per square meter (20 cfm per square foot) at 1,000 Pa (4 inches water gauge) static pressure when closed. Seals shall be suitable for an operating temperature range of minus 40 to plus 93 degrees C (minus 40 to plus 200 degrees F). Dampers shall be rated at not less than 10 m/s (2000 fpm) air velocity.

2.6.3 Mechanical and Electrical Space Ventilation Dampers

The dampers shall be as shown. Dampers shall not leak in excess of 406 L/s per square meter (80 cfm per square foot) at 1,000 Pa (4 inches water gauge) static pressure when closed. Dampers shall be rated at not less than 7.8 m/s (1500 fpm) air velocity.

2.6.4 Smoke Dampers

Smoke-damper and actuator assembly required per NFPA 90A shall meet the Class II leakage requirements of UL 555S. Dampers shall be rated at not less than 10 m/s (2000 fpm) air velocity.

2.6.5 Damper End Switches

Each end switch shall be a hermetically-sealed switch with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever shall be aligned with the damper blade.

2.7 DUCT SMOKE DETECTORS

Duct smoke detectors shall conform to the requirements of UL 268A. Duct smoke detectors shall have perforated sampling tubes extended into the air duct. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. Detectors shall have manual reset. Detectors shall be rated for air velocities that include air flows between 2.5 and 20 m/s (500 and 4000 fpm). Detectors shall be powered from the HVAC control panel. Detectors shall have two sets of normally open alarm contacts and two sets of normally closed alarm contacts. [Detectors shall be connected to the building fire alarm panel for alarm initiation.] A remote annunciation lamp and accessible remote reset switch shall be provided for duct detectors that are mounted eight feet or more above the finished floor and for detectors that are not readily visible. Remote lamps and switches as well as each affected fan unit shall be properly identified in etched rigid plastic placards.

2.8 INSTRUMENTATION

2.8.1 Measurements

Transmitters shall be factory calibrated to provide an output of 4 to 20 mAdc over the indicated ranges:

a. Conditioned space temperature, from 10 to 30 degrees C (50 to 85 degrees F).

b. Duct temperature, from 5 to 60 degrees C (40 to 140 degrees F) except that return-air temperature for economizer operation shall be minus 35 to plus 55 degrees C (minus 30 to plus 130 degrees F).

c. High-temperature hot-water temperature, from 94 to 260 degrees C (200 to 500 degrees F).

d. Chilled-water temperature, from minus 1 to plus 38 degrees C (30 to 100 degrees F).

e. Dual-temperature water, from minus 1 to plus 116 degrees C (30 to 240 degrees F).

f. Heating hot-water temperature, from 10 to 121 degrees C (50 to 250 degrees F).

g. Condenser-water temperature, from minus 1 to plus 55 degrees C (30 to 130 degrees F).

h. Outside-air temperature, from minus 35 to plus 55 degrees C (minus 30 to 130 degrees F).

i. Relative humidity, 0 to 100 percent for space and duct high-limit applications.

j. Differential pressure for VAV supply-duct static pressure from 0 to 500 Pa (0 to 2.0 inches water) (gauge).

k. Pitot-tube air-flow measurement station and transmitter, from 0 to 25 Pa (0 to 0.1 inch water) (gauge) for flow velocities of 3.5 to 6 m/s (700 to 1200 fpm), 0 to 60 Pa (0 to 0.25 inch water gauge) for velocities of 3.5 to 9 m/s (700 to 1800 fpm), or 0 to 125 Pa (0 to 0.5 inch water gauge) for velocities of 3.5 to 13 m/s (700 to 2500 fpm).

l. Electronic air-flow measurement station and transmitter, from 0.6 to 13 m/s (125 to 2500 fpm).

2.8.2 Temperature Instruments

2.8.2.1 Resistance Temperature Detectors (RTD)

Temperature sensors shall be 100 ohms 3- or 4-wire RTD. Each RTD shall be platinum with a tolerance of plus or minus 0.30 degrees C (0.54 degrees F) at 0 degrees C (32 degrees F) with a temperature coefficient of resistance (TCR) of 0.00385ohms/ohm/degC (0.00214ohmn/ohm/degF). Each RTD shall be furnished with an RTD transmitter as specified, integrally-mounted unless otherwise shown.

2.8.2.2 Continuous-Averaging RTD

Continuous-averaging RTDs shall have a tolerance of plus or minus 0.5 degree C (1.0 degree F) at the reference temperature, and shall be of sufficient length to ensure that the resistance represents an average over the cross-section in which it is installed. The sensing element shall have a bendable copper sheath. Each averaging RTD shall be furnished with an RTD transmitter as specified, to match the resistance range of the averaging RTD.

2.8.2.3 RTD Transmitter

The RTD transmitter shall accept a 3-wire 100 ohm RTD input. The transmitter shall be a 2-wire, loop-powered device. The transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required temperature measurement. The output error shall not exceed 0.1 percent of the calibrated span. The transmitter shall include offset and span adjustments.

2.8.3 Relative-Humidity Instruments

A relative-humidity instrument for indoor application shall have a measurement range from 0 to 100 percent relative-humidity and be rated for operation at ambient air temperatures within the range of minus 4 to plus 55 degrees C (25 to 130 degrees F). It shall be capable of being exposed to a condensing air stream (100 percent RH) with no adverse effect to the sensor's calibration or other harm to the instrument. The instrument shall be of the wall-mounted or duct-mounted type, as required by the application, and shall be provided with any required accessories. Instruments used in duct high-limit applications shall have a bulk polymer resistive sensing element. Duct-mounted instruments shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. The instrument (sensing element and transmitter) shall be a 2-wire, loop-powered device and shall have an accuracy of plus or minus 3 percent of full scale within the range of 20 to 80 percent relative humidity. The instrument shall have a typical long-term stability of 1 percent or less drift per year. The transmitter shall convert the sensing element's output to a linear 4-20 mAdc output signal in proportion to the measured relative-humidity value. The transmitter shall include offset and span adjustments.

2.8.4 Electronic Air-Flow-Measurement Stations and Transmitters

2.8.4.1 Stations

Each station shall consist of an array of velocity sensing elements and an air-flow straightener. Air-flow straighteners shall be contained in a flanged sheet-metal or aluminum casing. The velocity sensing elements shall be of the RTD or thermistor type, producing a temperature compensated output. The sensing elements shall be distributed across the duct cross-section in the quantity and pattern specified by the published application data of the station manufacturer. The resistance to airflow through the air-flow measurement station shall not exceed 20.0 Pa (0.08 inch water gauge) at an air-flow of 10 m/s (2,000 fpm). Station construction shall be suitable for operation at air-flows of up to 25.3 m/s (5,000 fpm) over a temperature range of 4.4 to 49 degrees C (40 to 120 degrees F), and accuracy shall be plus or minus 3 percent over a range of 0.6 to 13 m/s (125 to 2,500 fpm). In outside-air measurement or in low-temperature air delivery applications, the station shall be certified by the manufacturer to be accurate as specified over a temperature range of minus 30 to plus 50 degrees C (minus 20 to plus 120 degrees F). In outside-air measurement applications, the air-flow straightener shall be constructed of 3.175 mm (1/8 inch) aluminum honeycomb and the depth of the straightener shall not be less than 40 mm (1.5 inch).

2.8.4.2 Transmitters

Each transmitter shall produce a linear, 4-to-20 mAdc output corresponding to the required velocity measurement. The output error of the transmitter shall not exceed 0.5 percent of the calibrated measurement. Each transmitter shall have offset and span adjustments.

2.8.5 Pitot-Tube Air-Flow-Measurement Stations and Transmitters

2.8.5.1 Pitot-Tube Type Stations

Each station shall contain an array of velocity sensing elements and straightening vanes inside a flanged sheet-metal casing. The velocity sensing elements shall be of the multiple pitot-tube type with averaging manifolds. The sensing elements shall be distributed across the duct cross-section in the quantity and pattern specified by the published installation instructions of the station manufacturer. The resistance to air flow through the air-flow-measurement station shall not exceed 20 Pa (0.08 inch water gauge) at an air flow of 10 m/s (2000 fpm). Station construction shall be suitable for operation at air flows of up to 25.3 m/s (5000 fpm) over a temperature range of 4.4 to 49 degrees C, 40 to 120 F, and accuracy shall be plus or minus 3 percent over a range of 3.5 to 13 m/s (700 to 2500 fpm). This device will not be used if the required velocity measurement is below 3.5 m/s (700 feet per minute) or for outside air flow measurements.

2.8.5.2 Pitot-Tube Type Transmitters

Each transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required velocity pressure measurement. Each transmitter shall have a low-range differential-pressure sensing element and a square-root extractor. Sensing element accuracy shall be plus or minus 1 percent of full scale, and overall transmitter accuracy shall be plus or minus 0.25 percent of the calibrated measurement. Each transmitter shall have offset and span adjustments.

2.8.6 Differential Pressure Instruments

The instrument shall be a pressure transmitter with an integral sensing element. The instrument over pressure rating shall be 300 percent of the operating pressure. The sensor/transmitter assembly accuracy shall be plus or minus 2 percent of full scale. The transmitter shall be a 2-wire, loop-powered device. The transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required pressure measurement. Each transmitter shall have offset and span adjustments.

2.8.7 Thermowells

Thermowells shall be Series 300 stainless steel with threaded brass plug and chain, 50 mm (2 inch) lagging neck and extension-type well, and inside diameter and insertion length as required for the application.

2.8.8 Sunshields

Sunshields for outside-air temperature sensing elements shall prevent the sun from directly striking the temperature sensing elements. The sunshields shall be provided with adequate ventilation so that the sensing element responds to the ambient temperature of the surroundings. The top of each sunshield shall have a galvanized-metal rainshield projecting over the face of the sunshield. The sunshields shall be painted white or shall be unpainted aluminum.

2.9 THERMOSTATS

Thermostat ranges shall be selected so that the setpoint is adjustable without tools between plus or minus 5 degrees C (10 degrees F) of the setpoint shown. Thermostats shall be electronic or electric.

2.9.1 Nonmodulating Room Thermostats

Contacts shall be single-pole double-throw (SPDT), hermetically sealed, and wired to identified terminals. Maximum differential shall be 2.75 degrees C (5 degrees F). Room thermostats shall be enclosed with separate locking covers (guards). Thermostats shall have manual switches as required by the application.

2.9.2 Microprocessor-Based Room Thermostats

Microprocessor-based thermostats shall have built-in keypads for scheduling of day and night temperature settings. When out of the scheduling mode, thermostats shall have continuous display of time, with AM and PM indicator, continuous display of day of week, and either continuous display of room temperature with display of temperature setpoint on demand, or continuous display of temperature setpoint with display of room temperature on demand.

In the programmable mode, the display shall be used for interrogating time program ON-OFF setpoints for all 7 days of the week. The time program shall allow 2 separate temperature-setback intervals per day. The thermostats shall have a means for temporary and manual override of the program schedule, with automatic program restoration on the following day. Thermostats shall have a replaceable battery to maintain the timing and maintain the schedule in memory for 1 year in the event of a power outage. Maximum differential shall be 1 degree C (2 degrees F). When used for heat-pump applications, the thermostat shall have an emergency heat switch.

2.9.3 Modulating Room Thermostats

Modulating room thermostats shall have either one output signal, two output signals operating in unison, or two output signals operating in sequence, as required for the application. Each thermostat shall have an adjustable throttling range of 2 to 4 degrees C (4 to 8 degrees F) for each output. Room thermostats shall be enclosed with separate locking covers (guards).

2.9.4 Nonmodulating Capillary Thermostats and Aquastats

Each thermostat shall have a capillary length of at least 1.5 meters (5 feet), shall have adjustable direct-reading scales for both setpoint and differential, and shall have a differential adjustable from 3 to 9 degrees C (6 to 16 degrees F). Aquastats shall be of the strap-on type, with 5 degrees C (10 degrees F) fixed differential.

2.9.5 Low-Temperature-Protection Thermostats

Low-temperature-protection thermostats shall be, low-temperature safety thermostats, with NO and NC contacts and manual reset, with an element length of 6 meters (20 feet), which shall respond to the coldest 460 mm (18 inch) segment.

2.9.6 Modulating Capillary Thermostats

Each thermostat shall have either one output signal, two output signals operating in unison, or two output signals operating in sequence, as required for the application. Thermostats shall have adjustable throttling ranges of 2 to 4 degrees C (4 to 8 degrees F) for each output.

2.9.7 Fan-Coil Unit Room Thermostats

Fan-coil unit room thermostats in personnel living spaces shall be of the low-voltage type with locking covers. Electrical rating shall not exceed 2.5 amperes at 30 volts ac. Housing shall be corrosion resistant metal or molded plastic. Transformer and fan relay shall be provided for the proper operation of each thermostatic control system as necessary to suit the design of the control system using the thermostats specified below. Either separate heating thermostats and separate cooling thermostats or dual element heating-cooling thermostats may be provided. Motor speed switches shall be provided for 3-speed fan control.

2.9.7.1 Heating Thermostats

Fan-coil heating thermostats shall be provided with fixed heat anticipation and shall have a single-pole, single-throw (SPST) switch hermetically sealed and actuated by a bimetallic or bellows type element. Thermostats shall be provided with external temperature setting devices with a factory set maximum of 20 degrees C (68 degrees F). Heating thermostats shall have an adjustable range of at least 7 degrees below 20 degrees C (13 degrees below 68 degrees F).

2.9.7.2 Cooling Thermostats

Fan-coil cooling thermostats shall be provided with fixed cooling anticipation heater and shall have a single-pole, single-throw (SPST) switch hermetically sealed and actuated by a bimetallic or bellows type element. Thermostats shall be provided with external temperature setting devices with a factory set minimum of 25 degrees C (78 degrees F). Cooling thermostats shall have an adjustable range of at least 4 degrees C (7 degrees F) above 25 degrees C (78 degrees F).

2.9.7.3 Dual Element Thermostats

Fan-coil unit combination heating-cooling thermostats shall be provided with separate temperature sensing elements for each system, and shall have a single-pole, single-throw (SPST) switch hermetically sealed and actuated by a bimetallic or bellows type element. Each element shall operate switches to provide single stage control for heating and cooling. Scales and ranges shall be as specified for individual thermostats. Thermostats shall contain, or a subbase shall be provided which contains, selector switches for Heat-Off-Cool. A changeover controller providing automatic summer-winter changeover for thermostats by sensing the supplied fluid temperature shall be provided. A limited range heating-cooling dead band thermostat shall control cooling when temperature is above the upper setpoint and heating when temperature is below the lower setpoint and shall have a dead band, with no heating or cooling, when temperature is between the setpoints. Setpoint adjustment shall be concealed.

2.10 PRESSURE SWITCHES AND SOLENOID VALVES

2.10.1 Pressure Switches

Each switch shall have an adjustable setpoint with visible setpoint scale. Range shall be as shown. Differential adjustment shall span 20 to 40 percent of the range of the device.

2.10.2 Differential-Pressure Switches

Each switch shall be an adjustable diaphragm-operated device with two SPDT contacts, with taps for sensing lines to be connected to duct pressure fittings designed to sense air pressure. These fittings shall be of the angled-tip type with tips pointing into the air stream. The setpoint shall not be in the upper or lower quarters of the range and the range shall not be more than three times the setpoint. Differential shall be a maximum of 35 Pa (0.15 inch water gauge) at the low end of the range and 85 Pa (0.35 inch water gauge) at the high end of the range.

2.10.3 Pneumatic Electric (PE) Switches

Each switch shall have an adjustable setpoint range of 20 to 140 kPa (3 to 20 psig) with a switching differential adjustable from 15 to 35 kPa (2 to 5 psig). The switch action shall be SPDT.

2.10.4 Solenoid-Operated Pneumatic (EP) Valves

Each valve shall have three-port operation: common, normally open, and normally closed. Each valve shall have an outer cast-aluminum body and internal parts of brass, bronze, or stainless steel. The air connection shall be a 10 mm (3/8 inch) NPT threaded connection. Valves shall be rated for 345 kPa (50 psig) when used in a control system that operates at 172 kPa (25 psig) or less, or 1035 kPa (150 psig) when used in a control system that operates in the range of 172 to 690 kPa (25 to 100 psig).

2.11 INDICATING DEVICES

2.11.1 Thermometers

Mercury shall not be used in thermometers.

2.11.1.1 Piping System Thermometers

Piping system thermometers shall have brass, malleable iron or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 230 mm (9 inch) scale. Thermometers for piping systems shall have rigid stems with straight, angular, or inclined pattern.

2.11.1.2 Piping System Thermometer Stems

Thermometer stems shall have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem shall be filled with a heat-transfer medium.

2.11.1.3 Non-Averaging Air-Duct Thermometers

Air-duct thermometers shall have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.11.1.4 Averaging Air-Duct Thermometers

Averaging thermometers shall have a 90 mm (3-1/2 inch) (nominal) dial, with black legend on white background, and pointer traveling through a 270-degree arc.

2.11.1.5 Accuracy

Thermometers shall have an accuracy of plus or minus 1 percent of scale range. Thermometers shall have a range suitable for the application.

2.11.2 Pressure Gauges

Gauges shall be 50 mm (2 inch) (nominal) size, back connected, suitable for field or panel mounting as required, shall have black legend on white background, and shall have a pointer traveling through a 270-degree arc. Accuracy shall be plus or minus 3 percent of scale range. Gauges shall meet requirements of ASME B40.1. Gauges for hydronic-system applications shall have ranges and graduations as shown.

2.11.3 Low Differential Pressure Gauges

Gauges for low differential-pressure measurements shall be a minimum of 90 mm (3.5 inch) (nominal) size with two sets of pressure taps, and shall have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauges shall have ranges and graduations as shown. Accuracy shall be plus or minus 2 percent of scale range.

2.12 SINGLE-LOOP CONTROLLERS

2.12.1 Controller Features

The controller shall be a microprocessor-based single-loop device that does not require Contractor generated software. The controller shall be mountable in a panel cutout measuring 92 by 92 mm (3.62 by 3.62 inches). The controller shall have field scalable process variable, a remote setpoint analog input, which is field scalable independent of the process variable, and an analog output with adjustable high and low end limits and proportional control manual reset adjustment. The analog output shall result from proportional, integral and derivative (PID) control. The analog output shall be configurable as direct acting and reverse acting. The controller shall have keyboard, display, auto/manual selection for control of its analog output, remote setpoint adjustment/local setpoint adjustment selection with adjustable high-end and low-end limits, ratio and bias adjustments on remote setpoint input, operator-initiated self-tune/manual-tune selection, anti-reset wind-up feature, and 2 independent SPDT contact-closure outputs (PV alarm and deviation alarm). The controller shall be configurable to power-up in automatic with local setpoint control and in automatic with remote setpoint control. The range of hysteresis adjustment shall be not smaller than from 1 percent to 5 percent of process variable input span. The controller shall power the analog output loop to 20 milliamperes when connected to a load of 600 ohms. The controller shall be capable of retransmitting the process variable to 20 milliamperes when connected to 600 ohms. The controller shall have 5-year battery backup to store operating parameters or shall have nonvolatile memory.

2.12.2 Parameter Input and Display

Control parameters shall be entered and displayed directly, in the correct engineering units, through a series of keystrokes on a front-panel display with a 3-1/2 digit, 7-segment display, with decimal point and polarity indication. The use of this display shall allow manual interrogation of setpoint, mode constants, and values of the process variable and output.

2.12.3 Controller Electrical Requirements

Each controller shall be powered by 120 volts ac. Power consumption shall not be greater than 25 watts. Each controller shall provide electrical noise isolation between the ac power line and the process variable input, remote setpoint input, and output signals and of not less than 100 db at 60 Hz common-mode rejection ratio, and not less than 60 db at 60 Hz normal-mode rejection ratio.

2.12.4 Controller Accuracy

The controller shall have an accuracy of plus or minus 0.30 percent of input span, plus or minus 1 digit.

2.12.5 Self-Tuning

The controller self-tuning operation shall apply proportional, integral, and derivative modes of control and shall modify the mode constants as required. Self-tuning shall only be in operation when selected from the front panel.

2.12.6 Manual-Tuning

The controller manual-tuning operation shall provide proportional, integral, and derivative control modes, or any combination thereof, by means of individual mode constant adjustments. These adjustments shall be set for the appropriate value if a particular control mode action is desired, or to zero if that particular mode is not desired. The proportional-mode constant shall be adjustable from 0 to 200 percent of input signal range, the integral-mode constant shall be adjustable from 0 to 20 repeats per minute, and derivative-mode constant shall be adjustable from 0 to 5 minutes.

2.13 CONTROL DEVICES AND ACCESSORIES

Control device and accessory input impedance shall not exceed 250 ohms.

2.13.1 Function Modules

Function modules shall accept mAdc analog input signals to produce mAdc analog output signals or contact output signals. Modules shall have zero and span adjustments for analog outputs, and setpoint adjustments for contact outputs. Module output span accuracy shall be plus or minus 1 percent of input span. Modules shall be rail-mounted as shown. Power consumption shall be not greater than 5 watts.

2.13.1.1 Minimum-Position Switch and Temperature-Setpoint Device

Minimum-position switch and temperature-setpoint device shall accept a 1000 ohms potentiometer input and shall produce a steady analog output. In temperature setpoint applications the potentiometer shall be single-turn, suitable for wall mounting, enclosed in a locking metal or heavy duty plastic enclosure and shall have a graduated dial corresponding to the range of the setpoint adjustment. In a minimum position switch application the potentiometer shall be mounted on or internal to the minimum position switch. The device shall have its input signal electrically or optically isolated from output. Mounting socket shall be an 8 pin base with pins 1, 2, 3 ac power input, 4, 5, 6 input signal, 7, 8, output signal.

2.13.1.2 Signal-Inverter Modules

Signal inverter shall accept an analog input signal and shall have sufficient output capacity to drive the output signal through a circuit with an impedance of not less than 600 ohms. The output shall be electrically isolated from the input and the device shall have a moisture resistant coating. Mounting socket shall be an 8 pin base with pins 1, 2, 3 ac power input, 4, 5, 6 input signal, 7, 8, output signal.

2.13.1.3 High-Low Signal Selector

High-low signal-selector modules shall accept analog input signals and select either the highest or the lowest input signal as the output signal. The signal selector shall be powered by 120 Vac and the output signal shall be electrically isolated from the input signal.

2.13.1.4 Sequencer Modules (Dual Limit Alarm)

Sequencer modules (dual limit alarms) shall accept an analog input signal and shall provide two contact closure outputs. Each output shall have an adjustable independent contact setpoint with an adjustable switching differential range between 1 percent and 100 percent of the input span. The setpoint shall be adjustable between 0 percent and 100 percent of the input span. Setpoint and switching differential (dead band) adjustment potentiometers shall be internal, top-accessed potentiometers or screws. Sequencers shall return all contacts to their zero input signal condition when power is interrupted. The device shall have moisture resistant coating.

2.13.1.5 Loop Driver Modules

Loop driver module shall accept an analog input signal and shall have a circuit input impedance not greater than 100 ohms. The loop driver module shall have sufficient output capacity to drive the output signal through a circuit with an impedance range of not less than 1000 ohms. The output shall be electrically isolated from the input and the device shall have moisture resistant coating. Mounting socket shall be an 8 pin base with pins 1, 2, 3 ac power input, 4, 5, 6 input signal, 7, 8 output signal.

2.13.2 Relays

Relays shall be 2-pole, double-throw (2PDT) with a 10-ampere resistive rating at 120 Vac, and shall have an enclosed 120-Vac coil with 8 pin blade connectors, and a matching rail-mounted socket. Power consumption shall not be greater than 3 watts.

2.13.3 Time-Delay Relays

Time delay relays shall be 2PDT with 8 pin connectors, dust cover, and a matching rail-mounted socket. Adjustable timing range shall be 0 to 5 minutes. Power consumption shall be not greater than 3 watts.

2.13.4 Current Sensing Relays

Current sensing relays shall provide a normally-open contact rated at a minimum of 50 volts peak and 1/2 ampere or 25 VA, noninductive. There shall be a single hole for passage of current carrying conductors. The devices shall be sized for operation at 50 percent rated current based on the connected load. Voltage isolation shall be a minimum of 600 volts.

2.13.5 Time Clocks

Each time clock shall be a 365-day programmable timing device with 4 independently timed circuits. Each clock shall have a manual scheduling keypad and an alphanumeric display of all timing parameters. Timing parameters shall include: date in Gregorian calendar for month, day and day-of-month indication; and 24-hour time-of-day display, with one-minute resolution for programming the ON and OFF times for each circuit. Each clock shall allow programming of each circuit for 12 holiday periods for either ON or OFF events for any selected duration of the 365-day program. Each clock shall have capacity for programming 4 ON events and 4 OFF events per day for each circuit. The programmed events shall be assignable to a 365-day schedule. Each clock shall have automatic Standard Time and Daylight Saving Time adjustment, by input of the appropriate dates. Each time clock shall have automatic leap year correction. Each clock shall be provided with 4-day battery backup. Power consumption shall not be greater than 10 watts.

2.13.6 Current-to-Pneumatic (IP) Transducers

The transducers shall be 2-wire current-to-pressure transmitters that convert a 4-to-20 mAdc input signal to a 21 to 103 kPa (3 to 15 psig), or a 103 to 21 kPa (15 to 3 psig), pneumatic output, with a conversion accuracy SECTION 15950A of plus or minus 2 percent of full scale, including linearity and hysteresis. Input impedance shall not exceed 250 ohms. Air consumption shall not be greater than 0.12 L/s (0.25 scfm).

2.13.7 Direct Current (DC) Power Supply

One DC power supply shall be used to power all transmitters connected to the control panel. The power supply shall be 24 Vdc at not less than 1.2 amperes, with a peak-to-peak ripple not to exceed 0.03 percent of output voltage. Each power supply shall have a fused input, and shall be protected from voltage surges and powerline transients. The power supply output shall be protected against overvoltage and short circuits.

2.13.8 Power Line Conditioner (PLC)

PLCs shall be furnished for each controller panel. The PLCs shall provide both voltage regulation and noise rejection. The PLCs shall be of the ferro-resonant design, with no moving parts and no tap switching, while electrically isolating the secondary from the power line side. The PLCs shall be sized for 125 percent of the actual connected kva load. Characteristics of the PLC shall be as follows:

a. At 85 percent load, the output voltage shall not deviate by more than plus or minus 1 percent of nominal voltage when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal voltage.

b. During load changes of zero to full load, the output voltage shall not deviate by more than plus or minus 3 percent of nominal voltage. Full correction of load switching disturbances shall be accomplished within 5 cycles, and 95 percent correction shall be accomplished within 2 cycles of the onset of the disturbance.

c. Total harmonic distortion shall not exceed 3-1/2 percent at full load.

2.14 PILOT LIGHTS AND MANUAL SWITCHES

Pilot lights and switches shall be rectangular devices arranged in a horizontal matrix as shown. Momentary switches shall be non-illuminated. Interlocking switches shall have separately illuminated sections. Split legend lights shall have separately illuminated sections. Device illumination shall be by light-emitting diode or neon lamp.

2.15 HVAC SYSTEM CONTROL PANELS

2.15.1 Panel Assembly

The control panel shall be factory assembled and shipped to the job site as a single unit. The panel shall be fabricated as shown, and the devices shall be mounted as shown. Each panel shall be fabricated as a bottom-entry connection point for control-system electric power, control-system main air source, control-system wiring, pneumatic tubing, interconnection of control systems, interconnection of starters and external shutdown devices, and energy monitoring and control systems (EMCS) interface. Each panel shall have an operating temperature rise of not greater than 11 degrees C (20 degrees F) above an ambient temperature of 38 degrees C (100 degrees F).

2.15.2 Panel Electrical Requirements

Each control panel shall be powered by nominal 120 volts ac, fused at 5 amps, terminating at the panel on terminal blocks. Instrument cases shall be grounded. Interior panel, interior door, and exterior panel enclosure shall be grounded.

2.15.3 Enclosure

The enclosure for each panel shall be a NEMA 12 single-door wall-mounted box conforming to NEMA 250, with continuous hinged and gasketed exterior door with print pocket and key lock, continuous hinged interior door, interior back panel, and ventilation louvers in back surface as shown. Inside finish shall be white enamel, and outside finish shall be gray primer over phosphatized surfaces.

2.15.4 Mounting and Labeling

Controllers, pilot lights, switches, IP's, and pressure gauge shall be mounted on the interior door as shown. Power conditioner, fuses and duplex outlet shall be mounted on the interior of the cabinet as shown. All other components housed in the panel shall be mounted on the interior back panel surface of the enclosure, behind the door on rails as shown. Controllers and gauges mounted on the front of the inner door shall be identified by a plastic or metal nameplate as shown that is mechanically attached to the panel. Function modules, relays, timeclocks, IP transducers, DC power supply, and other devices interior to the panel shall be identified by a plastic or metal nameplate that is mechanically attached to the panel. The nameplate shall have the inscription as shown. Lettering shall be cut or stamped into the nameplate to a depth of not less than 0.4 mm (1/64 inch), and shall show a contrasting color, produced by filling with enamel or lacquer or by the use of a laminated material. Painting of lettering directly on the surface of the interior door or panel is not permitted.

2.15.5 Wiring and Tubing

2.15.5.1 Current-to-Pneumatic Transducers (IP)

Current-to-pneumatic transducers (IP) shall be piped to bulkhead fittings in the bottom of the panel with a 50 mm (2 inch) loop to accommodate IP replacement and shall be wired to identified terminal blocks.

2.15.5.2 Panel Wiring

Interconnections Wiring shall be installed in wiring ducts in such a way that devices can be added or replaced without disturbing wiring that is not affected by the change. Wiring to all devices shall have a 100 mm (4 inch) wiring loop in the horizontal wiring duct at each wiring connection. There shall be no wiring splices within the control panel. All interconnections required for power or signals shall be made on device terminals or panel terminal blocks, with not more than two wires connected to a terminal.

2.15.5.3 Panel Terminal Blocks

Terminal blocks shall be arranged in groups as shown. Instrument signal grounds at the same ground reference level shall end at a grounding terminal for connection to a common ground point. Wiring-shield grounds at the same reference level shall end at a grounding terminal for connection to a common ground point. Grounding terminal blocks shall be identified by reference level.

2.15.5.4 Wiring Identification

All wiring connected to controllers, time clocks and function modules shall be identified by function and polarity with full word identifiers, i.e., process variable input, remote setpoint input and control output.

2.15.6 EMCS Terminal Blocks

Terminal blocks shall be provided for connections to EMCS as shown. Analog signals shall require only the removal of jumpers to interface to EMCS.

2.16 ELECTRONIC VARIABLE AIR VOLUME (VAV) TERMINAL UNIT CONTROLS

2.16.1 VAV Terminal Units

The VAV terminal units shall be as specified in Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM. All VAV terminal box controllers associated with an AHU shall be networked together such that configuration parameters for any controller may be monitored and modified from the controller of any other terminal unit served by the same AHU.

2.16.2 Terminal-Unit Controls

2.16.2.1 Box Control Device

Controls for pressure independent boxes with recirculating fans or with series fans shall consist of a velocity-sensing device in the primary air entering the box, a room temperature sensing element with occupant setpoint adjustment, a damper actuator, a duct pressure switch to operate the series fan, and an adjustable microprocessor-based VAV box controller. Each controller shall operate a damper for cooling and heating and the recirculation fan and duct coil for heating. Terminal unit controls shall meet the requirements of UL 916 and 47 CFR 15.

2.16.2.2 Communication and Programming Device

One hand-held communication and programming device with instruction manual, plus one additional hand-held communicating device and instruction manual per 100 terminal units, shall be provided. The communication and programming device shall connect to the controller directly or to a jack at the room-temperature-sensing element location. The communication and programming device shall be used to read and set minimum velocity, maximum velocity, heating setpoint, and cooling setpoint, and to read velocity and space temperature.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION CRITERIA

The HVAC control system shall be installed and ready for operation, as specified and shown. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exterior shall be made watertight. The HVAC control system installation shall provide clearance for control system maintenance by maintaining access space between coils, access space to mixed-air plenums, and other access space required to calibrate, remove, repair, or replace control system devices. The control system installation shall not interfere with the clearance requirements for mechanical installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.1 Device Mounting Criteria

Devices mounted in or on piping or ductwork, on building surfaces, in mechanical/electrical spaces, or in occupied space ceilings shall be installed in accordance with manufacturer's recommendations and as shown. Control devices to be installed in piping and ductwork shall be provided with all required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used except as specified.

3.1.2 Wiring Criteria

Wiring external to control panels, including low-voltage wiring, shall be installed in metallic raceways. Wiring shall be installed without splices between control devices and HVAC control panels. Cables and conductors shall be tagged at both ends, with the identifier shown on the shop drawings, in accordance with the requirements of Section 16415 ELECTRICAL WORK, INTERIOR.

Other electrical work shall be as specified in Section 16415 ELECTRICAL WORK, INTERIOR and as shown.

3.1.2.1 Power-Line Surge Protection

SEquipment connected to ac circuits shall be protected from powerline surges. Equipment protection shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

3.1.2.2 Surge Protection for Transmitter and Control Wiring

HVAC system control panel equipment shall be protected against surges induced on control and transmitter wiring installed outside and as shown. The equipment protection shall be tested in the normal mode and in the common mode, using the following two waveforms:

a. A 10-microsecond by 1000-microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8-microsecond by 20-microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

3.1.2.3 Controller Output Loop Impedance Limitation

Controller output loops shall be constructed so that total circuit impedance connected to the analog output of a single-loop controller shall not exceed 600 ohms.

3.2 CONTROL SYSTEM INSTALLATION

3.2.1 Damper Actuators

Actuators shall not be mounted in the air stream. Multiple actuators operating a common damper shall be connected to a common drive shaft. Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

3.2.2 Local Gauges for Actuators

Pneumatic actuators shall have an accessible and visible receiver gauge installed in the tubing lines at the actuator as shown.

3.2.3 Room-Instrument Mounting

Room instruments, such as wall mounted thermostats, shall be mounted 1.5 m (5 feet) above the floor unless otherwise noted. Temperature setpoint device shall be recess mounted.

3.2.4 Smoke Detectors

Duct smoke detectors shall be provided in supply and return air ducts in accordance with NFPA 90A.

3.2.5 Manual Emergency Fan Shutdown Switches

Manual emergency fan shutdown switches shall be provided for air distribution fans in accordance with NFPA 90A. Switches shall be the manual-reset type. Switches shall be located and mounted in an accessible manner, approximately 1.2 m (48 inches) above the finished floor. Switches shall be properly identified in etched rigid plastic placards.

3.2.6 Low-Temperature-Protection Thermostats

For each 1.8 square meters (20 square feet) of coil-face area, or fraction thereof, a thermostat shall be provided to sense the temperature at the location shown. The thermostat sensing element shall be installed in a serpentine pattern.

3.2.7 Averaging-Temperature Sensing Elements

Sensing elements shall have a total-element minimum length equal to 3.3 linear meter per square meter (one linear foot per square foot) of duct cross-sectional area.

3.2.8 Duct Static-Pressure Sensing Elements and Transmitters

The duct static-pressure sensing element and transmitter sensing point shall be located at 75% to 100% of the distance between the first and last air terminal units.

3.2.9 Indication Devices Installed in Piping and Liquid Systems

Gauges in piping systems subject to pulsation shall have snubbers. Gauges for steam service shall have pigtail fittings with cock. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.

3.3 CONTROL SEQUENCES OF OPERATION

3.3.1 System Requirements

These requirements shall apply to all primary HVAC systems unless modified herein. The sequences describe the actions of the control system for one direction of change in the HVAC process analog variable, such as temperature, humidity or pressure. The reverse sequence shall occur when the direction of change is reversed.

3.3.1.1 HVAC System Supply Fan Operating

HVAC system outside-air, return-air, and relief-air dampers shall function as described hereinafter for specific modes of operation unless control of the dampers is assumed by the fire and smoke control system. Smoke dampers shall open before fans are allowed to start. Interlocked exhaust fans shall be stopped in the unoccupied and ventilation delay modes and their dampers shall be closed. Interlocked exhaust fans shall run in the occupied mode, and their dampers shall open. Cooling-coil control valves and cooling-coil circulating pumps shall function as described hereinafter for the specific modes of operation unless their control is assumed by the freeze-protection system. Heating coil valves shall be under control.

3.3.1.2 HVAC System Supply Fan Not Operating

When an HVAC system is stopped, interlocked fans shall stop, the smoke dampers shall close, the outside-air and relief-air dampers shall close, the return-air damper shall open, all stages of direct-expansion cooling shall stop, the system shall pump down if it has a pump down cycle, humidification shall stop, and cooling-coil valves for coils located indoors shall close to the coil. Cooling-coil valves of units located outdoors shall open to the coil. Heating-coil valves shall remain under control.

3.3.1.3 HVAC System Hydronic Heating Distribution Pump Operation

Hydronic heat-exchanger valves shall be under control.

3.3.1.4 HVAC System Hydronic Heating Distribution Pump Not Operating

Hydronic heat-exchanger valves shall close.

3.3.2 Perimeter-Radiation Control Sequence

A room thermostat, located as shown, shall operate a control valve to maintain the setpoint shown.

3.3.3 Unit-Heater and Cabinet-Unit-Heater

A wall-mounted thermostat with an "AUTO-OFF" switch located as shown, shall cycle the fan to maintain its setpoint as shown when the switch is in the "AUTO" position. When the switch is in the "OFF" position, the fan shall be stopped.

3.3.4 Gas-Fired Infrared-Heater

A microprocessor-based room thermostat with "AUTO-OFF" switch, located as shown, shall control the infrared heater. When the switch is in the "AUTO" position, the thermostat shall cycle the infrared heater to maintain the day and night setpoints as shown. Programmed occupied times shall be considered "day" and programmed unoccupied times shall be considered "night." When the switch is in the "OFF" position, the infrared heater shall be off.

3.3.5 All-Air Small Package Unitary System

A microprocessor-based room thermostat, located as shown, with "HEAT-OFF-COOL" and "AUTO-ON" switches shall control the system. When the switch is in the "HEATING" position, the cooling unit shall be off, and heating shall be active. The thermostat shall operate the condensing unit and system fan to maintain the day and night setpoints as shown. Programmed occupied times shall be considered "day" and programmed unoccupied times shall be considered "night." When the switch is in the "COOLING" position, the heating unit shall be off. The thermostat shall operate the condensing units and system fan to maintain the setpoint as shown during the day. The condensing unit shall be off at night. When the switch is in the "OFF" position, the system shall be off. When the "AUTO-ON" switch is in the "ON" position, the system fan shall run continuously. In the "AUTO" position, the system fan shall operate whenever heating or cooling is required.

3.3.6 Dual-Temperature Fan-Coil Unit

A wall-mounted thermostat, located as shown, shall cycle the fan to maintain the setpoint as shown. When the fan is on, a three-way valve shall open to the coil. When the fan is off, the three-way valve shall bypass the coil. An aquastat shall switch the wall-mounted thermostat action from heating mode to cooling mode whenever the hydronic dual-temperature medium is below the setpoint shown.

3.3.7 Central Plant Hydronic-Heating with Steam/Hot Water Converter

a. All Modes - The outside-air temperature controller shall accept a signal at its process variable input from a sunshielded outside-air temperature sensing element and transmitter located as shown. The outside-air temperature controller process variable relay contact output shall start and stop pump at the outside-air temperatures shown. The analog output of the outside-air temperature controller shall send a signal to the remote setpoint input of the primary hydronic-heating system temperature controller to reset the hydronic-heating supply temperature setpoint in a linear schedule based on the outside-air temperature as shown. The hydronic-heating supply temperature controller shall accept a signal at its process variable input from a temperature sensing element and transmitter located in the hydronic-heating supply line and the controller output shall modulate the converter steam control valve to maintain the reset schedule setpoint in the hydronic-heating supply line.

b. Occupied Mode - When the time clock places the system in the occupied mode, a space-temperature sensing element and transmitter located as shown shall signal a space-temperature controller which shall maintain the setpoint as shown by modulating the secondary-hydronic-system zone valve. In this mode of operation, the controller setpoint shall be adjustable from the sensing element and transmitter location.

c. Unoccupied Mode - When the time clock places the system in the unoccupied mode, the setpoint of the controller shall be as shown and shall be adjustable at the HVAC control panel.

3.3.8 Single Building Hydronic Heating with Hot Water Boiler

a. All Modes - The outside-air temperature controller shall accept a signal at its process variable input from a sunshielded outside-air temperature sensing element and transmitter located as shown. The outside-air temperature controller process variable relay contact output shall start and stop the distribution pump and boiler at the outside-air temperatures shown. The analog output of the outside-air temperature controller shall send a signal to the remote setpoint input of the primary hydronic-heating system temperature controller to reset the hydronic-heating supply temperature setpoint in a linear schedule based on the outside-air temperature as shown. The hydronic-heating supply temperature controller shall accept a signal at its process variable input from a temperature sensing element and transmitter located in the hydronic-heating supply line and the controller output shall modulate the hydronic-heating system control valve to maintain the reset schedule setpoint in the hydronic-heating supply line.

b. Occupied Mode - When the time clock places the system in the occupied mode, a space-temperature sensing element and transmitter located as shown shall signal a space-temperature controller which shall maintain the setpoint as shown by modulating the secondary-hydronic-system zone valve. In this mode of operation, the controller setpoint shall be adjustable from the sensor and transmitter location.

c. Unoccupied Mode - When the time clock places the system in the unoccupied mode, the setpoint of the controller shall be as shown and shall be adjustable at the HVAC control panel.

3.3.9 Central Plant High-Temperature Hot-Water Hydronic Heating

a. All Modes - The outside-air temperature controller shall accept a signal at its process variable input from a sunshielded outside-air temperature sensing element and transmitter located as shown. The outside-air temperature controller process variable relay contact output shall start and stop pump at the outside-air temperatures shown. The analog output of the outside-air temperature controller shall send a signal to the remote setpoint input of the primary hydronic-heating system temperature controller to reset the hydronic-heating supply temperature setpoint in a linear schedule based on the outside-air temperature as shown. The hydronic-heating supply temperature controller shall accept a signal at its process variable input from a temperature sensing element and transmitter located in the hydronic-heating supply line and the controller output shall modulate the converter high-temperature hot-water control valve to maintain the reset schedule setpoint in the hydronic-heating supply line.

b. Occupied Mode - When the time clock places the system in the occupied mode, a space-temperature sensing element and transmitter located as shown shall signal a space-temperature controller which shall maintain the setpoint as shown by modulating the secondary-hydronic-system zone valve. In this mode of operation, the controller setpoint shall be adjustable from the sensing element and transmitter location.

c. Unoccupied Mode - When the time clock places the system in the unoccupied mode, the setpoint of the controller shall be as shown and shall be adjustable at the HVAC control panel.

3.3.10 Central Plant Steam Dual-Temperature Hydronic

Heating and cooling modes shall be manually selected.

a. Heating Mode - When the heating mode is selected, the system changeover valves shall close to the Central Plant chilled water flow and shall open to flow through the converter, the heating pilot light shall turn on, the cooling pilot light shall turn off, and pump shall be under control of the outside-air temperature controller. The outside-air temperature controller shall accept a signal at its process variable input from a sunshielded outside-air temperature sensing element and transmitter located as shown. The outside-air temperature controller process variable relay contact output shall start and stop pump at the outside-air temperatures shown. The analog output of the outside-air temperature controller shall send a signal to the remote setpoint input of the primary hydronic-heating system temperature controller to reset the hydronic-heating supply temperature setpoint in a linear schedule based on the outside-air temperature as shown. The hydronic-heating supply temperature controller shall accept a signal at its process variable input from a temperature-sensing element and transmitter located in the hydronic-heating supply line and the controller output shall modulate the converter steam control valve to maintain the reset schedule setpoint in the hydronic-heating supply line.

b. Cooling Mode - When the cooling mode is selected, the converter steam valve shall be closed. Pump shall continue to operate to circulate water through the system. When the system return-water temperature drops below the setpoint shown, the system-return aquastat shall allow the changeover valves to close to flow through the converter and to open to the central plant chilled-water flow, and place the control of pump under control of the system time clock, the cooling pilot light shall turn on and the heating pilot light shall turn off. During the occupied mode, pump shall operate continuously. When the time clock places the control system in the unoccupied mode, pump shall stop.

3.3.11 Central Plant High-Temperature Hot-Water Dual-Temperature Hydronic
Heating and cooling modes shall be manually selected.

a. Heating Mode - When the heating mode is selected, the system changeover valves shall close to the central plant chilled-water flow and shall open to flow through the converter, the heating pilot light shall turn on, the cooling pilot light shall turn off, and pump shall be under control of the outside-air temperature controller. The outside-air temperature controller shall accept a signal at its process variable input from a sunshielded outside-air temperature sensing element and transmitter located as shown. The outside-air temperature controller process variable relay contact output shall start and stop pump at the outside-air temperatures shown. The analog output of the outside-air temperature controller shall send a signal to the remote setpoint input of the primary hydronic-heating system temperature controller to reset the hydronic-heating supply temperature setpoint in a linear schedule based on the outside-air temperature as shown. The hydronic-heating supply temperature controller shall accept a signal at its process variable input from a temperature-sensing element and transmitter located in the hydronic-heating supply line and the controller output shall modulate the converter high-temperature-water control valve to maintain the reset schedule setpoint in the hydronic-heating supply line.

b. Cooling Mode - When the cooling mode is selected, the converter high-temperature-water control valve shall be closed. Pump shall continue to operate to circulate water through the system. When the system return-water temperature drops below the setpoint shown, the system-return aquastat shall allow the changeover valves to close to flow through the converter and to open to the central plant chilled-water flow, and place the control of pump under control of the system time clock, the cooling pilot light shall turn on and the heating pilot light shall turn off. During the occupied mode, pump shall operate continuously. When the time clock places the control system in the unoccupied mode, pump shall stop.

3.3.12 Single Building Dual-Temperature Hydronic

Heating and Cooling Modes shall be manually selected. The position of the dual-temperature changeover valves shall be manually selected.

a. Heating Mode - When the heating mode is selected, chiller shall be stopped and the cooling pilot light shall turn off. Distribution pump shall continue to operate until the expiration of a time delay as recommended by the chiller manufacturer. At the expiration of the time delay, the distribution pump shall be under control of the outside-air temperature controller. The outside-air temperature controller shall accept a signal at its process variable input from a sunshielded outside-air temperature sensing element and transmitter located as shown. On a drop in outside-air temperature below its setpoint, the outside-air temperature controller process variable relay contact output shall start distribution pump. Starting of distribution pump shall start boiler, turn on the heating pilot light, and enable control of the hydronic-heating system control valve, once flow through the heating loop is proven by the flow switch. The analog output of the outside-air temperature controller shall send a signal to the remote setpoint input of the primary hydronic-heating system temperature controller to reset the hydronic-heating supply temperature setpoint in a linear schedule based on the outside-air temperature as shown. The hydronic-heating supply temperature controller shall accept a signal at its process variable input from a temperature sensing element and transmitter located in the hydronic-heating supply line and the controller output shall modulate the hydronic-heating system control valve to maintain the reset schedule setpoint in the hydronic-heating supply line.

b. Cooling Mode - When the cooling mode is selected, boiler shall be stopped, the heating pilot light shall turn off, and control of the hydronic heating system control valve shall be disabled. The distribution pump shall continue to circulate water through the system with the boiler shut off. When the system return-water temperature drops below the setpoint shown, the aquastat shall allow the changeover valves to close to flow through the boiler and to open to flow through the chiller, and place distribution pump and chiller under control of the system time clock. During the occupied mode, distribution pump shall operate continuously, the chiller shall be permitted to operate, and the cooling pilot light shall be lit. When the timeclock places the control system in the unoccupied mode, chiller shall shut down and the cooling pilot light shall turn off. Distribution pump shall continue to operate until the expiration of the time delay.

3.3.13 Heating and Ventilating Sequence

3.3.13.1 Occupied, Unoccupied, and Ventilation-Delay Operating Modes

Ventilation-delay-mode timing shall start prior to the occupied-mode timing. The time clock shall close a contact, which shall turn on the ventilation-delay pilot light and energize a relay which shall prevent the outside-air damper from opening. At the time shown, the time clock shall close a contact which shall turn on the occupied-mode pilot light and shall place the system in the occupied mode. At the expiration of the ventilation-delay-mode timing period, the time clock shall open the contact to turn off the ventilation-delay-mode pilot light and de-energize a relay to allow the outside-air damper to open. At the time shown, the time clock shall open the contact to turn off the occupied-mode pilot light and shall place the control system in the unoccupied mode of operation.

3.3.13.2 Outside-Air, Return-Air, and Relief-Air Dampers

a. Occupied Mode - The outside-air, return-air, and relief-air dampers shall be under space temperature control.

b. Unoccupied and Ventilation-Delay Modes - The dampers shall return to their normal positions.

3.3.13.3 Supply-Fan Control

a. Occupied and Ventilation-Delay Modes - Supply fan shall start and shall operate continuously.

b. Unoccupied Mode - The supply fan shall cycle from a night-thermostat. The fan shall start at and stop at the setpoints shown.

3.3.13.4 Filter

A differential-pressure switch across the filter shall turn on the filter pilot light when the pressure drop across the filter reaches the setpoint shown.

3.3.13.5 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside-air, return-air, and relief-air dampers to return to their normal position as shown; and turn on the low-temperature pilot light in the HVAC control panel if the temperature drops below the freezestat's setpoint as shown. Return to the normal mode of operation shall require manual reset at the freezestat and at the HVAC control panel.

3.3.13.6 Space Temperature Control

A space-temperature sensing-element and transmitter operating through a space-temperature controller shall first gradually shut off the heating-coil valve. After the heating-coil valve is fully closed, the controller shall then gradually operate the outside-air damper to admit outside air beyond the minimum quantity to maintain the setpoint shown.

3.3.13.7 Emergency Fan Shutdown

Activation of a duct smoke detector in the supply-air or return-air ductwork, or activation of a manual emergency fan shutdown switch shall cause the associated fan to shutdown in accordance with NFPA 90A. Activation of these devices shall operate a pilot light on the HVAC control panel. The panel shall require manual resetting after the detector and the manual switch are reset.

3.3.14 Multizone Control Sequence with Return Fan

Multizone control sequence shall consist of the following:

3.3.14.1 Occupied, Unoccupied, and Ventilation-Delay Modes

Ventilation-delay-mode timing shall start prior to the occupied-mode timing. The time clock shall close a contact, which shall turn on the ventilation-delay pilot light and energize a relay which shall prevent the outside-air damper from opening. At the time shown, the time clock shall close a contact which shall turn on the occupied-mode pilot light and shall place the system in the occupied mode. At the expiration of the ventilation-delay-mode timing period, the time clock shall open the contact to turn off the ventilation-delay-mode pilot light and de-energize a relay to allow the outside-air damper to open. At the time shown, the time clock shall open the contact to turn off the occupied-mode pilot light and shall place the control system in the unoccupied mode of operation.

3.3.14.2 Outside-Air, Return-Air, and Relief-Air Dampers

a. Occupied Mode - The outside-air, return-air, and relief-air dampers shall be under mixed-air temperature and economizer control.

b. Unoccupied and Ventilation-Delay Modes - The dampers shall return to their normal positions.

3.3.14.3 Supply-Fan and Return-Fan Control

a. Occupied and Ventilation-Delay Modes - Supply fan and return fan shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan and the return fan shall cycle from a night-thermostat. The fans shall start at and stop at the setpoints shown.

3.3.14.4 Filter

A differential-pressure switch across the filter shall turn on the filter pilot light when the pressure drop across the filter reaches the setpoint shown.

3.3.14.5 Hot-Deck Heating Coil

All Modes - The heating coil temperature controller shall accept a signal at its process variable input from a temperature sensing element and transmitter located in the discharge air of the coil, and the controller output shall modulate the heating coil control valve to maintain the setpoint shown.

3.3.14.6 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply and return fans, cause the outside air, return air, and relief air dampers to return to their normal position as shown, and shall turn on the low-temperature pilot light in the HVAC control panel if the temperature drops below the freezestat's setpoint as shown. Return to the normal mode of operation shall require manual reset at the freezestat and at the HVAC control panel.

3.3.14.7 Cold-Deck Coil

a. Occupied and Ventilation-Delay Modes - The control valve shall be modulated by the cooling-coil temperature controller from the signal of a temperature-sensing element and transmitter located in the coil discharge air to maintain the setpoint shown.

b. Unoccupied Mode - The cooling-coil temperature-controller output signal shall be interrupted and the cooling-coil control valve shall be closed.

3.3.14.8 Economizer Control

An economizer controller shall accept the signal of an outside-air temperature-sensing element and transmitter at its process variable input and shall accept the signal of a return-air temperature-sensing element and transmitter at its remote setpoint input. The economizer controller shall perform switch-over between outside-air economizer control mode and minimum outside-air mode. Until the outside-air temperature rises above the setpoint as shown, the economizer controller shall hold the system in the minimum-outside-air mode and the economizer pilot light shall be off. When the outside-air temperature rises above the setpoint, the economizer controller shall place the control system in the economizer mode or in the SECTION 15950A Page 57 minimum-outside-air mode as determined by a comparison of the outside-air and return-air temperatures in accordance with the differential temperature setpoints as shown. When the outside-air temperature is low with respect to the return-air temperature, the control system shall be in the economizer mode and the economizer pilot light shall be on. When the economizer controller places the control system in the minimum-outside-air mode, the outside-air damper shall be open to the setting determined by the minimum-position switch.

3.3.14.9 Mixed-Air Temperature Control

When the economizer controller places the system in the economizer mode, the mixed-air temperature controller shall modulate the dampers from the signal of a temperature-sensing element and transmitter located in the mixed-air stream to maintain the setpoint shown.

3.3.14.10 Zone-Damper Control

All Modes - A space thermostat for each zone shall gradually operate the zone-mixing damper to heat and cool its respective zone by mixing cold-deck air and hot-deck air to maintain the setpoint as shown. On a rise in space temperature, the hot-deck damper shall gradually close, and the cold-deck damper shall gradually open.

3.3.14.11 Emergency Fan Shutdown

Activation of a duct smoke detector in the supply-air or return-air ductwork, or activation of a manual emergency fan shutdown switch shall cause the associated fan to shutdown in accordance with NFPA 90A. Activation of these devices shall operate a pilot light on the HVAC control panel. The panel shall require manual resetting after the detector and the manual switch are reset.

3.3.15 Dual-Duct Multizone Control Sequence with Return Fan

3.3.15.1 Occupied, Unoccupied, and Ventilation-Delay Modes

Ventilation-delay mode timing shall start prior to the occupied-mode timing. The time clock shall close a contact, which shall turn on the ventilation-delay pilot light and energize a relay which shall prevent the outside air-damper from opening. At the time shown, the time clock shall close a contact which shall turn on the occupied-mode pilot light and shall place the system in the occupied mode. At the expiration of the ventilation-delay-mode timing period, the time clock shall open the contact to turn off the ventilation-delay-mode pilot light and de-energize a relay to allow the outside-air damper to open. At the time shown, the time clock shall open the contact to turn off the occupied-mode pilot light and shall place the control system in the unoccupied mode of operation.

3.3.15.2 Outside-Air, Return-Air, and Relief-Air Dampers

a. Occupied Mode - The outside-air, return-air, and relief-air dampers shall be under mixed-air temperature and economizer control.

b. Unoccupied and Ventilation-Delay Modes - The dampers shall return to their normal positions.

3.3.15.3 Supply-Fan and Return-Fan Control

a. Occupied and Ventilation-Delay Modes - Supply fan and return fan shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan and the return fan shall cycle from a night-thermostat. The fans shall start and stop at the setpoints shown.

3.3.15.4 Filter

A differential-pressure switch across the filter shall turn on the filter pilot light when the pressure drop across the filter reaches the setpoint shown.

3.3.15.5 Hot-duct Heating Coil

All Modes - The heating coil temperature controller shall accept a signal at its process variable input from a temperature sensing element and transmitter located in the discharge air of the coil, and the controller output shall modulate the heating coil control valve to maintain the setpoint shown.

3.3.15.6 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply and return fans, cause the outside air, return air, and relief air dampers to return to their normal position as shown, and shall turn on the low-temperature pilot light in the HVAC control panel if the temperature drops below the freezestat's setpoint as shown. Return to the normal mode of operation shall require manual reset at the freezestat and at the HVAC control panel.

3.3.15.7 Cold-Duct Cooling Coil

a. Occupied and Ventilation-Delay Modes - The control valve shall be modulated by the cooling-coil temperature controller from the signal of a temperature-sensing element and transmitter located in the coil discharge air to maintain the setpoint shown.

b. Unoccupied Mode - The cooling-coil temperature controller output signal shall be interrupted, and the cooling-coil control valve shall be closed.

3.3.15.8 Economizer Control

An economizer controller shall accept the signal of an outside-air temperature-sensing element and transmitter at its process variable input and shall accept the signal of a return-air temperature-sensing element and transmitter at its remote setpoint input. The economizer controller shall perform switchover between outside-air economizer control mode and minimum outside-air mode. Until the outside-air temperature rises above the setpoint as shown, the economizer controller shall hold the system in the minimum-outside-air mode and the economizer pilot light shall be off. When the outside-air temperature rises above the setpoint, the economizer controller shall place the control system in the economizer mode or in the minimum-outside-air mode as determined by a comparison of the outside-air and return-air temperatures in accordance with the differential temperature setpoints as shown. When the outside-air temperature is low with respect to the return-air temperature, the control system shall be in the economizer mode and the economizer pilot light shall be on. When the economizer controller places the control system in the minimum-outside-air SECTION 15950A Page 60 mode, the outside-air damper shall be open to the setting determined by the minimum-position switch.

3.3.15.9 Mixed-Air Temperature Control

When the economizer controller places the system in the economizer mode, the mixed-air temperature controller shall modulate the dampers from the signal of a temperature-sensing element and transmitter located in the mixed-air stream to maintain the setpoint shown.

3.3.15.10 Dual-Duct Terminal Box

All Modes - The control dampers of the dual-duct box shall modulate in response to the signal of a space thermostat. When the space temperature decreases, the controller shall gradually close the cold-duct damper and shall gradually open the hot-duct damper to maintain the setpoint shown.

3.3.15.11 Emergency Fan Shutdown

Activation of a duct smoke detector in the supply-air or return-air ductwork, or activation of a manual emergency fan shutdown switch shall cause the associated fan to shutdown in accordance with NFPA 90A. Activation of these devices shall operate a pilot light on the HVAC control panel. The panel shall require manual resetting after the detector and the manual switch are reset.

3.3.16 Bypass Multizone Control Sequence with Return Fan

3.3.16.1 Occupied, Unoccupied, and Ventilation-Delay Modes

Ventilation-delay-mode timing shall start prior to the occupied-mode timing. The time clock shall close a contact which shall turn on the ventilation-delay pilot light and energize a relay which shall prevent the outside-air damper from opening. At the time shown, the time clock shall close a contact which shall turn on the occupied-mode pilot light and shall place the system in the occupied mode. At the expiration of the ventilation-delay-mode timing period, the time clock shall open the contact to turn off the ventilation-delay-mode pilot light and de-energize a relay to allow the outside-air damper to open. At the time shown, the time clock shall open the contact to turn off the occupied-mode pilot light and shall place the control system in the unoccupied mode of operation.

3.3.16.2 Outside-Air, Return-Air, and Relief-air Dampers

a. Occupied Mode - The outside-air, return-air, and relief-air dampers shall be under mixed-air temperature and economizer control.

b. Unoccupied and Ventilation-Delay Modes - The dampers shall return their normal positions.

3.3.16.3 Supply-Fan and Return-Fan Control

a. Occupied and Ventilation-Delay Modes - Supply fan and return fan shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan and the return fan shall cycle from a night-thermostat. The fans shall start at and stop at the setpoints shown.

3.3.16.4 Filter

A differential-pressure switch across the filter shall turn on the filter pilot light when the pressure drop across the filter reaches the setpoint shown.

3.3.16.5 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply and return fans, cause the outside air, return air, and relief air dampers to return to their normal position as shown, and shall turn on the low-temperature pilot light in the HVAC control panel if the temperature drops below the freezestat's setpoint as shown. Return to the normal mode of operation shall require manual reset at the freezestat and at the HVAC control panel.

3.3.16.6 Cold-Deck Coil

a. Occupied and Ventilation-Delay Modes - The control valve shall be modulated by the cooling-coil temperature controller from the signal of a temperature-sensing element and transmitter located in the coil discharge air to maintain the setpoint shown.

b. Unoccupied Mode - The cooling-coil temperature-controller output signal shall be interrupted and the cooling-coil control valve shall be closed.

3.3.16.7 Economizer Control

An economizer controller shall accept the signal of an outside-air temperature-sensing element and transmitter at its remote setpoint input and shall accept the signal of a return-air temperature-sensing element and transmitter at its process variable input. The economizer controller shall perform switchover between outside-air economizer control mode and minimum outside-air mode. Until the return-air temperature rises above the setpoint as shown, the economizer controller shall hold the system in the minimum-outside-air mode and the economizer pilot light shall be off. When the return-air temperature rises above the setpoint, the economizer controller shall place the control system in the economizer mode or in the minimum-outside-air mode as determined by a comparison of the outside-air and return-air temperatures in accordance with the differential temperature setpoints as shown. When the outside-air temperature is low with respect to the return-air temperature, the control system shall be in the SECTION 15950A Page 62 economizer mode and the economizer pilot light shall be on. When the economizer controller places the control system in the minimum-outside-air mode, the outside-air damper shall be open to the setting determined by the minimum-position switch.

3.3.16.8 Mixed-Air Temperature Control

When the economizer controller places the system in the economizer mode, the mixed-air temperature controller shall modulate the dampers from the signal of a temperature-sensing element and transmitter located in the mixed-air stream to maintain the setpoint shown.

3.3.16.9 Zone Control

All Modes - A space thermostat for each zone shall gradually operate the zone-mixing damper and heating coil to heat and cool its respective zone by mixing cold-deck air and bypass-deck air to maintain the setpoint as shown. On a rise in space temperature the heating coil valve shall gradually close, and after a dead band as shown, the bypass damper shall gradually close, and the cold-deck damper shall gradually open.

3.3.16.10 Emergency Fan Shutdown

Activation of a duct smoke detector in the supply-air or return-air ductwork, or activation of a manual emergency fan shutdown switch shall cause the associated fan to shutdown in accordance with NFPA 90A. Activation of these devices shall operate a pilot light on the HVAC control panel. The panel shall require manual resetting after the detector and the manual switch are reset.

3.3.17 Variable Air Volume Control Sequence without Return Fan

3.3.17.1 Occupied, Unoccupied, and Ventilation Delay Modes

Ventilation delay mode timing shall start prior to the occupied mode timing. The time clock shall close a contact, which shall turn on the ventilation delay pilot light and energize a relay which shall prevent the outside air damper from opening, except when under economizer control. At the time shown, the time clock shall close a contact which shall turn on the occupied mode pilot light and shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the time clock shall open the contact to turn off the ventilation delay mode pilot light and de-energize a relay to allow the minimum outside air damper to open. At the time shown, the time clock shall open the contact to turn off the occupied mode pilot light and shall place the control system in the unoccupied mode of operation.

3.3.17.2 Outside Air, Return Air, and Relief Air Dampers

a. Occupied Mode - The economizer outside air, return air, and relief air dampers shall be under mixed air temperature and economizer control. The minimum outside air damper shall be under minimum outside air flow control.

b. Unoccupied Mode - The dampers shall return to their normal positions shown.

c. Ventilation Delay Modes - The minimum outside air damper shall remain closed. The other dampers shall remain in their normal positions as shown, except when under economizer control.

3.3.17.3 Supply Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan shall start and shall operate continuously.

b. Unoccupied Mode - The supply fan shall cycle from a night thermostat located as shown. The fan shall start at and stop the setpoints shown.

3.3.17.4 Supply Duct Pressurization Control

When the supply fan starts, the duct static pressure controller shall modulate the inlet vanes from the signal of a pressure sensing element and transmitter to maintain the setpoint as shown. A high limit static pressure switch in the fan discharge shall stop the fan and turn on the high static pilot light when the static pressure exceeds the setpoint. Restarting the supply fan and turning off the pilot light shall require manual reset at the HVAC control panel. When the fan is off, the inlet vane shall be closed.

3.3.17.5 Filter

A differential pressure switch across the filter shall turn on the filter pilot light when the pressure drop across the filter reaches the setpoint shown.

3.3.17.6 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside air, return air, and relief air dampers to return to their normal position as shown, and shall turn on the low temperature pilot light in the HVAC control panel if the temperature drops below the freezestat's setpoint as shown. Return to the normal mode of operation shall require manual reset [at the freezestat and] at the HVAC control panel.

3.3.17.7 Cooling Coil

a. Occupied and Ventilation Delay Modes - The control valve shall be modulated by the cooling coil temperature controller from the signal of a temperature sensing element and transmitter located in the coil discharge air to maintain the setpoint shown.

b. Unoccupied Mode - The cooling coil temperature controller output signal shall be interrupted and the cooling coil control valve shall be closed.
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3.3.17.8 Minimum Outside Air Control

a. Occupied Mode - The minimum outside air damper shall be modulated by the outside air flow controller to maintain the minimum outside air flow at setpoint, as sensed by an air flow measurement station located in the minimum outside air duct.

b. Unoccupied and Ventilation Delay Modes - The minimum outside air damper shall remain closed.

3.3.17.9 Economizer Control

An economizer controller shall accept the signal of an outside air temperature sensing element and transmitter at its remote setpoint input and shall accept the signal of a return air temperature sensing element and transmitter at its process variable input. When the return air temperature rises above the setpoint and the outside air temperature is sufficiently below the return air temperature to be effective for cooling, as determined by a comparison of the outside air and return air temperatures in accordance with the differential temperature setpoints, the economizer controller shall place the control system in the economizer mode and turn on the economizer pilot light. When the system is not in economizer mode, the economizer outside air and relief air dampers shall remain closed, the return air damper shall remain open, and the economizer pilot light shall be off.

3.3.17.10 Mixed Air Temperature Control

When the economizer controller places the system in the economizer mode, the mixed air temperature controller shall modulate the economizer outside air, relief air, and the return air dampers to maintain the mixed air temperature at setpoint, as sensed by a temperature sensing element and transmitter located in the mixed air stream as shown. As the economizer outside air and relief air dampers open, the return air damper shall close. When the system is not in economizer mode, the economizer outside air and relief air dampers shall remain closed and the return air damper shall remain open.

3.3.17.11 Pressure Independent Terminal VAV Box

All Modes - The control damper of the VAV box shall modulate in response to the signal from a flow sensing element at the discharge or inlet of the VAV box to a microprocessor-based VAV box velocity controller. The velocity controller shall control the box damper from the minimum flow position to the full flow position from the signal of a space temperature sensing element located as shown. When the space temperature decreases, the damper shall gradually close to the minimum flow position to maintain the cooling setpoint as shown. When the space temperature calls for heating after the minimum flow position is reached, control shall then pass through a temperature dead band as shown. When the space temperature has dropped through the dead band, the duct heater coil shall be gradually controlled to maintain the heating setpoint shown.

3.3.17.12 Fan Powered Terminal VAV Box

a. Series Fan Powered Terminal VAV Box: All Modes - The VAV box fan shall be energized from an upstream duct pressure switch confirming HVAC system fan operation. A space temperature sensing element, located as shown, acting through a microprocessor-based VAV-box controller, shall modulate the supply air control damper, mixing the supply air and recirculating room air to provide a constant volume of air to the space to maintain the cooling set point until the supply air damper closes to minimum supply airflow. When the space temperature calls for heat after the supply air damper is closed to minimum flow and the VAV box is in maximum recirculation, control shall then pass through the temperature dead band as shown. When the space temperature has dropped through the temperature dead band, the duct heater coil shall be gradually controlled to maintain the heating setpoint.

b. Parallel Fan Powered Terminal VAV box: All Modes - A space temperature sensing element, located as shown, acting through a microprocessor-based VAV box controller, shall modulate the supply air control damper to maintain the cooling setpoint until the supply air damper closes to minimum supply airflow. When the space temperature calls for heat after the supply air damper is closed to minimum flow, control shall then pass through the temperature dead band as shown. When the space temperature has dropped through the temperature dead band, the VAV box fan shall be energized. When the space temperature has dropped through a second temperature dead band, the duct heater coil shall be gradually controlled to maintain the heating setpoint.

3.3.17.13 Emergency Fan Shutdown

Activation of a duct smoke detector in the supply air or return air ductwork, or activation of a manual emergency fan, shutdown switch shall cause the associated fan to shut down in accordance with NFPA 90A. Activation of these devices shall operate a pilot light on HVAC control panel. The panel shall require manual resetting after the detector and the manual switch are reset.

3.3.18 Variable Air Volume Control Sequence with Return Fan

3.3.18.1 Occupied, Unoccupied, and Ventilation Delay Modes

Ventilation delay mode timing shall start prior to the occupied mode timing. The time clock shall close a contact, which shall turn on the ventilation delay pilot light and energize a relay which shall prevent the outside air damper from opening, except when under economizer control. At the time shown, the time clock shall close a contact which shall turn on the occupied mode pilot light and shall place the system in the occupied mode. At the expiration of the ventilation delay mode timing period, the time clock shall open the contact to turn off the ventilation delay mode pilot light and de-energize a relay to allow the minimum outside air damper to open. At the time shown, the time clock shall open the contact to turn off the occupied mode pilot light and shall place the control system in the unoccupied mode of operation.

3.3.18.2 Outside Air, Return Air, and Relief Air Dampers

a. Occupied Mode - The economizer outside air, return air, and relief air dampers shall be under mixed air temperature and economizer control. The minimum outside air damper shall be under minimum outside air flow control.

b. Unoccupied Mode - The dampers shall return to their normal positions shown.

c. Ventilation Delay Modes - The minimum outside air damper shall remain closed. The other dampers shall remain in their normal positions as shown, except when under economizer control.

3.3.18.3 Supply Fan and Return Fan Control

a. Occupied and Ventilation Delay Modes - Supply fan and return fan shall start and operate continuously.

b. Unoccupied Mode - The supply fan and the return fan shall cycle from a night thermostat. The fans shall start at and stop the setpoints shown.

3.3.18.4 Supply Duct Pressurization Control

When the supply fan starts, the duct static pressure controller shall modulate the inlet vanes from the signal of a pressure sensing element and transmitter to maintain the setpoint shown. A high limit static pressure switch in the fan discharge shall stop the supply fan and the return fan and turn on the high static pilot light when the static pressure exceeds the setpoint. Restarting the supply fan and the return fan and turning off the pilot light shall require manual reset at the HVAC control panel. When the fan is off, the inlet vane shall be closed.

3.3.18.5 Return Fan Volume Control

When the return fan starts, the return fan volume controller shall modulate the return fan inlet vanes, from the signals of an airflow measurement station and transmitter located in the return fan inlet ductwork, and an airflow measurement station and transmitter located in the supply fan outlet ductwork. A constant difference between supply air and return air flow rates shall be maintained as shown.

3.3.18.6 Filter

A differential pressure switch across the filter shall turn on the filter pilot light when the pressure drop across the filter reaches the setpoint shown.

3.3.18.7 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply and return fans, cause the outside air, return air, and relief air dampers to SECTION 15950A Page 67 return to their normal position, and shall turn on the low temperature pilot light in the HVAC control panel if the temperature drops below the freezestat's setpoint. Return to the normal mode of operation shall require manual reset at the freezestat and at the HVAC control panel.

3.3.18.8 Cooling Coil

a. Occupied and Ventilation Delay Modes - The control valve shall be modulated by the cooling coil temperature controller from the signal of a temperature sensing element and transmitter located in the coil discharge air to maintain the setpoint shown.

b. Unoccupied Mode - The cooling coil temperature controller output signal shall be interrupted and the cooling coil control valve shall be closed.

3.3.18.9 Minimum Outside Air Control

a. Occupied Mode - The minimum outside air damper shall be modulated by the outside air flow controller to maintain the minimum outside air flow at setpoint, as sensed by an air flow measurement station located in the minimum outside air duct.

b. Unoccupied and Ventilation Delay Modes - The minimum outside air damper shall remain closed.

3.3.18.10 Economizer Control

An economizer controller shall accept the signal of an outside air temperature sensing element and transmitter at its remote setpoint input and shall accept the signal of a return air temperature sensing element and transmitter at its process variable input. When the return air temperature rises above the setpoint and the outside air temperature is sufficiently below the return air temperature to be effective for cooling, as determined by a comparison of the outside air and return air temperatures in accordance with the differential temperature setpoints, the economizer controller shall place the control system in the economizer mode and turn on the economizer pilot light. When the system is not in economizer mode, the economizer outside air and relief air dampers shall remain closed, the return air damper shall remain open, and the economizer pilot light shall be off.

3.3.18.11 Mixed Air Temperature Control

When the economizer controller places the system in the economizer mode, the mixed air temperature controller shall modulate the economizer outside air, relief air, and the return air dampers to maintain the mixed air temperature at setpoint, as sensed by a temperature sensing element and transmitter located in the mixed air stream, as shown. As the economizer outside air and relief air dampers open, the return air damper shall close. When the system is not in economizer mode, the economizer outside air and relief air dampers shall remain closed and the return air damper shall remain open.

3.3.18.12 Pressure Independent Terminal VAV Box

All Modes - The control damper of the VAV box shall modulate in response to the signal from a flow sensing element at the discharge or inlet of the VAV box to a microprocessor-based VAV box velocity controller. The velocity controller shall control the box damper from the minimum flow position to the full flow position from the signal of a space temperature sensing element located as shown. When the space temperature decreases, the damper shall gradually close to the minimum flow position to maintain the cooling setpoint. When the space temperature calls for heating after the minimum flow position is reached, control shall then pass through a temperature dead band, as shown. When the space temperature has dropped through the dead band, the duct heater coil shall be gradually controlled to maintain the heating setpoint.

3.3.18.13 Fan Powered Terminal VAV Box

a. Series Fan Powered Terminal VAV Box: All Modes - The VAV box fan shall be energized from an upstream duct pressure switch confirming HVAC system fan operation. A space temperature sensing element, located as shown, acting through a microprocessor-based VAV box controller, shall modulate the supply air control damper, mixing the supply air and recirculating room air to provide a constant volume of air to the space to maintain the cooling setpoint until the supply air damper closes to minimum supply airflow. When the space temperature calls for heat after the supply air damper is closed to minimum flow and the VAV box is in maximum recirculation, control shall then pass through the temperature dead band, as shown. When the space temperature has dropped through the temperature dead band, the duct heater coil shall be gradually controlled to maintain the heating setpoint.

b. Parallel Fan Powered Terminal VAV Box: All Modes - A space temperature sensing element, located as shown, acting through a microprocessor-based VAV box controller, shall modulate the supply air control damper to maintain the cooling setpoint until the supply air damper closes to minimum supply airflow. When the space temperature calls for heat after the supply air damper is closed to minimum flow, control shall then pass through the temperature dead band, as shown. When the space temperature has dropped through the temperature dead band, the VAV box fan shall be energized. When the space temperature has dropped through a second temperature dead band, the duct heater coil shall be gradually controlled to maintain the heating setpoint.

3.3.18.14 Emergency Fan Shutdown

Activation of a duct smoke detector in the supply air or return air ductwork, or activation of a manual emergency fan shutdown switch shall cause the associated fan to shut down in accordance with NFPA 90A. Activation of these devices shall operate a pilot light on the HVAC control panel. The panel shall require manual resetting after the detector and the manual switch are reset. SECTION 15950A Page 69

3.3.19 Single-Zone with Hydronic Heating/Cooling Coils No Return Fan

3.3.19.1 Occupied, Unoccupied, and Ventilation-Delay Modes

Ventilation-delay-mode timing shall start prior to the occupied-mode timing. The time clock shall close a contact, which shall turn on the ventilation-delay pilot light and energize a relay which shall prevent the outside-air damper from opening. At the time shown, the time clock shall close a contact which shall turn on the occupied-mode pilot light and shall place the system in the occupied mode. At the expiration of the ventilation-delay-mode timing period, the time clock shall open the contact to turn off the ventilation-delay-mode pilot light and de-energize a relay to allow the outside-air damper to open. At the time shown, the time clock shall open the contact to turn off the occupied-mode pilot light and shall place the control system in the unoccupied mode of operation.

3.3.19.2 Outside-Air, Return-Air, and Relief-Air Dampers

a. Occupied Mode - The outside-air, return-air, and relief-air dampers shall be under space temperature and economizer control.

b. Unoccupied and Ventilation-Delay Modes - The dampers shall return to their normal positions.

3.3.19.3 Supply-Fan Control

a. Occupied and Ventilation-Delay Modes - Supply fan shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan shall cycle from a night thermostat. The fan shall start and stop at the setpoints shown.

3.3.19.4 Filter

A differential-pressure switch across the filter shall turn on the filter pilot light when the pressure drop across the filter reaches the setpoint shown.

3.3.19.5 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside air, return air, and relief air dampers to return to their normal position as shown, and shall turn on the low-temperature pilot light in the HVAC control panel if the temperature drops below the freezestat's setpoint shown. Return to the normal mode of operation shall require manual reset at the freezestat and at the HVAC control panel.

3.3.19.6 Hydronic Cooling Coil

a. Occupied and Ventilation-Delay Modes - The control valve shall be modulated by the space-temperature controller.

b. Unoccupied Mode - The space-temperature controller output signal shall be interrupted and the cooling-coil control valve shall be closed.

3.3.19.7 Economizer Control

An economizer controller shall accept the signal of an outside-air temperature-sensing element and transmitter at its remote setpoint input and shall accept the signal of a return-air temperature-sensing element and transmitter at its process variable input. The economizer controller shall perform switchover between outside-air economizer control mode and minimum outside-air mode. Until the return-air temperature rises above the setpoint as shown, the economizer controller shall hold the system in the minimum-outside-air mode and the economizer pilot light shall be off. When the return-air temperature rises above the setpoint, the economizer controller shall place the control system in the economizer mode or in the minimum-outside-air mode as determined by a comparison of the outside-air and return-air temperatures in accordance with the differential temperature setpoints as shown. When the outside-air temperature is low with respect to the return-air temperature, the control system shall be in the economizer mode and the economizer pilot light shall be on. When the economizer controller places the control system in the minimum-outside-air mode, the outside-air damper shall be open to the setting determined by the minimum-position switch.

3.3.19.8 Space-Temperature-Sequenced Heating and Cooling Control

A space-temperature sensing element and transmitter operating through a space-temperature controller shall maintain the setpoint by sequencing the valves and dampers as shown. On a rise in space temperature, the space-temperature controller shall first gradually close the heating-coil valve. After the controller output passes through a dead band, the controller shall then gradually operate the outside-air damper to admit outside air beyond the minimum quantity, except that when the economizer controller places the system in the minimum-outside-air mode, the outside-air damper shall be open to the setting as determined by the minimum-position switch. After the outside-air damper is fully open, upon a further rise in space temperature, the controller shall then gradually open the cooling-coil valve to maintain the setpoint shown.

3.3.19.9 Emergency Fan Shutdown

Activation of a duct smoke detector in the supply-air or return-air ductwork, or activation of a manual emergency fan shutdown switch shall cause the associated fan to shutdown in accordance with NFPA 90A. Activation of these devices shall operate a pilot light on the HVAC control panel. The panel shall require manual resetting after the detector and the manual switch are reset.

3.3.20 Single-Zone with Dual-Temperature Coil; No Return Fan

3.3.20.1 Occupied, Unoccupied, and Ventilation-Delay Modes

Ventilation-delay-mode timing shall start prior to the occupied-mode timing. The time clock shall close a contact, which shall turn on the ventilation-delay pilot light and energize a relay which shall prevent the SECTION 15950A Page 71 outside-air damper from opening. At the time shown, the time clock shall close a contact which shall turn on the occupied-mode pilot light and shall place the system in the occupied mode. At the expiration of the ventilation-delay-mode timing period, the time clock shall open the contact to turn off the ventilation-delay-mode pilot light and de-energize a relay to allow the outside-air damper to open. At the time shown, the time clock shall open the contact to turn off the occupied-mode pilot light and shall place the control system in the unoccupied mode of operation.

3.3.20.2 Outside-Air, Return-Air, and Relief-Air Dampers

a. Occupied Mode - The outside-air, return-air, and relief-air dampers shall be under space temperature and economizer control.

b. Unoccupied and Ventilation-Delay Modes - The dampers shall return to their normal positions shown.

3.3.20.3 Supply-Fan Control

a. Occupied and Ventilation-Delay Modes - Supply fan shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan shall cycle from a night thermostat. The fan shall start at and stop at the setpoints shown.

3.3.20.4 Filter

A differential-pressure switch across the filter shall turn on the filter pilot light when the pressure drop across the filter reaches the setpoint shown.

3.3.20.5 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside air, return air, and relief air dampers to return to their normal position as shown, and shall turn on the low-temperature pilot light in the HVAC control panel if the temperature drops below the freezestat's setpoint as shown. Return to the normal mode of operation shall require manual reset at the freezestat and at the HVAC control panel.

3.3.20.6 Dual-Temperature Coil Changeover Control

An aquastat, set at the setpoint shown, shall select the heating-season space-temperature controller or the cooling-season space-temperature controller to operate the dual-temperature coil control valve. When hydronic heating is supplied to the dual-temperature coil, the heating-season controller shall be selected to control the dual-temperature control valve as a heating-coil valve in sequence with the outside-air, return-air and relief-air dampers, the heating pilot light shall turn on and the cooling pilot light shall turn off. When hydronic cooling is supplied to the dual-temperature coil, the cooling-season controller shall be selected to operate the dual-temperature control valve as a cooling-coil SECTION 15950A Page 72 valve in sequence with outside-air, return-air and relief-air dampers, the cooling pilot light shall turn on and the heating pilot light shall turn off.

3.3.20.7 Dual-Temperature Coil

All Modes - The dual-temperature coil valve shall be modulated by the heating-season controller or by the cooling-season controller as selected.

3.3.20.8 Economizer Control

An economizer controller shall accept the signal of an outside-air temperature-sensing element and transmitter at its remote setpoint input and shall accept the signal of a return-air temperature-sensing element and transmitter at its process variable input. The economizer controller shall perform switchover between outside-air economizer control mode and minimum outside-air mode. Until the return-air temperature rises above the setpoint as shown, the economizer controller shall hold the system in the minimum-outside-air mode and the economizer pilot light shall be off. When the return-air temperature rises above the setpoint, the economizer controller shall place the control system in the economizer mode or in the minimum-outside-air mode as determined by a comparison of the outside-air and return-air temperatures in accordance with the differential temperature setpoints as shown. When the outside-air temperature is low with respect to the return-air temperature, the control system shall be in the economizer mode and the economizer pilot light shall be on. When the economizer controller places the control system in the minimum-outside-air mode, the outside-air damper shall be open to the setting determined by the minimum-position switch.

3.3.20.9 Space-Temperature-Sequenced Heating Control

A space-temperature sensing element and transmitter operating through the heating-season space-temperature controller shall maintain the setpoint by sequencing the dual-temp coil valve and the dampers as shown. On a rise in space temperature, the controller shall first gradually close the coil valve. After the controller output passes through a dead band, the controller shall then gradually operate the outside-air damper to admit outside air beyond the minimum quantity, except that when the economizer controller places the system in the minimum-outside-air mode, the outside-air damper shall be open to the setting as determined by the minimum-position switch.

3.3.20.10 Space-Temperature Sequenced Cooling Control

A space-temperature sensing element and transmitter operating through the cooling-season space-temperature controller shall maintain the setpoint by sequencing the dual-temp coil valve and the dampers as shown. On a rise in space temperature, the controller shall first gradually open the outside-air damper to admit outside-air beyond the minimum quantity, except that when the economizer controller places the system in the minimum-outside-air mode, the outside-air damper shall be open to the setting as determined by the minimum-position switch. When the outside-air damper is fully open, on a further rise in space temperature, the controller shall gradually open the coil valve.

3.3.20.11 Emergency Fan Shutdown

Activation of a duct smoke detector in the supply-air or return-air ductwork, or activation of a manual emergency fan shutdown switch shall cause the associated fan to shutdown in accordance with NFPA 90A. Activation of these devices shall operate a pilot light on the HVAC control panel. The panel shall require manual resetting after the detector and the manual switch are reset.

3.3.21 Single-Zone Control Sequence with Humidity Control; No Return Fan

3.3.21.1 Occupied, Unoccupied, and Ventilation Delay Modes

Ventilation-delay-mode timing shall start prior to the occupied-mode timing. The time clock shall close a contact, which shall turn on the ventilation-delay pilot light and energize a relay which shall prevent the outside-air damper from opening. At the time shown, the time clock shall close a contact which shall turn on the occupied-mode pilot light and shall place the system in the occupied mode. At the expiration of the ventilation-delay-mode timing period, the time clock shall open the contact to turn off the ventilation-delay-mode pilot light and de-energize a relay to allow the outside-air damper to open. At the time shown, the time clock shall open the contact to turn off the occupied-mode pilot light and shall place the control system in the unoccupied mode of operation.

3.3.21.2 Outside-Air Damper

a. Occupied Mode - The outside-air damper shall open.

b. Unoccupied and Ventilation-Delay Modes - The damper shall close.

3.3.21.3 Supply-Fan Control

a. Occupied and Ventilation-Delay Modes - Supply fan shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan shall cycle from a night thermostat. The fan shall start and stop at the setpoint shown.

3.3.21.4 Filter

A differential-pressure switch across the filter shall turn on the filter pilot light when the pressure drop across the filter reaches the setpoint shown.

3.3.21.5 Outside-Air Preheat-Coil Control

All Modes - The preheat-coil temperature controller shall modulate the control valve from the signal of a temperature-sensing element and transmitter in the coil discharge air to maintain the setpoint shown.

3.3.21.6 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside air, return air, and relief air dampers to return to their normal position as shown, and shall turn on the low-temperature pilot light in the HVAC control panel if the temperature drops below the freezestat's setpoint as shown. Return to the normal mode of operation shall require manual reset at the freezestat and at the HVAC control panel.

3.3.21.7 Cooling Coil

a. Occupied and Ventilation Delay Modes - A high-signal selector shall compare the outputs from a space-temperature controller and a space- relative-humidity controller and use the highest of the two to modulate the cooling coil control valve.

b. Unoccupied Mode - The high-signal selector output signal shall be interrupted and the cooling coil control valve shall be closed.

3.3.21.8 Humidity Control

a . Occupied Mode - The space-relative-humidity controller shall operate the humidifier control valve and the cooling coil valve. The space-relative-humidity controller shall operate through a signal inverter and a high-signal selector to open the cooling coil valve in the event that the space relative humidity continues to rise after the humidifier valve is closed. The space-relative-humidity controller and a duct high-limit relative-humidity controller shall operate through a low-signal selector to control the humidifier valve. The space-relative-humidity controller shall gradually operate the humidifier valve from the signal of a relative-humidity sensing element and transmitter in the space to maintain the relative-humidity setpoint as shown. The duct high-limit relative-humidity controller shall receive a signal from a relative-humidity sensing element and transmitter in the ductwork downstream of the humidifier and shall limit the relative humidity at that point to a high-limit relative-humidity setpoint shown.

b. Unoccupied and Ventilation-Delay Modes - The signal to the humidifier valve shall be interrupted, and the humidifier valve shall be closed.

3.3.21.9 Constant-Temperature Hydronic-Heating Control

All Modes - A temperature controller shall accept signals from a temperature sensing element and transmitter in the heating supply line, and shall modulate the system control valve to maintain the setpoint shown.

3.3.21.10 Reheat

All Modes - A space thermostat shall gradually close the reheat-coil valve on a rise in space temperature to maintain the setpoint shown.

3.3.21.11 Emergency Fan Shutdown

Activation of a duct smoke detector in the supply-air or return-air ductwork, or activation of a manual emergency fan shutdown switch shall cause the associated fan to shutdown in accordance with NFPA 90A. Activation of these devices shall operate a pilot light on the HVAC control panel. The panel shall require manual resetting after the detector and the manual switch are reset.

3.3.22 Single-Zone - Hydronic Heating and Direct-Expansion Cooling Coils

3.3.22.1 Occupied, Unoccupied, and Ventilation-Delay Modes

Ventilation-delay mode timing shall start prior to the occupied-mode timing. The time clock shall close a contact, which shall turn on the ventilation-delay pilot light and energize a relay which shall prevent the outside-air damper from opening. At the time shown, the time clock shall close a contact which shall turn on the occupied-mode pilot light and shall place the system in the occupied mode. At the expiration of the ventilation-delay-mode timing period, the time clock shall open the contact to turn off the ventilation-delay mode pilot light and de-energize a relay to allow the outside-air damper to open. At the time shown, the time clock shall open the contact to turn off the occupied-mode pilot light and shall place the control system in the unoccupied mode of operation.

3.3.22.2 Outside-Air, Return-Air, and Relief-Air Dampers

a. Occupied Mode - The outside-air, return-air, and relief-air dampers shall be under mixed-air temperature and economizer control.

b. Unoccupied and Ventilation-Delay Modes - The dampers shall return to their normal positions shown.

3.3.22.3 Supply-Fan Control

a. Occupied and Ventilation-Delay Modes - Supply fan shall start, and shall operate continuously.

b. Unoccupied Mode - The supply fan shall cycle from a night-thermostat. The fan shall start at and stop at the setpoints shown.

3.3.22.4 Filter

A differential-pressure switch across the filter shall turn on the filter pilot light when the pressure drop across the filter reaches the setpoint shown.

3.3.22.5 Freeze Protection

All Modes - A freezestat, located as shown, shall stop the supply fan, cause the outside air, return air, and relief air dampers to return to their normal position as shown, and shall turn on the low-temperature pilot SECTION 15950A Page 76 light in the HVAC control panel if the temperature drops below the freezestat's setpoint shown. Return to the normal mode of operation shall require manual reset at the freezestat and at the HVAC control panel.

3.3.22.6 Direct Expansion Cooling Coil

a. Occupied and Ventilation-Delay Modes - The stages of cooling shall be operated by the space-temperature controller.

b. Unoccupied Mode - The space-temperature controller output signal shall be interrupted and cooling shall be off.

3.3.22.7 Economizer Control

An economizer controller shall accept the signal of an outside-air temperature-sensing element and transmitter at its remote setpoint input and shall accept the signal of a return-air temperature-sensing element and transmitter at its process variable input. The economizer controller shall perform switchover between outside-air economizer control mode and minimum-outside-air mode. Until the return-air temperature rises above the setpoint shown, the economizer controller shall hold the system in the minimum-outside-air mode and the economizer pilot light shall be off. When the return-air temperature rises above the setpoint, the economizer controller shall place the control system in the economizer mode or in the minimum-outside-air mode as determined by a comparison of the outside-air and return-air temperatures in accordance with the differential temperature setpoints shown. When the outside-air temperature is low with respect to the return-air temperature, the control system shall be in the economizer mode and the economizer pilot light shall be on. When the economizer controller places the control system in the minimum-outside-air mode, the outside-air damper shall be open to the setting determined by the minimum-position switch.

3.3.22.8 Space-Temperature-Sequenced Heating and Cooling Control

A space-temperature sensing element and transmitter operating through a space-temperature controller shall maintain the setpoint by sequencing the heating coil valve, dampers, and stages of DX cooling as shown. On a rise in space temperature, the controller shall first gradually close the heating-coil valve. After the controller output passes through a dead band, the controller shall then gradually operate the outside-air damper to admit outside air beyond the minimum quantity, except that when the economizer controller places the system in the minimum-outside-air mode, the outside-air damper shall be open to the setting as determined by the minimum-position switch. After the outside-air damper is fully open, upon a further rise in space temperature, the controller shall then operate the stages of cooling in sequence to maintain the setpoint shown.

3.3.22.9 Emergency Fan Shutdown

Activation of a duct smoke detector in the supply-air or return-air ductwork, or activation of a manual emergency fan shutdown switch shall cause the associated fan to shutdown in accordance with NFPA 90A. Activation of these devices shall operate a pilot light on the HVAC control panel. The panel shall require manual resetting after the detector and the manual switch are reset.

3.4 COMMISSIONING PROCEDURES

3.4.1 General Procedures

3.4.1.1 Evaluations

The Contractor shall make the observations, adjustments, calibrations, measurements, and tests of the control systems, tune the controllers, set the time clock schedule, and make any necessary control-system corrections to ensure that the systems function as described in paragraph CONTROL SEQUENCES OF OPERATION. The Contractor shall permanently record, on system equipment schedule, the final setting of controller proportional, integral and derivative constant settings, setpoint, manual reset setting, maximum and minimum controller output, and ratio and bias settings, in units and terminology specific to the controller.

3.4.1.2 Item Check

An item-by-item check of the sequence of operation requirement shall be performed using Steps 1 through 4 in the specified control system commissioning procedures. Steps 1, 2, and 3 shall be performed with the HVAC system shutdown; Step 4 shall be performed after the HVAC systems have been started. Signals used to change the mode of operation shall originate from the actual HVAC control device intended for the purpose, such as the time clock. External input signals to the HVAC control panel (such as EMCS, starter auxiliary contacts, and external systems) may be simulated in Steps 1, 2, and 3. With each operational-mode change signal, pilot lights and HVAC-panel output-relay contacts shall be observed to ensure that they function. All terminals assigned to EMCS shall be checked and observed to ensure that the proper signals are available.

3.4.1.3 Weather-Dependent Test Procedures

Weather-dependent test procedures that cannot be performed by simulation shall be performed in the appropriate climatic season. When simulation is used, the Contractor shall verify the actual results in the appropriate season.

3.4.1.4 Configuration

The Contractor shall configure each controller for its specified service.

3.4.1.5 Two-Point Accuracy Check

A two-point accuracy check of the calibration of each HVAC-control-system sensing element and transmitter shall be performed by comparing the HVAC-control-panel readout to the actual value of the variable measured at the sensing element and transmitter or airflow measurement station location. Digital indicating test instruments shall be used, such as digital thermometers, motor-driven psychrometers, and tachometers. The test instruments shall be at least twice as accurate as the specified sensing element-to-controller readout accuracy. The calibration of the test instruments shall be traceable to NIST standards. The first check point shall be with the HVAC system in the shutdown condition, and the second check point shall be with the HVAC system in an operational condition. Calibration checks shall verify that the sensing element-to-controller readout accuracies at two points are within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced and the calibration check repeated.

3.4.1.6 Insertion, Immersion Temperature

Insertion-temperature and immersion-temperature sensing element and transmitter-to-controller readout calibration accuracy shall be checked at one physical location along the axis of the sensing element.

3.4.1.7 Averaging Temperature

Averaging-temperature sensing element and transmitter-to-controller readout calibration accuracy shall be checked every 1/2 meter (2 feet) along the axis of the sensing element in the proximity of the sensing element, for a maximum of 10 readings. These readings shall then be averaged.

3.4.1.8 Controller Stations

The Contractor shall use the controllers' MANUAL/AUTOMATIC stations as the means of manipulating control devices, such as dampers and valves, to check IP operation and to effect stable conditions prior to making measurement checks.

3.4.1.9 Controller-Tuning Procedure

The Contractor shall perform a controller-tuning procedure, which shall consist of setting the initial proportional, integral, and derivative (PID) mode constants, controller setpoints, and logging the settings. Tuning shall be self-tuning operation by the controller unless manual tuning is necessary.

3.4.1.10 Controller Manual-Tuning Procedure

Where required, the controller manual-tuning procedure shall be performed in three steps. Using a constant-temperature-setpoint controller as an example, these steps are:

a. Step A:

(1) The controller MANUAL/AUTO station shall be indexed to the AUTO position and the integral- and derivative-mode constants set to zero.

(2) The proportional-mode constant shall be set to an initial setting of 8 percent. [This corresponds to 3.6 ma per degree C (2.0 ma per degree F) proportional controller output change for a 55.5 degree C (100 degree F) transmitter span.] This causes the controller output signal to vary from live zero output to full output for an input signal change representing an 4.5 degree C (8 degree F change).

(3) Controllers for other variables, such as relative humidity and static pressure, shall have their proportional-mode constants set initially in a similar manner for an achievable output range proportional to the transmitter span.

b. Step B:

(1) The controller temperature setpoint shall be set at any achievable temperature. The controller output and transmitter input shall be observed.

(2) If the transmitter input continuously oscillates above and below the setpoint without settling at a fixed value, or if such oscillation increases, the proportional-mode constant is too small.

(3) If the proportional-mode constant is too small, increase it in steps until the transmitter input indicates stable control at any temperature, provided that the controller output is not at either extreme of the output range.

(4) If the temperature control point slowly drifts toward or away from the controller setpoint, the proportional-mode constant is too large. Its setting shall be decreased in steps until oscillations occur as described in the preceding paragraphs, and then the setting shall be increased until stable control occurs.

(5) A step change in controller setpoint shall be introduced. This should cause the controller to overshoot the setpoint slightly, with each subsequent overshoot peak value decreasing by a factor of 2/3 until stable control is achieved at, above, or below the setpoint.

(6) Next, the integral-mode constant setting shall be increased in small steps, and setpoint changes shall be introduced until control point and controller setpoint coincide at stable control. This should happen consistently after a setpoint change within a short time, such as 5 to 10 minutes.

c. Step C:

(1) Unless the HVAC process variable changes rapidly, the derivative-mode constant setting can remain at zero.

(2) If derivative control is needed, the derivative-mode constant shall be gradually increased.

(3) Step changes in controller setpoint shall be introduced, and the derivative-mode constant setting adjusted until stable control is achieved.

3.4.1.11 Setting the Controller

After the controller manual-tuning procedure is complete, the controller shall be set at the setpoint as shown.

3.4.2 Space-Temperature-Controlled Perimeter Radiation

The heating medium shall be turned on, and the thermostat temperature setpoint shall be raised. The valve shall open. The thermostat temperature shall be lowered and the valve shall close. The thermostat shall be set at the setpoint shown.

3.4.3 Unit Heater and Cabinet Unit Heater

The "OFF/AUTO" switch shall be placed in the "OFF" position. Each space-thermostat temperature setting shall be turned up so that it makes contact to turn on the unit-heater fans. The unit-heater fans shall not start. The "OFF/AUTO" switch shall be placed in the "AUTO" position. The unit-heater fans shall start. Each space-thermostat temperature setting shall be turned down, and the unit-heater fans shall stop. The thermostats shall be set at their temperature setpoints shown. The results of testing of one of each type of unit shall be logged.

3.4.4 Gas-Fired Infrared-Heater

Each space-thermostat temperature setting shall be turned up so that it makes contact to turn on the infrared heater; the heater shall turn on. Each space-thermostat temperature shall be turned down and the infrared heater shall turn off. The thermostats shall be set at their temperature setpoints as shown. The results of testing of one of each type of unit shall be logged.

3.4.5 All-Air Small Packaged Unitary

The schedules shall be manually entered for day-temperature and night-temperature setpoints as shown. The fan "AUTO/ON" switch shall be set to "ON". The time shall be manually entered as "DAY". The heating-cooling switch shall be raised to "HEATING" and cooling shall be off. The temperature setpoint shall be raised and heating shall start. The heating/cooling switch shall be set to "COOLING" and heat shall be off. The temperature setpoint shall be lowered and cooling shall start. The fan "AUTO/ON" switch shall be set to "AUTO" and the foregoing procedure repeated. The fan shall start and stop automatically with the starting and stopping of heating and cooling. The time shall be manually entered as "NIGHT". The foregoing procedures shall be repeated. When the system is verified as operational, the correct "DAY" and "NIGHT" temperature settings shall be restored and the correct time restored. The power to the thermostat shall be shut off and it shall be verified that the thermostat clock keeps time. The results of testing of one of each type of unit shall be logged.

3.4.6 Fan-Coil-Unit

The dual-temperature hydronic system shall be set to heating. Each space thermostat temperature setting shall be turned up so that it makes contact and turns the fan-coil unit on. The fan-coil unit fan shall start and the valves shall open to flow through the coils. Each space thermostat temperature setting shall be turned down and the fan-coil unit fans shall stop. The valves shall close to flow through the coils. The dual-temperature hydronic system shall be switched to cooling. Each space thermostat temperature setting shall be turned up; contact shall be broken and the fan-coil unit fans shall stop. The valves shall close to flow through the coil. Each space thermostat temperature setting shall be turned down. The fan-coil unit fans shall start and the valves shall open to flow through the coils. The thermostats shall be set at the temperature setpoints as shown. The results of testing of one of each type of unit shall be logged.

3.4.7 Central Plant Hydronic-Heating with Steam/Hot Water Converter

Installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The converter valve shall be closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air temperature and system-supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL". The proper operation of the actuators and positions for all valves shall be verified. The signal shall be varied from live zero of 4 ma [or 21 kPa3 psig] to 20 ma [or 103 kPa 15 psig], and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) The outside-air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position and the two-point calibration sensing element-to-controller readout accuracy check for the outside-air temperature performed. The controller proportional band adjustment, the

setpoint, the manual reset, and the maximum controller output shall be set to achieve the outside-air temperature schedule as shown.

(2) A signal shall be applied to simulate that the outside-air temperature is above the setpoint as shown. It shall be verified that pump stops. A signal shall be applied to simulate that the outside-air temperature is below the setpoint as shown. It shall be verified that pump starts.

(3) The system's supply-temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check of the sensing element-to-controller readout for the system-supply temperature performed. The controller shall be placed in the remote-setpoint mode. The remote setpoint shall be set for temperature schedule as shown. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller setup and tuning procedures performed. The controller shall be set at a system-supply temperature setpoint within the schedule as shown and the mode-constant setpoints logged. Signals of 8 ma and 16 ma shall be sent to the remote setpoint from the outside-air temperature controller, to verify that the controller setpoint changes to the appropriate values. The outside-air temperature controller's "MANUAL/AUTO" station shall be indexed to "AUTO".

(4) An occupied-mode signal shall be applied. Each space-temperature controller's "MANUAL/AUTO" station shall be indexed to "MANUAL". The calibration accuracy check of sensing element-to-controller readout for each space temperature, shall be performed and the values logged. Each controller shall be placed in the remote-setpoint mode. The setpoint low-end limit shall be set to 19 degrees C 66 degrees F and the high-end limit shall be set to 22 degrees C. 72 degrees F. The proper action of each temperature-setpoint device at the space-temperature sensing element and transmitter location shall be verified. Each controller's "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure performed. An unoccupied-mode signal shall be applied, and it shall be verified that each controller's setpoint changes to the unoccupied-mode setting. Each temperature setpoint device shall be set to the space-temperature setpoint shown.

3.4.8 Single Building Hydronic-Heating with Hot Water Boiler

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. It shall be verified that power and main air are available at the HVAC system control panel.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown:

Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air temperature and system-supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all valves shall be verified visually. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

Example: NC actuators are closed at 4 ma and are open at 20 ma. The signal levels that move the controlled device to its extreme positions shall be logged.

d. Step 4 - Control-System Commissioning:

(1) The outside-air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position and the two-point calibration sensing element-to-controller readout accuracy check for the outside-air temperature performed. The controller proportional band adjustment, the setpoint, the manual reset, and the maximum controller output shall be set to achieve the outside-air temperature schedule shown.

(2) A signal shall be applied to simulate that the outside-air temperature is above the setpoint shown. It shall be verified that pumps and boiler stop. A signal shall be applied to simulate that the outside-air temperature is below the setpoint shown. It shall be verified that pumps start and boiler operates.

(3) The system's supply-temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check of the sensing element-to-controller readout for the system-supply temperature performed. The controller shall be placed in the remote-setpoint mode. The remote setpoint for temperature schedule shall be set as shown. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller setup and tuning procedures performed. The controller shall be set at a system-supply temperature setpoint within the schedule as shown and the mode-constant setpoints logged. Signals of 8 ma and 16 ma shall be sent to the remote setpoint from the outside-air temperature controller, to verify that the controller setpoint changes to the appropriate values. The outside-air temperature controller's "MANUAL/AUTO" station shall be indexed to "AUTO."

(4) An occupied-mode signal shall be applied. Each space-temperature controller "MANUAL/AUTO" station shall be indexed to "MANUAL." The calibration accuracy check of sensing element-to-controller readout for each space temperature shall be performed, and the values logged. The controller shall be placed in the remote-setpoint mode. The setpoint low-end limit shall be set to 19 degrees C (66 degrees F) and the high-end limit shall be set to 22 degrees C (72 degrees F). The proper action of the temperature-setpoint device at the space-temperature sensing element and transmitter location shall be verified. Each controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position and the controller-tuning procedure performed. An unoccupied-mode signal shall be applied and it shall be verified that each controller's setpoint changes to the unoccupied-mode setting. The temperature setpoint device shall be set to the space-temperature setpoint shown.

3.4.9 Central Plant High-Temperature Hot-Water Hydronic-Heating

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The converter valve shall be closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown:

Readings shall be taken with a digital thermometer at each temperature sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air temperature and system-supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) The outside-air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position and the two-point calibration sensing element-to-controller readout accuracy check for the outside-air temperature shall be performed. The controller proportional band adjustment, the setpoint, the manual reset, and the maximum controller output shall be set to achieve the outside-air temperature schedule shown.

(2) A signal shall be applied to simulate that the outside-air temperature is above the setpoint as shown. It shall be verified that pump stops. A signal shall be applied to simulate that the outside-air temperature is below the setpoint shown. It shall be verified that pump starts.

(3) The system's supply-temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check of the sensing element-to-controller readout for the system-supply temperature shall be performed. The controller shall be placed in the remote-setpoint mode. The remote setpoint shall be set for temperature schedule as shown. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller setup and tuning procedures performed. The controller shall be set at a system-supply temperature setpoint within the range as shown and the mode-constant setpoints logged. Signals of 8 ma and 16 ma shall be sent to the remote setpoint, from the outside-air temperature controller, to verify that the controller setpoint changes to the appropriate values. The outside-air temperature controller's "MANUAL/AUTO" station shall be indexed to "AUTO." A high-temperature condition shall be initiated in the system supply line by lowering the thermostat setting. It shall be verified that the high-temperature hot-water shutoff valve closes and the pilot light turns on. The thermostat shall be set at the setting shown, the safety circuit shall be manually reset, and it shall be verified that the shutoff valve opens and the pilot light turns off.

(4) An occupied-mode signal shall be applied. Each space-temperature controller "MANUAL/AUTO" station shall be indexed to "MANUAL". The calibration accuracy check of sensing element-to-controller readout for

each space temperature shall be performed, and the values logged. The controller shall be placed in the remote-setpoint mode. The setpoint low-end limit shall be set to 19 degrees C 66 degrees F and the high-end limit shall be set to 22 degrees C. 72 degrees F. The proper action of the temperature-setpoint device at the space-temperature sensing element and transmitter location shall be verified. Each controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure shall be performed. An unoccupied-mode signal shall be applied, and it shall be verified that each controller's setpoint changes to the unoccupied-mode setting. The temperature setpoint device shall be set to the space-temperature setpoint shown.

3.4.10 Central Plant Dual-Temperature Hydronic

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The converter valve shall be closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown:

Readings shall be taken with a digital thermometer at each temperature sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air temperature, system-supply temperature, and system-return temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) The outside-air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position and the two-point calibration sensing element-to-controller readout accuracy check for the outside-air temperature shall be performed. The controller proportional band adjustment, the setpoint, the manual reset, and the maximum controller output shall be set to achieve the outside-air temperature schedule as shown.

(2) The system shall be indexed to the heating mode and it shall be verified that the changeover valves open to flow through the converter and close to flow from central plant chilled water. It shall be verified that the heating pilot light turns on and the cooling pilot light turns off.

(3) A signal shall be applied to simulate that the outside-air temperature is above the setpoint as shown. It shall be verified that pump stops. A signal shall be applied to simulate that the outside-air temperature is below the setpoint as shown. It shall be verified that pump starts.

(4) The system's supply-temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point

calibration accuracy check of the sensing element-to-controller readout for the system-supply temperature shall be performed. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller setup and tuning procedures performed. The controller shall be set at a system-supply temperature setpoint within the schedule as shown and the mode-constant setpoints logged. Signals of 8 ma and 16 ma shall be sent to the remote setpoint from the outside-air temperature controller, to verify that the controller setpoint changes to the appropriate values. The outside-air temperature controller's "MANUAL/AUTO" station shall be indexed to "AUTO."

(5) The return-water aquastat shall be set to the setpoint as shown. An unoccupied-mode signal shall be applied from the system time clock and it shall be verified that the occupied pilot light turns off.

(6) The system shall be indexed to the cooling mode. It shall be verified that the converter control valve closes, the heating pilot light turns off, and that pump continues to operate until the return-water temperature falls below the setpoint of the return-water aquastat. It shall be verified that when the return-water temperature falls below the setpoint of the return-water aquastat that the changeover valves close to flow through the converter and open to flow from central plant chilled water, that the cooling pilot light turns on and that pump stops.

(7) An occupied-mode signal shall be applied from the system time clock and it shall be verified that the occupied pilot light turns on, and pump starts.

3.4.11 Central Plant High-Temperature Hot-Water Dual-Temperature Hydronic
Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The converter control valve shall be closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air temperature and system-supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) The outside-air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position and the two-point calibration sensing element-to-controller readout accuracy check for the outside-air temperature shall be performed. The controller proportional band adjustment,

the setpoint, the manual reset, and the maximum controller output shall be set to achieve the outside-air temperature schedule as shown.

(2) The system shall be indexed to the heating mode and it shall be verified that the changeover valves open to flow through the converter and close to flow from central plant chilled water. It shall be verified that the heating pilot light turns on and the cooling pilot light turns off.

(3) A signal shall be applied to simulate that the outside-air temperature is above the setpoint as shown. It shall be verified that pump stops. A signal shall be applied to simulate that the outside-air temperature is below the setpoint as shown. It shall be verified that pump starts.

(4) The system's supply-temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check of the sensing element-to-controller readout for the system-supply temperature shall be performed. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller setup and tuning procedures performed. The controller shall be set at a system-supply temperature setpoint within the schedule as shown and the mode-constant setpoints logged. Signals of 8 ma and 16 ma shall be sent to the remote setpoint from the outside-air temperature controller, to verify that the controller setpoint changes to the appropriate values. The outside-air temperature controller's "MANUAL/AUTO" station shall be indexed to "AUTO."

(5) The return-water aquastat shall be set to the setpoint as shown. An unoccupied-mode signal shall be applied from the system time clock and it shall be verified that the occupied pilot light turns off.

(6) The system shall be indexed to the cooling mode. It shall be verified that the converter control valve closes, the heating pilot light turns off, and that pump continues to operate until the return-water temperature falls below the setpoint of the return-water aquastat. It shall be verified that when the return-water temperature falls below the setpoint of the return-water aquastat that the changeover valves close to flow through the converter and open to flow from central plant chilled water, that the cooling pilot light turns on and that pump stops.

(7) An occupied-mode signal shall be applied from the system time clock and it shall be verified that the occupied pilot light turns on, and pump starts.

3.4.12 Single Building

Dual-Temperature Hydronic Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air availability at the HVAC system control panel shall be checked.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air temperature and system-supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL". The proper operation of the actuators and positioners for all valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range shall be made. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) The outside-air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position and the two-point calibration sensing element-to-controller readout accuracy check for the outside-air temperature performed. The controller proportional band adjustment, the setpoint, the manual reset, and the maximum controller output shall be set to achieve the outside-air temperature schedule as shown.

(2) The system shall be indexed to the heating mode and it shall be verified that chiller is shutdown, and the cooling pilot light turns off. It shall be verified that the changeover valves open to flow through boiler and close to flow through chiller.

(3) A signal shall be applied to simulate that the outside-air temperature is above the setpoint as shown. It shall be verified that distribution pump is off, boiler is stopped, heating pilot light is turned off, and control of the hydronic-heating system control valve is disabled. A signal shall be applied to simulate that the outside-air temperature is below the setpoint as shown. It shall be verified that distribution pump starts, boiler is started, heating pilot light is turned on, and control of the hydronic-heating system control valve is enabled.

(4) The system's supply-temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and thetwo-point calibration accuracy check of the sensing element-to-controller readout for the system-supply temperature shall be performed. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller setup and tuning procedures performed. The controller shall be set at a system-supply temperature setpoint within the schedule as shown and the mode-constant setpoints logged. Signals of 8 ma and 16 ma shall be sent to the remote setpoint from the outside-air temperature controller, to verify that the controller setpoint changes to the appropriate values. The outside-air temperature controller's "MANUAL/AUTO" station shall be indexed to "AUTO."

(5) The return-water aquastat shall be set to the setpoint as shown. An unoccupied mode signal shall be applied from the system time clock. It shall be verified that the occupied pilot light turns off.

(6) The system shall be indexed to the cooling mode. It shall be verified that boiler shuts down, the heating pilot light turns off, and distribution pump continues to operate until the expiration of the time delay. It shall be verified that when the return-water temperature falls below the setpoint of the return-water changeover aquastat, the changeover valves close to flow through the boiler and open to flow through chiller.

(7) An occupied-mode signal shall be applied from the system time clock and it shall be verified that the occupied pilot light turns on, distribution pump starts, and upon proof of flow by the flow switch, chiller operation is enabled and the cooling pilot light turns on.

(8) An unoccupied mode signal shall be applied from the system time clock and it shall be verified that the occupied pilot light turns off, the cooling pilot light turns off, chiller shuts down and distribution pump continues to operate until the expiration of the time delay and then stops.

3.4.13 Heating and Ventilating

Steps for installation are as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The outside-air damper and relief-air damper shall be closed and the return-air damper shall be open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown:

Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for space temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) With the fan ready to start, the ventilation-delay-mode signal shall be applied, and it shall be verified that the ventilation-delay-mode pilot light turns on. The occupied-mode signal shall be applied and it shall be verified that the occupied-mode pilot light turns on and that supply fan starts. It shall be verified that the outside-air and relief-air dampers are closed, the return-air damper is open, and the heating-coil valve is under control, by slightly changing the controller outputs. The ventilation-delay-mode signal shall be released, and it shall be verified that the ventilation-delay-mode pilot light turns off and that the outside-air, return-air, and relief-air dampers come under control by changing the controller output.

(2) The minimum-outside-air-mode signal shall be applied. It shall be verified that the outside-air damper opens to minimum position and the economizer pilot light is off.

(3) The space-temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the calibration accuracy check for sensing element-to-controller readout shall be performed. The controller shall be placed in the remote-setpoint mode. The setpoint low-end limit shall be set to 19 degrees C (66 degrees F) and the high-end limit shall be set to 22 degrees C (72 degrees F). Proper operation of the temperature setpoint device at the space temperature sensing element and transmitter location shall be verified. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position and the controller-tuning procedure shall be performed. The temperature setpoint device shall be set to the space temperature setpoint as shown.

(4) An unoccupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns off, the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The night-thermostat temperature setting shall be turned upward, and it shall be verified that the HVAC system starts; the setting shall be turned downward, and it shall be verified that the HVAC system stops. The night thermostat shall be set at the setpoint as shown.

(5) With the HVAC system running, a filter differential-pressure switch input signal shall be simulated, at the device. It shall be verified that the filter pilot light turns on, and that contact output at EMCS terminals is made. The differential-pressure switch shall be set at the setpoint as shown.

(6) With the HVAC system running, a freezestat trip input signal shall be simulated, at the device. HVAC system shutdown shall be observed. It shall be verified that the low-temperature pilot light turns on and that contact output at the EMCS terminals is made. The freezestat shall be set at the setpoint as shown. The HVAC shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(7) With the HVAC system running, a smoke-detector trip input signal shall be simulated at each detector, and verification of control-device actions and interlock functions as described in paragraph CONTROL SEQUENCES OF OPERATION shall be made. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke-detector pilot light turns on, and contact output at EMCS terminals shall be verified. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the pilot light turns off.

3.4.14 Multizone Control System with Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The outside-air and relief-air dampers shall be closed, the return-air damper open, and the cooling-coil valve closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air, return-air, mixed-air, cold-deck-air, and hot-deck-air temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) With the fans ready to start, the ventilation-delay-mode signal shall be applied, and it shall be verified that the ventilation-delay-mode pilot light turns on. The occupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns on and that supply fan and return fan start. It shall be verified that the outside-air and relief-air dampers are closed, the return-air damper is open, and the heating and cooling-coil valves are under control, by slightly changing the controller outputs. The ventilation-delay-mode signal shall be released, and it shall be verified that the ventilation-delay-mode pilot light turns off, and that the outside-air, return-air, and relief-air dampers come under control, by changing the controller output.

(2) The minimum-outside-air-mode signal shall be applied. It shall be verified that the outside-air damper opens to minimum position and that the economizer pilot light is off.

(3) The mixed-air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position. An economizer-mode input signal shall be simulated and it shall be verified that the economizer-mode pilot light turns on. The mixed-air temperature controller output shall be changed to slightly open the outside-air damper and the second point of the two-point calibration accuracy check of sensing element-to-controller readout for outside-air, return-air, and mixed-air temperatures shall be performed. The controller-tuning procedure shall be performed. The mixed-air temperature controller "MANUAL/AUTO" switch shall be indexed to the "AUTO" position. The mixed-air temperature controller shall be placed in the local setpoint mode and set at the temperature setpoint as shown.

(4) The outside-air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position and the two-point calibration sensing element-to-controller readout accuracy check for the outside-air temperature shall be performed. The controller proportional band adjustment, the setpoint, the manual reset, and the maximum controller output shall be set to achieve the outside-air temperature schedule as shown.

(5) The hot-deck temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check of sensing element-to-controller readout for outside-air and hot-deck temperatures shall be performed. The controller shall be placed in the remote-setpoint mode. The remote setpoints at 20-ma input and 4-ma input shall be set as indicated. Send a 12-ma signal to the remote setpoint for tuning at midrange. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure performed. Three signals shall be applied simulating outside-air temperature changes. The signals shall be selected at midrange, lower 1/3 range, and upper 1/3 range of the temperature schedule. It shall be verified that the hot-deck temperature controller setpoint tracks the schedule. The hot-deck temperature controller setpoint shall be set for the existing outside-air temperature as shown.

(6) The hot-deck temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check of sensing element-to-controller readout shall be performed. The controller shall be placed in the local-setpoint mode, and set at the temperature setpoint as shown. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure performed.

(7) The cold-deck temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the calibration accuracy check of sensing element-to-controller readout shall be performed. The controller shall be placed in the local-setpoint mode, and set at the temperature setpoint as shown. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure performed.

(8) An unoccupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns off, the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The night-thermostat temperature setting shall be turned upward, and it shall be verified that the HVAC system starts; the setting shall be turned downward, and it shall be verified that the HVAC system stops. The night thermostat shall be set at the setting as shown.

(9) With the HVAC system running, a filter differential-pressure switch input signal shall be simulated at the device. It shall be verified that the filter pilot light turns on, and that contact output at the EMCS terminals is made. The differential-pressure switch shall be set at the setpoint as shown.

(10) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be observed. It shall be verified that the low-temperature pilot light turns on, and that contact output at the EMCS terminals is made. The freezestat shall be set at the setpoint as shown. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(11) With the HVAC system running, a smoke-detector trip input signal shall be simulated at each detector, and control-device actions and interlock functions, as described in paragraph CONTROL SEQUENCES OF OPERATION, shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke-detector pilot light turns on, and contact output at the EMCS terminals is made. The detectors shall be reset. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(12) The setpoint of each zone thermostat shall be raised and it shall be verified that the zone damper closes to the cold deck and opens to the hot deck. The thermostat of each zone shall be calibrated and set at its setpoint as shown.

3.4.15 Dual-Duct Multizone Control System with Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The outside-air and relief-air dampers shall be closed, the return-air damper open, and the cooling-coil valve closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown:

Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air, return-air, mixed-air, cold-duct-air, and hot-duct-air temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) With the fans ready to start, the ventilation delay mode signal shall be applied, and it shall be verified that the ventilation-delay-mode pilot light turns on. The occupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns on and that supply fan and return fan start. It shall be verified that the outside-air and relief-air dampers are closed, the return-air damper is open, and the heating and cooling-coil valves are under control, by slightly changing the controller outputs. The ventilation-delay-mode signal shall be released, and it shall be verified that the ventilation-delay-mode pilot light turns off and the outside-air, return-air, and relief-air dampers come under control by changing the controller output.

(2) The minimum-outside-air-mode signal shall be applied. It shall be verified that the outside-air damper opens to minimum position and that the economizer pilot light is off.

(3) The mixed-air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position. An economizer-mode input signal shall be simulated and it shall be verified that the economizer-mode pilot light turns on. The mixed-air temperature controller output shall be changed to slightly open the outside-air damper and the second point of the two-point calibration accuracy check of sensing element-to-controller readout for outside-air, return-air, and mixed-air temperatures shall be performed. The controller-tuning procedure shall be performed. The mixed-air temperature controller "MANUAL/AUTO" switch shall be indexed to the "AUTO" position. The mixed-air temperature controller shall be placed in the local setpoint mode and set at the temperature setpoint as shown.

(4) The outside-air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position and the two-point calibration sensing element-to-controller readout accuracy check for the outside-air temperature shall be performed. The controller proportional band adjustment, the setpoint, the manual reset, and the maximum controller output shall be set to achieve the outside-air temperature schedule as shown.

(5) The hot-deck temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check of sensing element-to-controller readout for outside-air and hot-deck temperatures shall be performed. The controller shall be placed in the remote-setpoint mode. The remote setpoints at 20-ma input and at 4-ma input shall be set as indicated. Send a 12-ma signal to the remote setpoint for tuning at midrange. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure performed. Three signals shall be applied simulating outside-air temperature changes. The signals SECTION 15950A Page 98 shall be selected at midrange, lower 1/3 range,

and upper 1/3 range of the temperature schedule. It shall be verified that the hot-deck temperature controller setpoint tracks the schedule. The hot-deck temperature controller setpoint shall be set for the existing outside-air temperature as shown.

(6) The hot-deck temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check of sensing element-to-controller readout shall be performed. The controller shall be placed in the local-setpoint mode, and set at the temperature setpoint as shown. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure performed.

(7) The cold-deck temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the calibration accuracy check of sensing element-to-controller readout shall be performed. The controller shall be placed in the local-setpoint mode, and set at the temperature setpoint as shown. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure performed.

(8) An unoccupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns off, the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The night-thermostat temperature setting shall be turned upward, and it shall be verified that the HVAC system starts; the setting shall be turned downward, and it shall be verified that the HVAC system stops. The night thermostat shall be set at the setting as shown.

(9) With the HVAC system running, a filter differential-pressure switch input signal shall be simulated at the device. It shall be verified that the filter pilot light turns on, and that contact output at the EMCS terminals is made. The differential-pressure switch shall be set at the setpoint as shown.

(10) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that the low-temperature pilot light turns on, and contact output at EMCS terminals shall be verified. The freezestat shall be set at the setpoint as shown. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(11) With the HVAC system running, a smoke-detector trip input signal shall be simulated at each detector, and control-device actions and interlock functions, as described in paragraph CONTROL SEQUENCES OF OPERATION, shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke-detector pilot light turns on, and contact output at the EMCS terminals is made. The detectors shall be reset. The HVAC system shall be restarted by manual restart, and it shall be SECTION 15950A Page 99 verified that the pilot light turns off.

(12) The setpoint of each zone thermostat shall be raised and it shall be verified that the dual-duct terminal box damper closes to the cold duct and opens to the hot duct. Each zone thermostat shall be calibrated and set at its setpoint as shown.

3.4.16 Bypass Multizone with Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The outside-air and relief-air dampers shall be closed, the return-air damper open, and the cooling-coil valve closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown:

Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air, return-air, mixed-air, and cold-deck-air temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) With the fans ready to start, the ventilation-delay-mode signal shall be applied, and it shall be verified that the ventilation-delay-mode pilot light turns on. The occupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns on and that supply fan and return fan start. It shall be verified that the outside-air and relief-air dampers are closed, the return-air damper is open, and the heating and cooling-coil valves are under control, by slightly changing the controller outputs. The ventilation-delay-mode signal shall be released, and it shall be verified that the ventilation-delay-mode pilot light turns off, and that the outside-air, return-air, and relief-air dampers come under control, by changing the controller output.

(2) The minimum-outside-air-mode signal shall be applied. It shall be verified that the outside-air damper opens to minimum position and that the economizer pilot light is off.

(3) The mixed-air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position. An economizer-mode input signal shall be simulated and it shall be verified that the economizer-mode pilot light turns on. The mixed-air temperature controller output shall be changed to slightly open the outside-air damper and the second point of the two-point calibration accuracy check of sensing element-to-controller readout for outside-air, return-air, and mixed-air temperatures shall be performed. The controller-tuning procedure shall be performed. The mixed-air temperature controller "MANUAL/AUTO" switch shall be indexed to the "AUTO" position. The mixed-air temperature controller shall be placed in the local setpoint mode and set at the temperature setpoint as shown.

(4) The cold-deck temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the calibration accuracy check of sensing element-to-controller readout shall be performed. The controller shall be placed in the local-setpoint mode, and set at the temperature

setpoint as shown. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure performed.

(5) An unoccupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns off, the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The night-thermostat temperature setting shall be turned upward, and it shall be verified that the HVAC system starts; the setting shall be turned downward, and it shall be verified that the HVAC system stops. The night thermostat shall be set at the setpoint as shown.

(6) With the HVAC system running, a filter differential-pressure switch input signal shall be simulated at the device. It shall be verified that the filter pilot light turns on, and that contact output at the EMCS terminals is made. The differential-pressure switch shall be set at the setpoint as shown.

(7) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be observed. It shall be verified that the low-temperature pilot light turns on, and that contact output at the EMCS terminals is made. The freezestat shall be set at the setpoint as shown. The HVAC system shall be restarted by manual restart and it shall be verified that the pilot light turns off.

(8) With the HVAC system running, a smoke-detector trip input signal shall be simulated at each detector, and control-device actions and interlock functions as described in paragraph CONTROL SEQUENCES OF OPERATION shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke-detector pilot light turns on, and contact output at the EMCS terminals is made. The detectors shall be reset. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(9) The setpoint of each zone thermostat shall be changed and correct operation of the zone damper and the heating coil valve shall be verified for each zone. Each zone thermostat shall be calibrated and set at its setpoint as shown.

3.4.17 Variable Air Volume, Without Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The outside air and relief air dampers shall be closed, the return air damper open, and the supply fan inlet vanes and cooling coil valve shall be closed.

b. Step 2 - Calibration Accuracy Check with HVAC System in Shutdown:

Readings shall be taken with a digital thermometer at each temperature sensing element location. Each controller display shall be read, and the thermometer and controller display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside air, return air, mixed air, and the cooling coil discharge air temperatures shall be checked. The minimum outside air flow shall be read, using a digital indicating velometer, and the velometer and controller display readings logged. The flow shall read zero.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the ventilation delay mode signal shall be applied, and it shall be verified that the ventilation delay mode pilot light turns on. The occupied mode signal shall be applied, and it shall be verified that the occupied mode pilot light turns on and that supply fan starts. It shall be verified that the outside air and relief air dampers are closed, the return air damper is open, and the cooling coil valve and inlet vanes are under control, by slightly changing the controller output. The ventilation delay mode signal shall be released, and it shall be verified that the ventilation delay mode pilot light turns off and that the economizer outside air and relief air dampers remain closed, the return air damper remains open, and the minimum outside air damper comes under control of the minimum outside air flow controller, by changing the controller output.

(2) The 2-point calibration accuracy check of sensing element-to-controller readout for the minimum outside air flow measurement station shall be performed. VAV box dampers shall be forced to the full open position, exhaust fans turned off, the supply duct static pressure controller output manually adjusted to achieve the design duct static pressure, and manually adjust the minimum outside air flow controller output to achieve a flow which is approximately 25% less than the desired air flow. Under these conditions, the minimum outside air flow control loop shall be tuned. Stable operation of the minimum outside air flow control loop in response to a process disturbance shall be confirmed.

(3) With supply fan running, a high static pressure input signal shall be simulated at the device, by pressure input to the differential pressure switch sensing device. HVAC system shutdown shall be observed. It shall be verified that the high static pressure pilot light turns on, and that contact output at the EMCS terminals is made. The differential pressure switch shall be set at the setpoint shown. The HVAC system shall be restarted by manual restart, and it shall be verified that the high static pressure pilot light turns off.

(4) The supply fan static pressure controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check for sensing element-to-controller readout shall be performed. The controller shall be placed in the local setpoint mode. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller tuning procedure performed. The controller shall be set at the static pressure setpoint shown, and the mode constants logged.

(5) The mixed air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position. An economizer mode input signal shall be simulated and it shall be verified that the economizer mode pilot light turns on. The mixed air temperature controller output shall be changed

to slightly open the economizer outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-controller readout for outside air, return air, and mixed air temperatures shall be performed. The controller tuning procedure shall be performed. The mixed air temperature controller "MANUAL/AUTO" switch shall be indexed to the "AUTO" position. The mixed air temperature controller shall be placed in the local setpoint mode and set at the temperature setpoint shown.

(6) The cooling coil temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the calibration accuracy check of sensing element-to-controller readout shall be performed. The controller shall be placed in the local setpoint mode, and set at the temperature setpoint shown. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller tuning procedure performed.

(7) An unoccupied mode signal shall be applied, and it shall be verified that the occupied mode pilot light turns off, the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The night thermostat temperature setting shall be turned upward, and it shall be verified that the HVAC system starts; the setting shall be turned downward, and it shall be verified that the HVAC system stops. The night thermostat shall be set at the setpoint shown.

(8) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter pilot light turns on, and that contact output at the EMCS terminals is made. The differential pressure switch shall be set at the setpoint shown.

(9) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be observed. It shall be verified that the low temperature pilot light turns on, and that contact output at the EMCS terminals is made. The freezestat shall be set at the setpoint shown. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(10) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions, as described in paragraph CONTROL SEQUENCES OF OPERATION shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector pilot light turns on, and contact output at the EMCS terminals is made. The detectors shall be reset. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(11) Velocity setpoints for minimum and maximum flow and temperature setpoints for the heating/cooling dead band shall be set, for each VAV terminal unit. The actions of the controller, the operation of the damper, and the operation of heating shall be verified. It shall be verified that space temperature is maintained.

3.4.18 Variable Air Volume Control

Steps for installation of system with return fan shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The outside air and relief air dampers shall be closed, the return air damper open, and the inlet vanes and cooling coil valve shall be closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown:

Readings shall be taken with a digital thermometer at each temperature sensing element location. Each controller display shall be read, and the thermometer and controller display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside air, return air, mixed air, and cooling coil discharge air temperatures shall be checked. The minimum outside air, supply air, and return air flows shall be read, using a digital indicating velometer, and the velometer and controller display readings logged. The flows shall read zero.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fans ready to start, the ventilation delay mode signal shall be applied, and it shall be verified that the ventilation delay mode pilot light turns on. The occupied mode signal shall be applied, and it shall be verified that the occupied mode pilot light turns on and that supply fan and return fan start. It shall be verified that the outside air and relief air dampers are closed, the return air damper is open, and the cooling coil valve and inlet vanes are under control, by slightly changing the controller output. The ventilation delay mode signal shall be released, and it shall be verified that the ventilation delay mode pilot light turns off and that the economizer outside air and relief air dampers remain closed, the return air damper remains open, and the minimum outside air damper comes under control of the minimum outside air flow controller, by changing the controller output.

(2) The 2-point calibration accuracy check of sensing element-to-controller readout for the minimum outside air flow measurement station shall be performed. VAV box dampers shall be forced to the full open position, exhaust fans shall be truned off, the supply duct static pressure controller outputshall be manually adjusted to achieve the design duct static pressure, the return fan volume controller output shall be manually adjsuted to achieve the design differential flow difference between the supply and return duct flows, the minimum outside air flow controller output shall be manually adjusted to achieve a flow which is approximately 25% less than the desired air flow. Under these conditions, the minimum outside air flow control loop shall be tuned. Stable operation of the minimum outside air flow control loop in response to a process disturbance shall be confirmed.

(3) With supply fan running, a high static pressure input signal shall be simulated at the device, by pressure input to the differential pressure switch sensing device. HVAC system shutdown shall be observed. It shall be verified that the high static pilot light turns on, and that contact

output at the EMCS terminals is made. The differential pressure switch shall be set at the setpoint shown. The HVAC system shall be restarted by manual restart, and it shall be verified that the high static pressure pilot light turns off.

(4) The supply fan static pressure controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check for sensing element-to-controller readout shall be performed. The controller shall be placed in the local setpoint mode. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller tuning procedure performed. The controller shall be set at the static pressure setpoint, and the mode constants logged.

(5) Each VAV terminal unit controller's minimum flow and maximum flow setpoints shall be set at the same setting, to prevent the VAV box damper from modulating under space temperature control and to achieve a constant supply duct system pressure drop. The return fan inlet vane shall be placed under control, and the starter switch shall be turned to the "AUTO" position so that the fan starts. The "MANUAL/AUTO" station of the return fan air volume controller shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check of sensing element-to-controller readout shall be performed. The controller shall be placed in the remote setpoint mode. Using the supply duct static pressure controller's "MANUAL" function, the supply fan inlet vane shall be operated to change the supply fan flow, and the controller ratio and bias settings shall be set as indicated. The supply fan flow shall be changed to verify that the return flow setpoint tracks the supply fan flow with the proper flow difference. A 12 ma signal shall be sent for tuning at setpoint midrange. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position and the controller tuning procedure shall be performed. A 4 ma, 12 ma and 20 ma signal shall be sent to the remote setpoint input, and it shall be verified that the return fan goes from minimum delivery setpoint to midrange delivery setpoint, and then to maximum delivery setpoint. The supply duct static pressure controller shall be placed in "AUTO."

(6) The mixed air temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position. An economizer mode input signal shall be simulated and it shall be verified that the economizer mode pilot light turns on. The mixed air temperature controller output shall be changed to slightly open the economizer outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-controller readout for outside air, return air, and mixed air temperatures shall be performed. The controller tuning procedure shall be performed. The mixed air temperature controller "MANUAL/AUTO" switch shall be indexed to the "AUTO" position. The mixed air temperature controller shall be placed in the local setpoint mode and set at the temperature setpoint shown.

(7) The cooling coil temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the calibration accuracy check of sensing element-to-controller readout shall be performed. The controller shall be placed in the local setpoint mode, and set at the temperature setpoint shown. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller tuning procedure performed.

(8) An unoccupied mode signal shall be applied, and it shall be verified that the occupied mode pilot light turns off, the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The

night thermostat temperature setting shall be turned upward, and it shall be verified that the HVAC system starts; the setting shall be turned downward, and it shall be verified that the HVAC system stops. The night thermostat shall be set at the setpoint shown.

(9) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter pilot light turns on, and that contact output at the EMCS terminals is made. The differential pressure switch shall be set at the setpoint shown.

(10) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shall shut down, and contact output at EMCS terminals shall be verified. It shall be verified that the low temperature pilot light turns on. The freezestat shall be set at the setpoint shown. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(11) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector and control device actions and interlock functions, as described in paragraph CONTROL SEQUENCES OF OPERATION shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down, that the smoke detector pilot light turns on, and that contact output at the EMCS terminals is made. The detectors shall be reset. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(12) For each VAV terminal unit, velocity setpoints shall be set for minimum and maximum flow, and temperature setpoints shall be set for the heating/cooling dead band. The actions of the controller, the operation of the damper, and the operation of heating shall be verified. It shall be verified that space temperature is maintained.

3.4.19 Single-Zone with Hydronic Heating and Cooling Coils; No Return Fan
Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be verified in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The outside-air and relief-air dampers shall be closed, the return-air damper shall be open, and the cooling-coil valve shall be closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown:

Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air, return-air, and space temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) With the fan ready to start, the ventilation-delay-mode signal shall be applied, and it shall be verified that the ventilation-delay-mode pilot light turns on. The occupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns on and that supply fan starts. It shall be verified that the outside-air and relief-air dampers are closed, the return-air damper is open, and the heating-coil and cooling-coil valves are under control, by slightly changing the controller outputs. The ventilation-delay-mode signal shall be released, and it shall be verified that the ventilation-delay-mode pilot light turns off and that the outside-air, return-air, and relief-air dampers come under control by changing the controller output.

(2) The minimum-outside-air-mode signal shall be applied. It shall be verified that the outside-air damper opens to minimum position and the economizer pilot light is off.

(3) The space-temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position. An economizer-mode input signal shall be simulated and it shall be verified that the economizer-mode pilot light turns on. The space-temperature controller output shall be changed and the second point of the two-point calibration accuracy check of sensing element-to-controller readout for outside-air, return-air, and space temperatures shall be performed. The controller shall be placed in the remote-setpoint mode. The setpoint low-end limit shall be set to 19 degrees C (66 degrees F) and the high-end limit shall be set to 22 degrees C (72 degrees F). Proper operation of the temperature setpoint device at the space-temperature sensing element and transmitter location shall be verified. The space-temperature controller tuning procedure shall be performed. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position and the temperature setpoint device shall be set to the space temperature setpoint as shown. A change in space temperature shall be simulated and it shall be verified that the heating-coil valve and the cooling-coil valve operate in sequence as shown.

(4) An unoccupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns off, the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The night-thermostat temperature setting shall be turned upward, and it shall be verified that the HVAC system starts; the setting shall be turned downward, and it shall be verified that the HVAC system stops. The night thermostat shall be set at the setpoint as shown.

(5) With the HVAC system running, a filter differential-pressure switch input signal shall be simulated at the device. It shall be verified that the filter pilot light turns on, and that contact output at the EMCS terminals is made. The differential-pressure switch shall be set at the setpoint as shown.

(6) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified, the low-temperature pilot light shall turn on, and contact output at the EMCS terminals shall be verified. The freezestat shall be set at the setpoint as

shown. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(7) With the HVAC system running, a smoke-detector trip input signal shall be simulated at each detector, and control-device actions and interlock functions, as described in paragraph CONTROL SEQUENCES OF OPERATION shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke-detector pilot light turns on, and contact output at the EMCS terminals is made. The detectors shall be reset. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

3.4.20 Single-Zone with Dual-Temperature Coil; No Return Fan Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be verified in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The outside-air and relief-air dampers shall be closed, the return-air damper shall be open, and the cooling-coil valve shall be closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown:

Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air, return-air, and space temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) With the fan ready to start, the ventilation-delay-mode signal shall be applied, and it shall be verified that the ventilation-delay-mode pilot light turns on. The occupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns on and that supply fan starts. It shall be verified that the outside-air and relief-air dampers are closed, the return-air damper is open, and the dual-temperature coil control valve is under control, by slightly changing the controller outputs. The ventilation-delay-mode signal shall be released, and it shall be verified that the ventilation-delay-mode pilot light turns off and that the outside-air, return-air, and relief-air dampers come under control by changing the controller output.

(2) The minimum-outside-air-mode signal shall be applied. It shall be verified that the outside-air damper opens to minimum position and the economizer pilot light is off.

(3) The heating-season and cooling-season space-temperature controllers "MANUAL/AUTO" stations shall be indexed to the "MANUAL" position. An

economizer-mode input signal shall be simulated and it shall be verified that the economizer-mode pilot light turns on. One space-temperature controller output shall be changed and the second point of the two-point calibration accuracy check of sensing element-to-controller readout for outside-air, return-air, and space temperatures (as indicated at both space-temperature controllers) shall be performed. The controllers shall be placed in the remote-setpoint mode. The setpoint low-end limit shall be set to 19 degrees C (66 degrees F) and the high-end limit shall be set to 22 degrees C (72 degrees F). Proper operation of the temperature setpoint device at the space-temperature sensing element and transmitter location shall be verified. The tuning procedure shall be performed for the heating-season and cooling-season space-temperature controllers. The controller "MANUAL/AUTO" station for the heating-season and cooling-season space-temperature controllers shall be indexed to the "AUTO" position and the temperature setpoint device shall be set to the space temperature setpoint as shown.

(4) Dual-temperature hydronic changeover operation of aquastat shall be simulated. Control system selection of opposite season space-temperature controller shall be verified.

(5) An unoccupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns off, the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The night-thermostat temperature setting shall be turned upward, and it shall be verified that the HVAC system starts; the setting shall be turned downward, and it shall be verified that the HVAC system stops. The night thermostat shall be set at the setpoint as shown.

(6) With the HVAC system running, a filter differential-pressure switch input signal shall be simulated at the device. It shall be verified that the filter pilot light turns on, and that contact output at the EMCS terminals is made. The differential-pressure switch shall be set at the setpoint as shown.

(7) With the HVAC system running, a freezestat trip input signal shall be simulated, at the device. HVAC system shutdown shall be verified. The low-temperature pilot light shall turn on; and contact output at EMCS terminals shall be verified. The freezestat shall be set at the setpoint as shown. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(8) With the HVAC system running, a smoke-detector trip input signal shall be simulated at each detector, and control-device actions and interlock functions, as described in paragraph CONTROL SEQUENCES OF OPERATION shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke-detector pilot light turns on, and contact output at the EMCS terminals is made. The detectors shall be reset. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

3.4.21 Single-Zone with Humidification; No Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be verified in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The outside-air damper, humidifier valve and cooling-coil valve shall be closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown:

Readings shall be taken with a digital thermometer at each temperature sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air and space temperatures shall be checked. Using a motor-driven psychrometer, the wet-bulb and dry-bulb temperatures of the humidifier discharge air and of the air in the space, shall be checked; the controller display shall be read, and the psychrometer and controller-display readings shall be logged.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) With the fan ready to start, the ventilation-delay-mode signal shall be applied, and it shall be verified that the ventilation-delay-mode pilot light turns on. The occupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns on and that supply fan starts. It shall be verified that the outside-air damper is closed, and the heating-coil, cooling-coil, and humidifier valves are under control, by slightly changing the controller outputs. The ventilation-delay-mode signal shall be released, and it shall be verified that the ventilation-delay-mode pilot light turns off and that the outside air damper opens.

(2) The outside-air preheat-coil temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the calibration accuracy check of sensing element-to-controller readout shall be performed. The controller shall be placed in the local-setpoint mode, and set at the temperature setpoint as shown. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure performed.

(3) The space-temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position. An economizer-mode input signal shall be simulated and it shall be verified that the economizer-mode pilot light turns on. The space-temperature controller output shall be changed and the second point of the two-point calibration accuracy check of sensing element-to-controller readout for outside-air, return-air, and space temperatures shall be performed. The controller shall be placed in the remote-setpoint mode. The setpoint low-end limit shall be set to 19 degrees C (66 degrees F) and the high-end limit shall be set to 22 degrees C (72 degrees F). Proper operation of the temperature setpoint device at the space-temperature sensing element and transmitter location shall be verified. The space-temperature controller tuning procedure shall be performed. The controller "MANUAL/AUTO" station

shall be indexed to the "AUTO" position and the temperature setpoint device shall be set to the space temperature setpoint as shown.

(4) The relative-humidity controller and high-limit-humidity controller "MANUAL/AUTO" stations shall be indexed to the "MANUAL" position. All controller outputs shall be set to minimum. The outputs of the relative-humidity controller and the space-temperature controller shall be changed to verify that the signal selector for the cooling valve selects the proper signal. The outputs of the relative-humidity controller and the high-limit relative-humidity controller shall be changed to verify that the signal selector for the humidifier valve selects the proper signal.

(5) The relative-humidity controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the two-point calibration accuracy check for sensing element-to-controller readout shall be performed. An identical calibration accuracy check and tuning procedure for the high-limit relative-humidity controller shall be performed. The controller shall be placed in the local setpoint mode, and the controller-tuning procedure shall be performed. The controller shall be set at the setpoint as shown. The high-limit relative-humidity controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure shall be performed. The controller shall be placed in the local setpoint mode. The duct high-limit-humidity controller shall be set at the setpoint as shown. A high-limit transmitter input signal equal to the high-limit value shall be simulated. It shall be verified that the humidifier valve closes. The signal shall be decreased to a value of 5 percent relative humidity below the high-limit value. It shall be verified that the primary controller resumes control.

(6) The hydronic-heating temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position. The controller output shall be changed to open the converter valve slightly. The two-point calibration accuracy check for sensing element-to-controller readout shall be performed. The controller shall be placed in the remote-setpoint mode. The remote setpoint shall be set for plus 5 degree F setpoint at 4 ma input. A 12 ma signal shall be sent to the remote setpoint for calibration at midrange. The temperature-controller "MANUAL/AUTO" switch shall be indexed to the "AUTO" position, the controller-tuning procedure shall be performed, and the mode-constants logged. Signals of 8 ma and 16 ma shall be sent to the remote setpoint, and it shall be verified that the controller setpoint changes to the appropriate values. The controller shall be set in the local-setpoint mode and set at the temperature setpoint as shown.

(7) An unoccupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns off, the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The night-thermostat temperature setting shall be turned upward, and it shall be verified that the HVAC system starts; the setting shall be turned downward, and it shall be verified that the HVAC system stops. The night thermostat shall be set at the setpoint as shown.

(8) With the HVAC system running, a filter differential-pressure switch input signal shall be simulated at the device. It shall be verified that the filter pilot light turns on, and that contact output at the EMCS terminals is made. The differential-pressure switch shall be set at the setpoint as shown.

(9) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified; the low-temperature pilot light shall turn on, and contact output at the EMCS terminals shall be verified. The freezestat shall be set at the setpoint as shown. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(10) With the HVAC system running, a smoke-detector trip input signal shall be simulated at each detector, and control-device actions and interlock functions, as described in paragraph CONTROL SEQUENCES OF OPERATION shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke-detector pilot light turns on, and contact output at the EMCS terminals is made. The detectors shall be reset. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

3.4.22 Single-Zone with Hydronic-Heating, Direct-Expansion Cooling

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be verified in its shutdown condition. Power and main air shall be available at the HVAC system control panel. The outside-air and relief-air dampers shall be closed, the return-air damper shall be open, and all stages of cooling shall be off.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown:

Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each controller display shall be read, and the thermometer and controller-display readings logged. The calibration accuracy of the sensing element-to-controller readout for outside-air, return-air, and space temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, using the controller "MANUAL/AUTO" station in "MANUAL." The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other. The signal levels that move the controlled device to its extreme positions shall be logged. The operating points of the sequence shall be set for each stage of cooling and the proper operation of each stage shall be verified.

d. Step 4 - Control-System Commissioning:

(1) With the fan ready to start, the ventilation-delay-mode signal shall be applied, and it shall be verified that the ventilation-delay-mode pilot light turns on. The occupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns on and that supply fan starts. It shall be verified that the outside-air and relief-air dampers are closed, the return-air damper is open, and the heating-coil and stages of cooling are under control, by slightly changing the controller output. The ventilation-delay-mode signal shall be released, and it shall be verified that the ventilation-delay-mode pilot light turns off and that the outside-air,

return-air, and relief-air dampers come under control by changing the controller output.

(2) The minimum-outside-air-mode signal shall be applied. It shall be verified that the outside-air damper opens to minimum position and the economizer pilot light is off.

(3) The space-temperature controller "MANUAL/AUTO" station shall be indexed to the "MANUAL" position, and the calibration accuracy check for sensing element-to-controller readout performed. The controller shall be placed in the remote-setpoint mode. The setpoint low-end limit shall be set to 19 degrees C (66 degrees F) and the high-end limit shall be set to 22 degrees C (72 degrees F). Proper operation of the temperature setpoint device at the space-temperature sensing element and transmitter location shall be verified. The controller "MANUAL/AUTO" station shall be indexed to the "AUTO" position, and the controller-tuning procedure shall be performed. The temperature setpoint device shall be set to the space temperature setpoint as shown. A change in space temperature shall be simulated and it shall be verified that the heating-coil valve and the stages of D/X cooling operate in sequence as shown.

(4) An unoccupied-mode signal shall be applied, and it shall be verified that the occupied-mode pilot light turns off, the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The night-thermostat temperature setting shall be turned upward, and it shall be verified that the HVAC system starts; the setting shall be turned downward, and it shall be verified that the HVAC system stops. The night thermostat shall be set at the setpoint as shown.

(5) With the HVAC system running, a filter differential-pressure switch input signal shall be simulated at the device. It shall be verified that the filter pilot light turns on, and that contact output at the EMCS terminals is made. The differential-pressure switch shall be set at the setpoint as shown.

(6) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified; the low-temperature pilot light shall turn on, and contact output at the EMCS terminals shall be verified. The freezestat shall be set at the setpoint as shown. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

(7) With the HVAC system running, a smoke-detector trip input signal shall be simulated at each detector, and control-device actions and interlock functions as described in paragraph CONTROL SEQUENCES OF OPERATION shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke-detector pilot light turns on, and contact output at the EMCS terminals is made. The detectors shall be reset. The HVAC system shall be restarted by manual restart, and it shall be verified that the pilot light turns off.

3.5 BALANCING, COMMISSIONING, AND TESTING

3.5.1 Coordination with HVAC System Balancing

Commissioning of the control system, except for tuning of controllers, shall be performed prior to or simultaneous with HVAC system balancing. The

Contractor shall tune the HVAC control system after all air-system and hydronic-system balancing has been completed, minimum damper positions set and a report has been issued.

3.5.2 Control System Calibration, Adjustments, and Commissioning

Control system commissioning shall be performed for each HVAC system, using test plans and procedures previously approved by the Government. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform commissioning and testing of the HVAC control system. All instrumentation and controls shall be calibrated and the specified accuracy shall be verified using test equipment with calibration traceable to NIST standards. Wiring shall be tested for continuity and for ground, open, and short circuits. Tubing systems shall be tested for leaks. Mechanical control devices shall be adjusted to operate as specified. HVAC control panels shall be pretested off-site as a functioning assembly ready for field connections, calibration, adjustment, and commissioning of the operational HVAC control system. Written notification of any planned commissioning or testing of the HVAC Control systems shall be given to the Government at least 14 calendar days in advance.

3.5.3 Performance Verification Test

The Contractor shall demonstrate compliance of the HVAC control system with the contract documents. Using test plans and procedures previously approved by the Government, the Contractor shall demonstrate all physical and functional requirements of the project. The performance verification test shall show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. The performance verification test shall not be started until after receipt by the Contractor of written permission by the Government, based on Government approval of the commissioning report and completion of balancing. The tests shall not be conducted during scheduled seasonal off-periods of base heating and cooling systems.

3.5.4 Posted and Panel Instructions

Posted and panel instructions, showing the final installed conditions, shall be provided for each system. The posted instructions shall consist of half-size laminated drawings and shall include the control system schematic, equipment schedule, ladder diagram, sequence of operation, panel arrangement drawings, wiring diagram, and valve and damper schedules. The posted instructions shall be permanently affixed, by mechanical means, to a wall near the control panel. Panel instructions shall consist of laminated letter-size sheets and shall include a routine maintenance checklist and controller configuration check sheets with final configuration record for each controller. Panel instructions and one copy of the operation and maintenance manuals, previously described herein, shall be placed inside each control panel.

3.6 TRAINING

3.6.1 Training-Course Requirements

A training course shall be conducted for operating staff members designated by the Contracting Officer. The training period, for a total of 24 hours of normal working time, shall be conducted within 30 days after successful completion of the performance verification test. The training course shall be conducted at the project site. Audiovisual equipment and all other training materials and supplies shall be provided. A training day is defined as 8 hours of classroom instruction, including two 15-minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

3.6.2 Training-Course Content

For guidance in planning the required instruction, the Contractor shall assume that attendees will have a high school education or equivalent, and are familiar with HVAC systems. The training course shall cover all of the material contained in the operating and maintenance instructions, the layout and location of each HVAC control panel, the layout of one of each type of unitary equipment and the locations of each, the location of each system-control device external to the panels, the location of the compressed-air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, and repair procedures. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. The results of the performance verification test and the calibration, adjustment and commissioning report shall be presented as benchmarks of HVAC control-system performance by which to measure operation and maintenance effectiveness.

SECTION 15990

TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ASSOCIATED AIR BALANCE COUNCIL (AABC)

AABC MN-1 (1989) National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB TABES (1991) Procedural Standards for Testing Adjusting Balancing of Environmental Systems

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

TAB Schematic Drawings and Report Forms; G

Six copies of the TAB Schematic Drawings and Report Forms, no later than 21 days prior to the start of TAB field measurements.

SD-03 Product Data

TAB Related HVAC Submittals

A list of the TAB Related HVAC Submittals, no later than 7 days after the approval of the TAB Specialist.

TAB Procedures; G

Proposed procedures for TAB, submitted with the TAB Schematic Drawings and Report Forms.

Calibration

List of each instrument to be used during TAB, stating calibration requirements required or recommended by both the TAB Standard and the instrument manufacturer and the actual calibration history of the instrument, submitted with the TAB Procedures. The calibration history shall include dates calibrated, the qualifications of the calibration laboratory, and the calibration procedures used.

Systems Readiness Check

Proposed date and time to begin the Systems Readiness Check, no later than 7 days prior to the start of the Systems Readiness Check.

TAB Execution

Proposed date and time to begin field measurements, making adjustments, etc., for the TAB Report, submitted with the Systems Readiness Check Report.

TAB Verification

Proposed date and time to begin the TAB Verification, submitted with the TAB Report.

SD-06 Test Reports

Design Review Report

A copy of the Design Review Report, no later than 14 days after approval of the TAB Firm and the TAB Specialist.

Systems Readiness Check

A copy of completed checklists for each system, each signed by the TAB Specialist, at least 7 days prior to the start of TAB Execution. All items in the Systems Readiness Check Report shall be signed by the TAB Specialist and shall bear the seal of the Professional Society or National Association used as the TAB Standard.

TAB Report; G

Six copies of the completed TAB Reports, no later than 7 days after the execution of TAB. All items in the TAB Report shall be signed by the TAB Specialist and shall bear the seal of the Professional Society or National Association used as the TAB Standard.

TAB Verification Report; G

Six copies of the completed TAB Verification Report, no later than 7 days after the execution of TAB Verification. All items in the TAB Verification Report shall be signed by the TAB Specialist and shall bear the seal of the Professional Society or National Association used as the TAB Standard.

SD-07 Certificates

Ductwork Leak Testing

A written statement signed by the TAB Specialist certifying that the TAB Specialist witnessed the Ductwork Leak Testing, it was successfully completed, and that there are no known deficiencies related to the ductwork installation that will prevent TAB from producing satisfactory results.

TAB Firm

Certification of the proposed TAB Firm's qualifications by either AABC or NEBB to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. The documentation shall include the date that the Certification was initially granted and the date that the current Certification expires. Any lapses in Certification of the proposed TAB Firm or disciplinary action taken by AABC or NEBB against the proposed TAB Firm shall be described in detail.

TAB Specialist

Certification of the proposed TAB Specialist's qualifications by either AABC or NEBB to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. The documentation shall include the date that the Certification was initially granted and the date that the current Certification expires. Any lapses in Certification of the proposed TAB Specialist or disciplinary action taken by AABC or NEBB against the proposed TAB Specialist shall be described in detail.

1.3 SIMILAR TERMS

In some instances, terminology differs between the Contract and the TAB Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results. The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding AABC or NEBB requirements where differences exist.

SIMILAR TERMS

Contract Term	AABC Term	NEBB Term
TAB Standard	National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems	Procedural Standards for Testing Adjusting Balancing of Environmental Systems
TAB Specialist	TAB Engineer	TAB Supervisor
Systems Readiness Check	Construction Phase Inspection	Field Readiness Check & Preliminary Field Procedures.

1.4 TAB STANDARD

TAB shall be performed in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved, i.e., AABC MN-1 or NEBB TABES, unless otherwise specified herein. All recommendations and suggested practices contained in the TAB Standard shall be considered mandatory. The provisions of the TAB Standard, including checklists, report forms, etc., shall, as nearly as practical, be used to satisfy the Contract requirements. The TAB Standard shall be used for all aspects of TAB, including qualifications for the TAB Firm and Specialist and calibration of TAB instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the TAB Standard, the manufacturer's recommendations shall be adhered to. All quality assurance provisions of the TAB Standard such as performance guarantees shall be part of this contract. For systems or system components not covered in the TAB Standard, TAB procedures shall be developed by the TAB Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the TAB Standard used (AABC or NEBB), the requirements and recommendations contained in these procedures and requirements shall be considered mandatory.

1.5 QUALIFICATIONS

1.5.1 TAB Firm

The TAB Firm shall be either a member of AABC or certified by the NEBB and certified in all categories and functions where measurements or performance are specified on the plans and specifications, including TAB of environmental systems, the performance of clean rooms and clean air devices, building systems commissioning and the measuring of sound and vibration in environmental systems. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor shall immediately notify the Contracting Officer and submit another TAB Firm for approval. Any firm that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections to be performed by the TAB Firm shall be considered invalid if the TAB Firm loses its certification prior to Contract completion and must be performed by an approved successor.

These TAB services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The TAB Firm shall be a subcontractor of the prime Contractor and shall be financially and corporately independent of the mechanical subcontractor, and shall report to and be paid by the prime Contractor.

1.5.2 TAB Specialist

The TAB Specialist shall be either a member of AABC or an experienced technician of the Firm certified by the NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the Contractor shall immediately notify the Contracting Officer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB Specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by the approved successor.

1.6 TAB SPECIALIST RESPONSIBILITIES

All TAB work specified herein and in related sections shall be performed under the direct guidance of the TAB Specialist. The TAB Specialist shall participate in the commissioning process specified in Section 15995 COMMISSIONING OF HVAC SYSTEMS.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 DESIGN REVIEW

The TAB Specialist shall review the Contract Plans and Specifications and advise the Contracting Officer of any deficiencies that would prevent the HVAC systems from effectively operating in accordance with the sequence of operation specified or prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a Design Review Report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

3.2 TAB RELATED HVAC SUBMITTALS

The TAB Specialist shall prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all HVAC TAB. The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the TAB Specialist when submitted to the Government. The TAB Specialist shall also ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.

3.3 TAB SCHEMATIC DRAWINGS AND REPORT FORMS

A schematic drawing showing each system component, including balancing devices, shall be provided for each system. Each drawing shall be accompanied by a copy of all report forms required by the TAB Standard used for that system. Where applicable, the acceptable range of operation or appropriate setting for each component shall be included on the forms or as an attachment to the forms. The schematic drawings shall identify all testing points and cross reference these points to the report forms and procedures.

3.4 DUCTWORK LEAK TESTING

The TAB Specialist shall witness the Ductwork Leak Testing specified in Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM and approve the results as specified in Paragraph TAB RELATED HVAC SUBMITTALS.

3.5 TESTING, ADJUSTING, AND BALANCING

3.5.1 TAB Procedures

Step by step procedures for each measurement required during TAB Execution shall be provided. The procedures shall be oriented such that there is a separate section for each system. The procedures shall include measures to ensure that each system performs as specified in all operating modes, interactions with other components (such as exhaust fans, kitchen hoods, fume hoods, relief vents, etc.) and systems, and with all seasonal operating differences, diversity, simulated loads, and pressure relationships required.

3.5.2 Systems Readiness Check

The TAB Specialist shall inspect each system to ensure that it is complete, including installation and operation of controls, and that all aspects of the facility that have any bearing on the HVAC systems, including installation of ceilings, walls, windows, doors, and partitions, are complete to the extent that TAB results will not be affected by any detail or touch-up work remaining. The TAB Specialist shall also verify that all items such as ductwork and piping ports, terminals, connections, etc., necessary to perform TAB shall be complete during the Systems Readiness Check.

3.5.3 Preparation of TAB Report

Preparation of the TAB Report shall begin only when the Systems Readiness Report has been approved. The Report shall be oriented so that there is a separate section for each system. The Report shall include a copy of the appropriate approved Schematic Drawings and TAB Related Submittals, such as pump curves, fan curves, etc., along with the completed report forms for each system. The operating points measured during successful TAB Execution and the theoretical operating points listed in the approved submittals shall be marked on the performance curves and tables. Where possible, adjustments shall be made using an "industry standard" technique which would result in the greatest energy savings, such as adjusting the speed of a fan instead of throttling the flow. Any deficiencies outside of the realm of normal adjustments and balancing during TAB Execution shall be noted along with a description of corrective action performed to bring the measurement into the specified range. If, for any reason, the TAB Specialist determines during TAB Execution that any Contract requirement cannot be met, the TAB Specialist shall immediately provide a written description of the deficiency and the corresponding proposed corrective action necessary for proper system operation to the Contracting Officer.

3.5.4 TAB Verification

The TAB Specialist shall recheck ten percent of the measurements listed in the Tab Report and prepare a TAB Verification Report. The measurements selected for verification and the individuals that witness the verification will be selected by the Contracting Officer's Representative (COR). The measurements will be recorded in the same manner as required for the TAB Report. All measurements that fall outside the acceptable operating range specified shall be accompanied by an explanation as to why the measurement does not correlate with that listed in the TAB Report and a description of corrective action performed to bring the measurement into the specified range. The TAB Specialist shall update the original TAB report to reflect any changes or differences noted in the TAB verification report and submit the updated TAB report. If over 20 percent of the measurements selected by the COR for verification fall outside of the acceptable operating range specified, the COR will select an additional 10 percent for verification. If over 20 percent of the total tested (including both test groups) fall outside of the acceptable range, the TAB Report shall be considered invalid and all contract TAB work shall be repeated beginning with the Systems Readiness Check.

3.5.5 Marking of Setting

Following approval of TAB Verification Report, the setting of all HVAC adjustment devices including valves, splitters, and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time.

3.5.6 Identification of Test Ports

The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leakage or to maintain integrity of vapor barrier.

STANDARD TECHNICAL SPECIFICATIONS

FOR

O&MA PROJECTS, KOREA

Volume IV

October 1, 2003

DEPARTMENT OF THE ARMY
INSTALLATION MANAGEMENT AGENCY
KOREA REGION OFFICE

DIVISION 16 ELECTRICAL

SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D709 (2000) Laminated Thermosetting Materials

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.147 Control of Hazardous Energy (Lock Out/Tag Out)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100 (1996) Dictionary of Electrical and Electronics Terms (ANSI/IEEE)

IEEE C2 (2002) National Electrical Safety Code (ANSI/IEEE)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C57.12.28 (1999) Pad-Mounted Equipment - Enclosure Integrity (Revision of ANSI C57.12.28-88)

NEMA ICS 6	(1993) Industrial Control and Systems Enclosures
NEMA MG 1	(1998; Errata 1999) Motors and Generators
NEMA MG 10	(1994) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 1992) Energy Management Guide for Selection and Use of Single-Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2002) National Electrical Code

1.2 RELATED REQUIREMENTS

This section applies to all sections of Division 16, "Electrical," of this project specification unless specified otherwise in the individual sections.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

c. The technical paragraphs referred to herein are those paragraphs in PART 2 - PRODUCTS and PART 3 - EXECUTION of the technical sections that describe products, systems, installation procedures, equipment, and test methods.

1.4 ELECTRICAL CHARACTERISTICS

Electrical characteristics for the project shall be as shown on contract drawings. Final connections to the power distribution system at the existing substation or manhole shall be made as specified.

1.5 SUBMITTALS

Submittals required in the sections which refer to this section shall conform to the requirements of Section 01330, "Submittal Procedures" and to the following additional requirements. Submittals shall include the manufacturer's name, trade name, place of manufacture, catalog model or number, nameplate data, size, layout dimensions, capacity, project specification and technical paragraph reference. Submittals shall also include applicable federal, military, industry, and technical society publication references, and years of satisfactory service, and other information necessary to establish contract compliance of each item to be provided. Photographs of existing installations are unacceptable and will be returned without approval.

1.5.1 Manufacturer's Catalog Data

Submittals for each manufactured item shall be current manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts. Handwritten and typed modifications and other notations not part of the manufacturer's preprinted data will result in the rejection of the submittal. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified for certificates of compliance.

1.5.2 Drawings

Submit drawings a minimum of 355 by 510 mm (14 by 20 inches) in size using a minimum scale of one mm per 100 mm (1/8 inch per foot) except as specified otherwise. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.5.3 Instructions

Where installation procedures or part of the installation procedures are required to be in accordance with manufacturer's instructions, submit printed copies of those instructions prior to installation. Installation of the item shall not proceed until manufacturer's instructions are received. Failure to submit manufacturer's instructions shall be cause for rejection of the equipment or material.

1.5.4 Certificates

Submit manufacturer's certifications as required for products, materials, finishes, and equipment as specified in the technical sections. Certificates from material suppliers are not acceptable. Preprinted certifications and copies of previously submitted documents will not be acceptable. The manufacturer's certifications shall name the appropriate products, equipment, or materials and the publication specified as controlling the quality of that item. Certification shall not contain statements to imply that the item does not meet requirements specified, such as "as good as"; "achieve the same end use and results as materials formulated in accordance with the referenced publications"; or "equal or exceed the service and performance of the specified material." Certifications shall simply state that the item conforms to the requirements specified. Certificates shall be printed on the manufacturer's letterhead and shall be signed by the manufacturer's official authorized to sign certificates of compliance.

1.5.4.1 Reference Standard Compliance

Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations such as American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), National Electrical Manufacturers Association (NEMA), Underwriters Laboratories (UL), Korean Standards (KS) and Association of

Edison Illuminating Companies (AEIC), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance.

1.5.4.2 Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.5.5 Operation and Maintenance Manuals

Comply with the requirements of Section 01781N, "Operation and Maintenance Data" and the technical sections.

1.5.5.1 Operating Instructions

Submit text of posted operating instructions for each system and principal item of equipment as specified in the technical sections.

1.6 QUALITY ASSURANCE

1.6.1 Material and Equipment Qualifications

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

1.6.2 Regulatory Requirements

Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70.

1.6.3 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.4 Service Support

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6.5 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.6.6 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer.

1.6.7 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

a. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.

b. Start up, proper adjustment, operating, lubrication, and shutdown procedures.

c. Safety precautions.

d. The procedure in the event of equipment failure.

e. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.8 NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each panelboard, equipment enclosure, relay, switch, and device; as specified in the technical sections or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm (0.125 inch) thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm (one by 2.5 inches). Lettering shall be a minimum of 6.35 mm (0.25 inch) high normal block style.

1.9 WARNING SIGNS

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with NEMA C57.12.28, such as for pad-mounted transformers and pad-mounted SF6 switches, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 178 by 255 mm (7 by 10 inches) with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 50 mm (2 inch) high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 355 by 255mm (14 by 10 inches) with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 75 mm (3 inch) high white letters on a red and black field.

1.10 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each cable or wire located in manholes, handholes, and vaults. Tag new wire and cable provided under this contract and existing wire and cable which are indicated to have splices and terminations provided by this contract. The first position on the tag shall denote the voltage. The second through sixth positions on the tag shall identify the circuit. The next to last position shall denote the phase of the circuit and shall include the Greek "phi" symbol. The last position shall denote the cable size or tag legend shall be as indicated. The tags shall be polyethylene or sheet lead. Do not provide handwritten letters. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A) 500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

1.10.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 22.4 MPa (3250 pounds per square inch); and that are two millimeter (0.08 inch) thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 77 degrees C (170 degrees F). Provide 1.3 mm (0.05 inch) minimum thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 778.75 N (175 pounds). The cable tags shall have black block letters, numbers, and symbols 25 mm (one inch) high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.

1.11 ELECTRICAL REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.11.1 Motors and Equipment

Provide electrical components of mechanical equipment, such as motors, motor starters, control or push-button stations, float or pressure switches, solenoid valves, and other devices functioning to control mechanical equipment, including control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors shall not be permitted. The interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit, the motor control equipment forming a part of motor control centers, and the electrical power circuits shall be provided under Division 16.

Provide motors, controllers, integral disconnects, and contactors with their respective pieces of equipment. Motors, controllers, integral disconnects, and contactors shall conform as specified. Extended voltage range motors shall not be permitted. Control voltage for controllers and contactors shall not exceed 120 volts nominal. When motors and equipment furnished are larger than sizes indicated, the cost of additional electrical service and related work shall be included under the section that specified that motor or equipment. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.

1.11.2 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment, and motor control equipment forming part of motor control centers or switchgear assemblies, the conduit and wiring connecting such centers, assemblies, or other power sources to equipment under Section 16415, "Electrical Work Interior". Power wiring and conduit shall conform to Section 16415, "Electrical Work Interior". Control wiring and conduit shall be provided under, and conform to the requirements of the section specifying the associated equipment.

1.11.3 New Work

Provide electrical components of mechanical equipment, such as motors, motor starters (except starters/controllers which are indicated as part of a motor control center), control or push-button stations, float or pressure switches, solenoid valves, integral disconnects, and other devices functioning to control mechanical equipment, as well as control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors shall not be permitted. The interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit, the motor control equipment forming a part of motor control centers, and the electrical power circuits shall be provided under Division 16, except internal wiring for components of packaged equipment shall be provided as an integral part of the equipment. When motors and equipment furnished are larger than sizes indicated, provide any required changes to the electrical service as may be necessary and related work as a part of the work for the section specifying that motor or equipment.

1.11.4 Modifications to Existing Systems

Where existing mechanical systems and motor-operated equipment require modifications, provide electrical components under Division 16.

1.11.5 High Efficiency Motors

1.11.5.1 High Efficiency Single-Phase Motors

Unless otherwise specified, single-phase fractional-horsepower alternating-current motors shall be high efficiency types corresponding to the applications listed in NEMA MG 11.

1.11.5.2 High Efficiency Polyphase Motors

Unless otherwise specified, polyphase motors shall be selected based on high efficiency characteristics relative to the applications as listed in NEMA MG 10. Additionally, polyphase squirrel-cage medium induction motors with continuous ratings shall meet or exceed energy efficient ratings in accordance with Table 12-10 of NEMA MG 1.

1.12 INSTRUCTION TO GOVERNMENT PERSONNEL

Where specified in the technical sections, furnish the services of competent instructors to give full instruction to designated Government personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section.

1.13 LOCKOUT REQUIREMENTS

Provide disconnecting means capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147. Mechanical isolation of machines and other equipment shall be in accordance with requirements of Division 15, "Mechanical."

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 PAINTING OF EQUIPMENT

3.1.1 Factory Applied

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA ICS 6 corrosion-resistance test.

3.1.2 Field Applied

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09900N, "Paints and Coatings" or the section specifying the associated electrical equipment.

3.2 NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 9 meters (30 feet) apart.

3.4 CABLE TAG INSTALLATION

Install cable tags in each manhole, handhole, and vault as specified, including each splice. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

SECTION 16234

DIESEL ENGINE-GENERATOR SETS - PRIME AND STANDBY - 10 TO 500 KW

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC S335	(1989)Structural Steel Buildings Allowable Stress Design and Plastic Design

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B18.2.1	(1996) Square and Hex Bolts and Screws Inch Series
ANSI C12.10	(1987) Electromechanical Watthour Meters
ANSI C37.16	(1997) Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations
ANSI C37.17	(1997) Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers
ANSI C39.1	(1981; R 1992) Electrical Analog Indicating Instruments
ANSI S1.4 (ASA 47)	(1983; R 1994) Sound Level Meters

AMERICAN PETROLEUM INSTITUTE (API)

API STD 599	(1994) Metal Plug Valves - Flanged and Welded Ends

ASME INTERNATIONAL (ASME)

ASME B1.1	(1998) Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI/ASME B15.1	(1996) Mechanical Power Transmission Apparatus
ASME/ANSI B16.1	(1989) Cast Iron Pipe Flanges and Flanged Fittings
ANSI/ASME B16.3	(1992) Malleable Iron Threaded Fittings
ASME/ANSI B16.5	(1996) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24
ASME/ANSI B16.9	(1993) Factory-Made Wrought Steel Buttwelding Fittings
ASME/ANSI B16.39	(1986; R 1994) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
ASME/ANSI B31.9	(1996) Building Services Piping
ASME BPVC SEC VIII D1	(1995; Addenda 1995, 1996, and 1997) Boiler and Pressure Vessel Code: Section VIII Pressure Vessels, Division 1

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53	(1998) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 126	(1995) Gray Iron Castings for Valves, Flanges, and Pipe Fittings

ASTM A 181/A 181M	(1995; Rev. B) Carbon Steel Forgings, for General-Purpose Piping
ASTM A 193/A 193M	(1997; Rev. A) Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 194/A 194M	(1996) Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
ASTM A 234/A 234M	(1998; Rev. B) Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperatures Service
ASTM A 307	(1997) Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM D 975	(1997) Diesel Fuel Oils

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-52557	Fuel Oil, Diesel; for Posts, Camps and Stations
FS O-S-801	(Rev. E) Sulfuric Acid, Electrolyte (for Storage Batteries)

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO)

ICBO UBC	(1994) Uniform Building Code

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 34	Rotating Electrical Machines Part 2: Methods for Determining Losses and Efficiency of Rotating Electrical Machinery from Tests (Excluding Machines for Traction Vehicles)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 115	(1995) Synchronous Machines
IEEE 421.1	(1986; R 1996) Definitions for Excitation Systems for Synchronous Machines
IEEE C37.2	(1996) Electrical Power System Device Function Numbers
ANSI/IEEE C37.13	(1990) Low-Voltage AC Power Circuit Breakers Used in Enclosures
ANSI/IEEE C57.13	(1993) Instrument Transformers

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-T-152	(Rev. B) Treatment, Moisture- and Fungus-Resistant, of Communications, Electronic, and Associated Electrical Equipment

MIL-V-173	(Rev. C) Varnish, Moisture and Fungus Resistant (for Treatment of Communications, Electronics, and Associated Equipment)
MIL-T-5544	(Rev. C) Thread Compound, Antiseize, Graphite-Petrolatum
MIL-PRF-5624	(Rev. S) Turbine Fuel, Aviation, Grades JP-4, JP-5 and JP-5/JP-8 ST
MIL-S-16165	(Rev. E) Shielding Harnesses, Shielding Items and Shielding Enclosures for Use in the Reduction of Interference from Engine Electrical Systems
MIL-F-16884	(Rev. J) Fuel, Naval Distillate
MIL-T-22361	(Am. 1) Thread Compound; Antiseize, Zinc Dust-Petrolatum
MIL-I-24092	(Rev. D; Supp. 1) Insulating Varnishes and Solventless Resins For Applications by the Dip Process
MIL-STD-461	(Rev. D) Control of Electromagnetic Interference Emissions and Susceptibility

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY(MSS)

MSS SP-70	(1990) Cast Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(1997) Cast Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-78	(1987; R 1992) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(1997) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(1994) Cast Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1991) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2001) Molded Case Circuit Breakers and Their Applications
NEMA MG 1	(1993; Rev. 1-4) Motors and Generators
NEMA PB 2	(1995) Deadfront Distribution Switchboards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(1996) Flammable and Combustible Liquids Code
NFPA 37	(1998) Installation and Use of Stationary Combustion Engines and Gas Turbines

NFPA 70	(2002) National Electrical Code
NFPA 99	(1996) Health Care Facilities

SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA DCS	(1985) HVAC Duct Construction Standards - Metal and Flexible

UNDERWRITERS LABORATORIES (UL)

UL 429	(1994; Bul. 1994, R 1995) Electrically Operated Valves
UL 489	(1996; R 1998) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 1236	(1994; R 1999) Battery Chargers for Charging Engine-Starter Batteries

KOREAN INDUSTRIAL STANDARDS (KS)

KS C 2302	(1986) Friction Tape
KS C 2306	(1999) Pressure Sensitive PVC Adhesive Tape
KS C 2347	(1986) Pressure Sensitive Polyester Adhesive Tape
KS C 3101	(1995) Copper Wire, Electrical, Solid, Softdrawn
KS C 3102	(1998) Copper Wire, Electrical, Solid Harddrawn
KS C 3103	(1986) Copper Wire, Electrical, Stranded, Softdrawn
KS C 3104	(1996) Copper Wire, Electrical, Stranded, Harddrawn
KS C 3302	(1990) 600V PVC Insulated Wire, IV
KS C 3323	(1999) 600V PVC Insulated and Sheathed Cable, VV
KS C 3328	(2002) 600V PVC Insulated and Sheathed Cable, HIV
KS C 8401	(1997) Rigid Steel Conduit
KS C 8422	(2002) Steel Flexible Conduit
KS C 8431	(2001) Unplasticized Polyvinyl Chloride (UPVC) Conduit
KS C 8458	(2001) Outlet Boxes, Switch Boxes, Special Outlet Boxes, Box Covers for Rigid Metal Conduit
KS C 8459	(1997) Coupling, Connector for Flexible Conduit
KS C 8460	(2001) Bushing, Saddles, Locknuts, Couplings, Insulated Bushings for Rigid Metal Conduit
KS C 8461	(1997) Universal Fittings, Terminal Caps, Surface Switch Boxes, Circular Surface Boxes For Rigid Metal Conduit

KS D 8308 (2001) Zinc Coating (Hot Dipped) on Iron and Steel

1.2 RELATED REQUIREMENTS

Section 16050, "Basic Electrical Materials and Methods," applies to this section with the additions and modifications specified herein.

1.3 DEFINITIONS

a. Intercooling - Cooling of charged air after it leaves turbocharger compressor.

b. IEEE Device Numbers - Described in IEEE Standard IEEE C37.2.

c. Gross and Net Bkw (Bhp) Ratings of Engine - Gross rating shall be total rated power output before deducting power requirements of electric motor-driven equipment. Net ratings shall be equal to gross ratings minus total power requirements of electric motor-driven accessories normally constituting part of "engine assembly."

1.4 SYSTEM DESIGN

1.4.1 Engine-Generator Set Data

Submit the following data pertaining to each engine-generator set.

a. Manufacturer of engine

b. Type or model of engine

c. Gross bkw (bhp) rating of engine

d. Net bkw (bhp) rating of engine

e. Strokes per cycle

f. Number of cylinders

g. Bore and stroke, mm (inches)

h. Engine speed, rpm

i. Piston speed, m/s (fpm)

j. BMEP at full load Pa (psig)

k. kW rating of generator set at specified voltage and temperature rise per NEMA MG 1

l. kVA rating of generator and power factor

m. Induction method (naturally aspirated, turbocharged)

n. Intercooler type (air-to-air or jacket water)

o. Governor type, make and model

p. Make and model of turbochargers

q. Motor starting kVA of generator set at 35 percent dip for voltage specified

1.4.2 Engine-Generator Unit Guarantees

Submit for the following. Fractional loads shall be calculated on basis of net ratings unless otherwise called for.

a. Fuel consumption at 0.80 power factor (Joules (Btu) per net kWh)

(1) 1/2 load

(2) 3/4 load

(3) Full load.

b. Generator efficiency at 0.80 power factor

(1) 1/2 of net-rated load

(2) 3/4 of net-rated load

(3) Full net-rated load.

c. Radiator capacity at design conditions

(1) Coolant shall be antifreeze mixture as specified under paragraph entitled "Cooling System."

(2) Engine jacket coolant flow, L/S (GPM)

(3) Air flow through radiator (cubic meter/minute) (CFM)

1.4.3 Diesel Engine Data

Submit the following data certified by the engine manufacturer:

a. Starting air pressure (Pa (psig))

b. Approximate exhaust temperature degrees C (F) at full load

c. Cubic meter/minute (CFM) of exhaust gas at full load

d. Cubic meter/minute (CFM) of intake air at full load

e. Total heat rejected to cooling system and to ambient air at full load at maximum ambient temperature

f. Maximum jacket coolant temperature from engine degrees C (F) at full load

g. Jacket coolant temperature from engine that will cause generator set shutdown for over-temperature, (Degrees C) (Degrees F)

h. Lubricating oil consumption in liters (gallons) per hour at full load (estimated)

i. Recommended grade and type of lubricating oil

j. Maximum overspeed limit

1.4.4 Parallel Operation Verification

Analyze existing plant governors, voltage regulators, and electro-mechanical energy transients to determine compatibility with sets supplied.

1.5 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Engine-generator unit and auxiliary equipment; G

Engine-generator unit electrical drawings; G

SD-03 Product Data

Engine-generator set; G

Engine-generator unit guarantees; G

SD-05 Design Data

Torsional vibrations analysis for each unit; G

Parallel operation verification; G

SD-06 Test Reports

Switchboard bus continuous current test; G

Piping tests; G

Preliminary operation; G

Phase relationship tests; G

Control panel and switchboard tests; G

Engine-generator set acceptance tests; G

Auxiliary equipment test; G

Submit test and inspection reports for work required under paragraph, "Field Quality Control."

SD-07 Certificates

Diesel engine generator successful operation; G

Field welding procedures; G

SD-09 Manufacturer's Field Reports

Engine-generator set tests; G

Submit certified factory test report within 15 calendar days after completion of tests.

SD-10 Operation and Maintenance Data; G

Engine-generator unit and auxiliary equipment, Data Package 4

Engine speed governing system, Data Package 3

Engine-generator set voltage regulator, Data Package 5

Engine control panel, Data Package 5

Generator switchboard, Data Package 5

SD-11 Closeout Submittals

Posted operating instructions for diesel engine-generator set

Provide text for each piece of equipment according to paragraph, "POSTED OPERATING INSTRUCTIONS."

1.6 QUALITY ASSURANCE

1.6.1 Experience Requirements

Engines installed shall meet the following operating experience requirements:

a. Only electric generation service is considered equivalent experience. Engines driving pumps, compressors, or those in marine propulsion or railroad service are not acceptable.

b. Only experience on the same engine model is acceptable. Engine model is considered to be a given series or class of identical bore and stroke and of the same type of engine, such as In-line or Vee. In-line and Vee engines with identical bore and stroke are considered as two separate models.

c. Only experience at identical or higher rotative speed as that specified is acceptable.

d. Only experience at identical or higher BMEP as that specified is acceptable.

e. Only experience with diesel-fueled engines is acceptable.

1.6.2 Regulatory Requirements

a. Provide devices designed and installed to comply with the following requirements:

(1) Power Transmission Apparatus: Guard in accordance with ANSI/ASME B15.1.

(2) Electrical Installations: Conform to NFPA 70.

(3) Operator Protection: Guard in accordance with 29 CFR 1910 as follows:

(a) Fan blades: Part 1910, Subpart O

(4) Mercury: Use of mercury in instruments, contacts, and manometers is not permitted.

b. File inspection certificates for compressed air storage system with proper authorities as may be required by law and furnish a copy to the Contracting Officer.

1.6.3 Drawing Requirements

1.6.3.1 Engine-Generator Unit and Auxiliary Equipment

Submit outline and installation drawings or catalog cuts containing installation details, including the following:

a. Certified outline, general arrangement (setting plan), and anchor bolt details. Show total weight and center of gravity of assembled equipment on the steel subbase.

b. General arrangement and detail piping of exhaust and air intake piping systems, and cooling piping details of units having remote cooling radiators.

c. General arrangement, size, and location of electrical interface points, and detailed elementary, schematic wiring, and interconnection diagrams of generator, exciter, governor, and other integral devices.

d. Dimensional drawings or catalog cuts of exhaust and intake silencers, intake filters, pumps, tanks, remote radiators, starting equipment, and other auxiliary equipment not integral with the generator set.

e. General arrangement or assembly drawings showing location of major auxiliary equipment in relation to the engine-generator set.

f. Piping schematics for fuel oil and engine coolant showing pipe sizes and valve locations.

g. Engine-generator control panel.

1.6.3.2 Engine-Generator Unit Electrical Drawings

Submit electrical drawings including elementary, schematic, wiring, and interconnection diagrams for the generator switchboard.

1.6.4 Switchboard Bus Continuous Current Test

Certify that switchboard bus meets NEMA PB 2 rated continuous current design test by listing bus size, bus quantity, bus material, rated amperes used, plus measured temperature rise and ambient temperature used during the test.

1.6.5 Field Welding Procedures (Piping)

Before performing field welding, submit to the Contracting Officer, welding procedure specifications for metals included in the work, with proof of qualification as outlined in ASME/ANSI B31.9.

1.7 DELIVERY, STORAGE AND HANDLING

Deliver equipment on pallets or blocking with each entire unit wrapped in heavy-duty plastic wrapping, sealed to protect unit from moisture and dirt. Plug and seal shut piping, conduit, exhaust, and air intake openings. Pack generator switchboard in shipping sections which can be handled and installed at the site. Protect and prepare batteries for shipment as recommended by battery manufacturer. Store equipment at the site in covered enclosures, protected from atmospheric moisture, dirt, and ground water. Properly label each package on exterior of wrapping to identify enclosed equipment, contract number, manufacturer, and purchaser. Manufacturer's standard practice in product protection and identification, meeting above requirements, is acceptable.

1.8 SITE CONDITIONS

The components of the engine-generator sets, including cooling system components, pumps, fans, and similar auxiliaries, shall be capable of the specified outputs in the following environment:

a. Site location: As specified.

b. Site elevation: As specified meters feet above mean sea level.

c. Seismic zone: As specified as defined by ICBO UBC.

d. Design wind velocity: As specified km/h mph.

e. Prevailing wind direction: As specified.

f. Atmospheric conditions: As specified.

h. Engine-generator set location: As specified.

1.9 EXTRA MATERIAL

1.9.1 Filters

Furnish two spare replacement elements in their original containers for each filter with each unit.

1.10 POSTED OPERATING INSTRUCTIONS

Provide operating instructions laminated between matte-surface thermoplastic sheets suitable for placement adjacent to corresponding equipment. Install operating instructions where directed.

PART 2 PRODUCTS

2.1 MATERIALS

Provide materials and equipment of manufacturers regularly engaged in production of such materials or equipment, and the manufacturer's latest standard commercial product that complies with specification requirements. Where two units of the same class of equipment are required, these units shall be products of a single manufacturer; however, component parts of the system need not be products of the same manufacturer.

2.2 ENGINE-GENERATOR SET

Provide engine-generator sets, correctly coordinated by engine-generator manufacturer to ensure an installed rating in the environment described in paragraph entitled "Site Conditions." Each set shall consist of a water cooled diesel engine direct-connected to an ac generator having a brushless excitation system, and shall be provided with necessary accessories, auxiliaries, appurtenances, control equipment, and cooling systems, resulting in a complete set and, except for external service connections, ready for operation. Mount each engine-generator set on a steel subbase sized to support the engine; generator-exciter, generator control panel; lubricating oil filters, heat exchangers and pump; fuel oil filters and pumps; jacket coolant heat exchangers and pumps; and interconnecting piping and wiring. Engine unit-mounted radiators and auxiliaries shall be mounted on engine-generator set subbase. Engine-generator set shall include electric starters, controls, and related wiring for electric starting. Batteries, battery racks and charger assembly may be mounted on the set subbase. Engine-generator set shall include starter, controls and related piping for compressed air starting. Mount air supply compressors and receivers separately. Provide subbase with vibration isolators suitable for loads and lateral forces involved in seismic zone indicated. Isolators shall be as recommended by engine-generator set and isolator manufacturers to suit specific equipment involved. Make electrical and mechanical field connections with flexible connectors. When standard with the manufacturer, combustion air filter/silencer units and exhaust muffler units may be mounted separately from the set, and connections made to engine with corrosion-resistant flexible connections. Factory align engines and generators on subbase and securely bolt into place in accordance with manufacturer's standard practice. Paint each set, after assembly, with manufacturer's standard paints and colors. After tests and before shipping, thoroughly clean each set and retouch paint as necessary to provide complete protection to the set. Arrange sets for automatic unattended starting in addition to manual start-and-stop by control panel switches. Each engine-generator set shall be capable of automatically starting, coming up to synchronous speed, and ready to accept full rated power within 10 seconds after receipt of start signal. House each engine-generator set in a weather resistant enclosure for outdoor installation.

2.2.1 Equipment Rating and Capability

Each engine-generator set shall have a net standby and/or prime rating capacity of not less than designed kW at 0.8 power factor and shall be designed to supply 480Y/277 and/or 208Y/120-volt, 60-Hz ac output. Both engine and generator of the set shall be capable of satisfactorily carrying a load 10 percent in excess of net rated generating capacity at 0.8 power factor for a period of 2 continuous hours out of 24 consecutive hours.

Auxiliary equipment shall be designed for continuous duty at 110 percent of rated net capacity of engine-generator set. Cooling system components and auxiliaries shall be properly sized relative to engine coolant specified under cooling system.

2.2.2 Torsional Vibrations

Each complete engine-generator set shall be free of torsional vibrations that might endanger satisfactory operation of the set. Satisfactory operation will be considered endangered, when torsional vibration stresses exceed 34.45 MPa (5,000 psi) within 10 percent above or below rated engine speed. Analysis of torsional vibrations shall be accomplished by calculations and by tests of a complete representative prototype of the engine-generator set. Results of the analysis shall be certified by a registered professional engineer.

2.2.3 Parallel Operation

Each engine-generator set shall operate satisfactorily in parallel with any combination of sets on the system, including existing sets and new sets provided under this contract. Winding pitch of generators operated in parallel shall be identical to prevent neutral currents.

2.3 GENERATOR SET DESIGN AND CONSTRUCTION

Isolate or shield rotating or reciprocating parts, or other parts that present a potential hazard to operating personnel.

2.3.1 Space Heaters

Space heaters shall be thermostatically controlled or constant-on and provided in the enclosures of generators, exciters, and outdoor motors. Heaters shall maintain a temperature inside the enclosure of not less than 6 degrees C (10 degrees F) above ambient at all times. Heaters shall be 120-Vac, single-phase, of ratings as recommended by the manufacturer for the atmosphere specified under the paragraph entitled "Site Conditions."

2.3.2 Diesel Generator Sets

Comply with MIL-S-16165 relative to radiated radio interference. For generators and other devices capable of producing radio interference comply with MIL-STD-461 relative to radiated and conducted radio interference.

2.3.3 Fungus Control

For electrical components, fungus control is required as follows:

a. Electrical components such as switches, fuses, contacts, and heater elements, shall not be treated. Other materials and components which are inherently fungus-resistant or are protected by hermetic sealing need not be treated.

b. Circuit elements, not covered above and which have a temperature rise of not more than 24 degrees C (75 degrees F) when operating at full load, shall be coated with a fungus-resistant varnish conforming to MIL-V-173. Method of treatment shall be in accordance with MIL-T-152. Circuit elements include, but are not limited to, cable, wire, switchboards, terminal and junction blocks, junction boxes, capacitors, and coils.

c. Circuit elements, such as motor coils, generator and transformer windings, and similar electrical components, which have a temperature rise exceeding 24 degrees C (75 degrees F) when operating at full load, shall not be coated with a fungitoxic compound. Instead, apply to such components two initial coats of varnish and one seal coat of varnish, each conforming to MIL-I-24092, Class 220, Type M, or with fungus and moisture resistant epoxy resin. Apply coats by vacuum-pressure immersion, centrifugal, pulsating pressure, or built-up method so as to fill interstices in the coils and prevent entrapment of air or moisture. Sealer coat may also be applied by brushing and spraying.

2.4 DIESEL ENGINES AND ACCESSORIES

Engines shall be two-cycle, naturally aspirated, turbocharged, or turbocharged and intercooled; or four-cycle, naturally aspirated, turbocharged or turbocharged and intercooled; vertical In-line or vertical Vee type; water cooled; designed for continuous electrical duty, stationary service. Provide each engine designed and constructed to eliminate undue heating, vibration, and wear and be efficient and trouble free in operation.

2.4.1 Construction

Construct engine to withstand sudden changes from no load to rated load, and to preserve alignment of integral components under all conditions of operation. Design shall incorporate pressure lubrication of bearings and wrist pins, and bearing journals shall be hardened or chromium plated to provide a hard shock-resistant surface with ductile core. Counterbalance crankshafts to reduce vibration to a minimum. Crankshaft and connecting rod bearings shall be replaceable precision sleeve type. Construct piston rings of heat-resisting alloy steel or chromium plated cast-iron. Camshafts shall be gear driven, and shall be high wear-resistant, at cams and journals. Clearly indicate timing marks on crankshaft and gears. Valves shall have removable or rebuildable stem guides and seat inserts. Flywheel shall be balanced, and capable of being rotated 50 percent above the maximum rated engine rotative speed without danger of breaking or exploding. Provide flywheel housing with a drain hole at the lowest point. Provide means for turning crankshaft manually. Turbocharger lubricating oil system shall not be a separate system, but shall be a part of engine lubricating oil system.

2.4.2 Assembly

Completely factory-assemble each engine. Mount turbocharger or mechanically driven supercharger and intercooler and piping integral with the engine, on the engine.

2.4.3 Engine Speed Governing System, IEEE Device 65

Provide 3 percent droop type engine speed governing system suitable for controlling generator set speed to meet the performance requirements specified below. Performance shall be met without intermediate adjustment and shall maintain specified stability without hunting or cycling. Provide governor with a speed changer arranged for remote manual operation. Governor shall permit automatic or parallel operation and load-sharing among all other indicated engine-generator sets, and with an infinite bus for the purpose of transferring load without interruption to commercial electrical service. Paralleled engine-generator sets shall share load nearly equally, so that maximum kW load difference between engine-generator sets of equal nameplate rating will not exceed 10 percent of rating of a single set.

a. Steady-state governing speedband shall not exceed plus or minus 0.5 percent expressed as a percent deviation from rated speed.

b. Transient speed deviation shall not exceed plus or minus 3.0 percent expressed as a percent of rated speed for any 50 percent load step, on or off.

c. Time to return to limits of observed speedband shall not exceed 4.0 seconds after sudden load change of transient speed deviation.

d. Minus 10 to plus 5 percent minimum range of speed changer expressed as a percent of rated speed.

Provide each engine with a speed governing system and an independently driven overspeed limiting engine shutdown device. Provide an adjustable isochronous governor, with suitable speed sensing. Governor shall be capable of either manually or automatically dividing the load when operating in parallel with other units having similar governors, or when paralleling with an infinite bus for the purpose of transferring load without interruption to the commercial electric service, and shall maintain specified stability without hunting, cycling, or other irregularities. Governor shall include provisions for adjusting speed droop and speed while the unit is in operation. Governor characteristics shall conform to the following:

a. Minus 10 to plus 5 percent minimum range of speed changer expressed as a percent of rated speed.

b. Steady-state governing speed band shall not exceed plus or minus 0.25 percent expressed as a percent deviation from rated speed.

c. Transient speed deviation shall not exceed plus or minus 3.0 percent expressed as a percent of rated speed for any 50 percent load step, on or off.

d. Time to return to limits of observed speed band shall not exceed 3 seconds after sudden load change of transient speed deviation.

e. 0 percent to 5 percent minimum manual speed regulation range adjustment, expressed as a percent of rated speed.

2.4.4 Engine Protective Devices

Provide each engine with protective devices as follows:

a. Engine Shutdown: Equip each engine with shutdown devices listed. These devices shall shut down the engine by shutting off the fuel supply to fuel injectors. Shutdown devices shall be positive, direct in action and independent of the governor. Shutdown devices shall have factory-set fixed set points and shall be equipped with either auxiliary electrical contacts, relays or equivalent device for shutdown. Auxiliary contacts shall be suitable for starting or control battery voltage. Provide the following shutdown devices:

(1) Overspeed device which operates when engine speed exceeds normal synchronous speed by 18 percent. Device shall require manual reset.

(2) Pressure switch which operates when engine and turbocharger lubricating oil pressure drops below a preset value.

(3) Temperature switch which operates when jacket coolant temperature exceeds a preset value.

(4) Other shutdown devices as recommended or normally provided by engine manufacturer.

b. Electrical Interlocks and Alarms: Equip starting mechanism with auxiliary contacts for interlocking with generator main breaker control circuit as determined by manufacturer. Auxiliary contacts shall be suitable for starting or control battery voltage.

2.4.5 Engine Alarm Contact Devices

Equip each engine with alarm devices, relays, and auxiliary contacts, as required, to actuate alarm system on associated engine control panel. Auxiliary contacts shall be suitable for starting or control battery voltage. Alarm devices shall have factory-set fixed set points. Provide following alarm contact devices:

a. Starting mechanism contacts or equivalent device operating to energize a portion of alarm system only when engine is running and not during cranking or shutdown.

b. Pressure switch in engine and turbocharger lubricating oil system piping from engine to operate when pressure drops below a preset value due to failure of engine-driven lubricating oil pump. In addition to alarm contacts, provide set of contacts to start an auxiliary oil pump, when such a pump is standard with engine manufacturer.

c. Temperature switch in jacket coolant discharge piping from engine to operate when temperature exceeds a preset value.

d. Other alarm devices as recommended by engine manufacturer.

2.4.6 Engine Accessories

Provide the following accessories for each engine-generator set when recommended by the manufacturer:

a. Piping on engine-generator set to inlet and outlet connections, including nonstandard companion flanges.

b. Foundation bolts, nuts, isolators, and sleeves for engine-generator set.

c. Leveling jack screws or shims, when applicable.

d. Chocks and shims for installation and leveling of engine-generator set subbase, when applicable.

e. Manually operated barring gear.

f. Indicating thermometer or temperature indicator in accordance with manufacturer's standard for engine coolant.

2.4.7 Air Intake and Exhaust Systems

Provide air intake and exhaust systems for each engine. Install field piping in accordance with manufacturer's requirements. Arrangement of air intake and exhaust systems shall be similar to that indicated and modified, as required, to suit engine furnished, subject to approval of the Contracting Officer. For two-cycle engines, provide an air intake shutoff operated by engine overspeed device.

a. Air intake filters: Provide dry type filter for each engine as standard with the engine manufacturer. Size filter to suit engine requirements at 110 percent of rated full load. Unit shall be designed to permit easy access to filter for maintenance purposes.

b. Exhaust silencers: Provide an exhaust silencer for each engine to reduce the exhaust sound spectrum to, or below, the following listed levels, when measured with a sound level meter conforming to ANSI S1.4 (ASA 47), Type 1 or 2, 23 meters (75 feet) from the outlet, under full engine load and clear weather. Silencer shall be complete with handhole openings and necessary brackets for supporting purposes. Sizing of silencer shall be in accordance with engine and silencer manufacturer's recommendations. Flanged inlet and outlet connections shall be provided.

Octave Band Center Frequency, Hz	Maximum Sound Level Decibels
63 and below	78
125	68
250	60
500	53
1,000	48
2,000	44
4,000	42
8,000	41

c. Expansion (flexible) joints: Provide sections of multiple corrugated stainless steel expansion joints with liners in the engine exhaust piping for each engine to absorb expansion strains and vibration in the piping. Flexible joints in exhaust piping shall be suitable for continuous operation at 93 degrees C (200 degrees F) above the normal exhaust gas temperature at 110 percent load. Air intake expansion joints shall be as specified for exhaust piping or may be reinforced rubber type suitable for the service. Joints shall be of the same size as pipe and provided with flanged connections. Air intake expansion joints may be for plain end pipe.

d. Air intake piping: Conform to manufacturer's recommendations for size, type, and connections.

e. Exhaust piping: Provide piping for each engine complete with necessary fittings, flanges, gaskets, bolts, and nuts. Pipe shall be steel conforming to ASTM A 53. Exhaust piping shall be Schedule 40 for 300 mm (12 inch) and smaller sizes and for larger sizes shall have wall thickness not less than 9.5 mm (0.375 inch). Exhaust piping shall slope away from engine. Flanges shall be 667.5 N (150 pound) slip-on forged steel welding flanges conforming to ASME/ANSI B16.5, with material in accordance with ASTM A 181/A 181M, Grade I. Fittings shall be butt-welding conforming to ASTM A 234/A 234M, with wall thickness same as adjoining piping. Built-up miter welded fittings may be used. Fittings shall be of same material as pipe. Miter angles of each individual section shall not exceed 0.393 rad (22.5 degrees) total and not more than 0.196 rad (11.25 degrees) relative to pipe axis at any one cut. Gaskets for piping shall be of high temperature asbestos-free material suitable for the service. Bolting material for exhaust flanges shall be alloy-steel bolt-studs conforming to ASTM A 193/A 193M, and alloy-steel nuts conforming to ASTM A 194/A 194M. Bolts shall be of sufficient length to obtain full bearing on nuts and shall project not more than two full threads beyond the nut.

2.5 GENERATORS AND EXCITATION AND VOLTAGE REGULATION SYSTEM

2.5.1 Generator

Provide 0.80 power factor, synchronous, ac, brushless-excited, revolving field, air-cooled, self-ventilated unit conforming to NEMA MG 1 and rated as specified in paragraph entitled "Equipment Rating and Capability." Enclosure frame shall be dripproof. Match generator speed to that of engine. Drive generator directly from engine crankshaft in a manner approved by both engine and generator manufacturers. Generator shall be capable of carrying at rated voltage and 0.8 power-factor, a load equal to net kW rating of the engine without exceeding temperature limits specified in NEMA MG 1 for standby duty. Winding insulation shall be Class F or H. An amortisseur winding shall be provided and generator and flywheel shall have sufficient flywheel effect to meet requirements of regulation and parallel operation as specified. Generator field voltage shall be manufacturer's standard voltage. Prime power generator neutral shall be solidly grounded. Standby generator neutral shall be solidly grounded when 4-pole transfer switch is used and shall not be bonded to ground at the generator when 3-pole transfer switch is used. Ground generator enclosure at two opposite mounting legs.

2.5.2 Excitation and Voltage Regulation Systems

Comply with IEEE 421.1.

2.5.2.1 Exciter

Integral with generator; synchronous, rotating armature, rotating rectifier, brushless or permanent magnet brushless type. Mount rotating rectifier assembly in a manner to provide ready access for inspection and replacement of rectifier diodes. Semiconductor rectifiers shall have minimum factor of safety of 300 percent for peak inverse voltage, and forward current ratings for operating conditions, including 110 percent generator output at 40 degrees C ambient. Provide safety devices for protection of rectifiers against overload currents and voltages unless design provides this protection inherently. Acceptable ratio of exciter ceiling voltage to exciter nominal voltage shall be not less than three to two.

2.5.2.2 Voltage Regulator, IEEE Device 90

Provide a solid state voltage regulator that automatically controls the generator field current through action on the exciter, and provides immunity from SCR tracking. Voltage regulator shall enable manual adjustment of set output voltage, while set is operating, by potentiometer adjustment at generator control panel. Voltage regulator shall enable parallel operation with like sets.

a. Operation: Voltage regulator shall have characteristics and sensors which enable generator to operate alone or in parallel with other generators in isochronous load sharing mode and in conjunction with common solid-state control to operate isochronously with proportional load sharing. Provide voltage transformers, when required, for voltage sensing and current transformer for crosscurrent compensation to operate in parallel with other generators in isochronous load sharing mode. Provide a contact to short out the current transformer when a generator is not connected to its output bus. Install instrument transformers and voltage regulator in the generator control panel along with a manual voltage setting control.

b. Regulation: Voltage regulator/excitation systems shall be capable of voltage regulation within plus or minus 1 percent from no-load to full-load. A 5 percent variation in frequency and effects of field heating shall not affect units regulation performance. System shall provide 300 percent rated generator current for at least 10 seconds to provide short-circuit current adequate to operate circuit breakers.

c. Electromagnetic interference (EMI) suppression: Provide as an integral part of the regulator, EMI suppression for conducted and radiation emissions complying with MIL-STD-461, Class C2.

2.6 FUEL OIL SYSTEM

Conform to NFPA 30 and NFPA 37 and requirements herein.

2.6.1 Fuel Oil Day Tanks

Provide tank with a minimum capacity of 8 hours of engine-generator set operation at full-rated load with a capacity as standard with engine-generator set manufacturer for each engine-generator set. Tank may be the standard design as provided by engine manufacturer or shall be constructed as specified in paragraph entitled "Tank Construction." Provide tank with a level gage and makeup control valve. Include connections of indicated sizes for inlet, outlet, overflow, vent, drain, and level controller and high and low level alarm switches.

2.6.1.1 Level Alarm Switches

Provide tank-top mounted or external float cage, single-pole, single-throw type designed for use on fuel oil tanks. Arrange high level alarm switches to close on rise of liquid level, and low level alarm switches to close on fall of liquid level. Mount float cage units with isolating and drain valves. Contacts shall be suitable for starting or control battery voltage.

2.6.1.2 Tank Gages

Provide tank gages for fuel oil day tanks. Gages for fuel oil day tanks shall be buoyant force type, with dial indicator not less than 100 mm (4 inches) in size and arranged for side mounting. Each dial or scale shall be calibrated for its specific tank to read from empty to full, with intermediate points of 1/4, 1/2, and 3/4.

2.6.2 Fuel Oil Transfer Pumps

Each pump unit shall consist of a horizontal, positive-displacement, rotary pump driven by an electric motor. Direct-connect each pump to its driving motor through a flexible coupling. Provide three-phase motors with pumps in accordance with paragraph entitled "Motors." Mount pump and motor on a common steel or cast-iron base plate and provide a suitable coupling guard. Equip each pump with a bypass relief valve and a suction strainer. Pump body shall be cast iron or steel with mechanical shaft seal.

2.6.3 Fuel Oil Filter

Provide manufacturer's standard.

2.6.4 Day Tank Makeup Control Valve

Valve shall be a solenoid valve actuated by the level control switch in the day tank that also controls fuel transfer pump operation. Solenoid valve shall conform to UL 429 for fuel oil service. Solenoid valve shall be two-way, direct acting, normally closed, open when energized, closed when de-energized, with brass body and resilient seat material. Electrical rating shall be 120 volt, single-phase, 60-Hz. Body connections shall be same size as connecting piping.

2.7 LUBRICATING OIL SYSTEM

2.7.1 Auxiliary Lubricating Oil Pumps

Where recommended by the engine manufacturer, provide one pump for each engine, each suitable for "before-and-after" lubricating and cooling service as required by the engine. Equip each pump with a bypass relief valve.

2.7.2 Lubricating Oil Filtration

Provide each engine with a pressurized lubricating oil filtration system capable of filtering the full rate of oil flow from the oil pumps at maximum engine speed in accordance with standard practice of engine manufacturer. Provide means to ensure delivery of lubricating oil to vital wearing surfaces regardless of the condition of filters without removing engine from service. Filters shall provide means of automatically bypassing filter when filter becomes flow-restricting. Provide throwaway type filter elements as recommended by engine manufacturer.

2.7.3 Lubricating Oil Coolers

When recommended by engine manufacturer, provide coolers for each engine to maintain lubricating oil within temperature limits recommended by the engine manufacturer under all operating conditions. Cooling system and components shall be as specified by the engine manufacturer for use with the class of engine being provided, and cooling medium to be used. Provide engine jacket coolant from the radiator as cooling medium. Each thermostat in the oil cooling system shall be nonadjustable and factory set at the temperature recommended by the engine manufacturer.

2.7.4 Thermostatic Control Valves

When recommended and standard practice with the engine manufacturer for the proposed engine, provide a valve installed in the lubricating oil system for each engine to maintain a constant lubricating oil temperature from the engine. Valve shall be as specified in paragraph entitled "Thermostatic Control Valves." Valve shall be capable of passing total lubricating oil flow requirement of the engine as determined by engine manufacturer with a pressure drop across the valve not to exceed 35 kPa (5 psi).

2.8 COOLING SYSTEM

2.8.1 Jacket Coolant Pumps

Provide one pump for each engine driven from engine crankshaft or camshaft. Each pump shall have ample capacity to circulate required flow of coolant specified through the system to remove total heat rejected from the engine and, where provided by design, from lubricating oil and intercoolers. Heat shall be rejected to jacket coolant to maintain optimum jacket coolant temperature leaving and entering engine as recommended by the engine manufacturer.

2.8.2 Radiators

Provide one radiator unit as specified by the manufacturer for each engine-generator set.

a. Design Conditions: Each radiator unit shall have ample capacity to remove not less than the total kW Btu per hour of heat rejected by its respective engine at 110 percent full-rated load to jacket coolant, to lubricating oil system, to air surrounding the engine on subbase-mounted radiator units and that necessary for turbocharger intercooler. Radiator capacity shall be rated at optimum temperature of coolant leaving engine and intercooler as recommended by the engine manufacturer, with a dry bulb air temperature of 43 degrees C (110 degrees F). Pressure drop through the radiator shall not exceed 41.34 kPa (6 psi) when circulating maximum required coolant flow. Radiator air velocity shall be a maximum of 4.57 m/s (900 feet per minute). Coolant solution shall be a mixture of clean water and a commercial standard methoxy-propanol or ethylene glycol coolant providing protection to minus 18 degrees C (0 degrees F). Mixture shall be to proportions recommended by the engine manufacturer to meet site conditions. Provide an antifreeze solution tester suitable for solution used.

b. Engine Subbase-Mounted Radiator Construction: Radiator fan shall direct air flow from the engine outward through the radiator. Fan may be driven directly from engine crankshaft through V-belt drive. Radiator shall have sufficient capacity to meet design conditions against a static restriction of 12.7 mm (0.5 inch) of water as may be imposed by louvers and ductwork. Cooling section shall have a tube and fin type core. Engine-driven fans shall be engine manufacturer's standard units, selected for quiet vibration-free operation. Provision shall be made for coolant expansion either by self-contained expansion tanks or separately mounted expansion tanks, as standard with manufacturer. Provide suitable guards for each fan and drive. Provide exhaust duct with flexible connections between radiator and wall louver. Ductwork shall conform to SMACNA DCS.

c. Remote Radiator Construction: Construct each remote radiator as an integral unit, complete with expansion tank, plenum chamber, supporting structure, fans, fan drives, walkway, and ladders, when required. Coil section shall consist of 25 mm outside diameter, admiralty brass tubes having 18 BWG minimum wall thickness with continuous helical fins. Fins shall be formed footed type uniformly wrapped under tension or mechanically bonded to tubes. Roll tubes into fabricated steel tank headers at each end. Construct headers to permit access to tubes at each end and provide removable bolted-on cover plates for access to tube openings. Flange connections to radiator with drilling dimensions in accordance with ASME/ANSI B16.1. Design supporting steel structure in accordance with AISC S335 and design to withstand specific design wind velocity. Distribution of air across cooling coils shall be uniform. Siding and decking shall be sheet steel of not less than 14-gage thickness. Design inlet housings for fans so that no noise objectionable to occupants in surrounding buildings will result.

(1) Include provisions for each radiator to protect exposed cooling coils from damage resulting from hail.

(2) Provide plenum chamber of each radiator unit with rolling doors arranged with a hand wheel for operation from ground level, or vertical sliding doors to control admission of air to the fans. Furnish a heavy canvas cover of a size to fit over the top of each radiator unit complete with suitable fasteners.

(3) Provide heavy-duty industrial shutter, interlocking type, to cover the entire area of coil sections. Construct blades of steel not lighter than 14-gage. When necessary, provide intermediate support plates with bronze bearings. Form blade edges for strength and to permit interlocking for shut-tight operation. Position blades through linkages to a common drive shaft supported by lubricated sleeve bearings. Provide control motors for positioning shutters. Control motors shall be heavy-duty reversible type with not less than five positions, and designed for single-phase operation with high torque characteristics, gear reduction, and built-in limit switches conforming to paragraph entitled "Motors." Unit shall be complete with necessary accessories and linkage and a five-position rotary selector switch with position indication for mounting on engine control panel for remote manual control. For standby applications, provide power to shutter control motors from the load side of the automatic transfer switch.

d. Remote Radiator Fans and Drives: Capacity of each fan shall be sufficient to supply the quantity of air necessary to obtain cooling effect required. Fans shall be propeller-type with multiblade construction, four blades or more, and operated at a tip speed not to exceed 63.5 m/s (12,500 feet per minute). Individually fasten blades to a common hub in such a manner that blade pitch may be adjusted. Each fan shall be driven by an electric motor through a multiple V-belt drive or reduction gears. Provide guards for each fan and drive. Total fan motor horsepower required for each radiator unit shall be not more than 1.25 percent of the full load gross kW rating of the engine. Motor shall be two-speed, single-winding, totally enclosed, fan-cooled, three-phase conforming to paragraph entitled "Motors." For standby applications, provide power to fan motors from the load side of the automatic transfer switch.

2.8.3 Thermostatic Control Valves

When recommended and standard with engine manufacturer for proposed engine, provide a valve installed in the jacket coolant system for each engine to maintain a constant jacket coolant temperature from the engine. Valve shall be as specified in paragraph entitled "Thermostatic Control Valves." Valve shall be capable of passing coolant flow, as determined by the engine manufacturer.

2.8.4 Starting Aids

Provide a factory-installed, electrically operated, jacket coolant heating system to ensure rapid starting. Thermostatically control heater at the temperature recommended by engine manufacturer. Connect power leads to a junction box which shall provide fusing and manual disconnection of the heater. Include necessary equipment, piping, controls, wiring, and accessories.

2.9 ELECTRIC STARTING SYSTEM

Provide a manufacturer recommended volt dc starting battery installation for starting of each engine-generator set utilizing an electric cranking system. Electric cranking system shall be capable of rotating the engine at a speed sufficient for rapid starting in an ambient temperature of minus 7 degrees C (20 degrees F). Signal for starting shall come from engine-generator set control system.

2.9.1 Cranking

Energize electric cranking system from negative polarity grounded starting batteries. Provide heavy-duty type cranking motors with capacity to crank the engine continuously to start the engine. Drive mechanism for engaging starting motors with engine flywheel shall be designed to inherently engage and release without binding. When engine starts, starting gearing shall automatically disengage and starting motors shall shut down. Automatic cranking panel shall crank engine as specified under paragraph entitled "Engine Cranking Relay."

2.9.2 Starting Battery Installation

Provide lead acid industrial engine cranking batteries designed for diesel engine starting of sufficient size and capacity in a fully charged condition to crank engine for four consecutive cycles of 30 seconds cranking followed by 120 seconds rest. Provide battery racks or enclosures, properly ventilated for the batteries and charger. Provide necessary cabling.

2.9.3 Starting Battery Charger

Provide enclosed, automatic, dual-rate, solid-state, constant voltage type battery charger having ac voltage compensation, dc voltage regulation, and current limiting. Charger shall employ transistor-controlled magnetic amplifier circuits to provide continuous taper charging. Charger shall have two ranges, float and equalize, with 0 to 24 hour equalizer time, dc cranking relay, silicon diode full-wave rectifiers, automatic surge suppressors, dc ammeter, dc voltmeter, and fused inputs and outputs. Charger shall have continuous rated output of not less than 10 amperes and conform to UL 1236.

2.10 COMPRESSED AIR STARTING SYSTEM

Provide one compressed air storage tank with sufficient storage capacity for not less than three consecutive normal engine starting sequences for up to four engines without recharging. Provide tanks designed for working air pressure of 1722.5 kPa (gage) (250 psig). Construct tanks of welded steel plate conforming to ASME BPVC SEC VIII D1. Provide each tank with supports or welded base and the following connections and accessories for vertical installation:

a. 25 mm (1 inch) valved drain.

b. Safety valve, capable of relieving full capacity of air compressor specified herein.

c. 12.7 mm (1/2 inch) connection for pressure gage.

d. 12.7 mm (1/2 inch) connection for pressure switch.

e. Flanged inlet connection of suitable size.

f. Flanged outlet connection of suitable size.

g. Inspection handhole or manhole.

h. Pressure regulating valve on tank outlet, adjustable from 340 to 1725 kPa (50 to 250 psi) to regulate starting air pressure to manufacturer's recommendation.

2.11 PIPING SYSTEMS

2.11.1 Engine Jacket Coolant and Fresh Water Piping Systems

Conform to the following except that factory installed piping may conform to engine-generator set manufacturer's standards:

a. Piping: Provide seamless steel pipe, Schedule 40, ASTM A 53, Grade A.

b. Fittings and Flanges: Fittings, 50 mm (2 inches) or smaller, malleable iron, ANSI/ASME B16.3 1335 N (300 pound) threaded type. Fittings, 65 mm (2 1/2 inches) and larger, steel butt-welding, ASME/ANSI B16.9. Utilize either ASME/ANSI B16.1 or Class A of ASTM A 126 for 556 N (125 pound) cast-iron flanged fittings. Flanges shall be in accordance with ASME/ANSI B16.5 for 667.5 N (150 pound) slip-on or welding neck forged steel welding flanges, material conforming to ASTM A 181/A 181M. Provide flat face flanges for connecting to 556 N (125 pound) standard cast-iron valves, fittings, and equipment connections.

c. Valves:

(1) Gate Valves: For valves, 50 mm (2 inches) and smaller, provide double disk, rising stem, inside screw, union bonnet type, 667.5 N (150 pound) class bronze gate conforming to MSS SP-80. For valves,65 mm (2 1/2 inches) and larger, provide double-disk, parallel seat type, hydraulic-rated, 861 kPa (125 psi) class, outside screw and yoke type with flanged ends and bronze trim conforming to MSS SP-70. Provide stem packing of material suitable for the service encountered.

(2) Globe Valves: For valves, 50 mm (2 inches) and smaller, provide rising stem, inside screw, union bonnet, 556 N (125 pound) class bronze valves conforming to MSS SP-80. For valves, 65 mm (2 1/2 inches) and larger, provide 667.5 N (150 pound) class cast iron, flanged ends, bronze

trim globe valves conforming to MSS SP-85. Valves shall have renewable composition discs suitable for the service encountered.

(3) Check Valves: MSS SP-80 or MSS SP-71, swing check type.

2.11.2 Fuel Oil and Lubricating Oil Piping System

Factory installed piping systems shall conform to engine-generator set manufacturer's standards.

2.11.3 HPCA Piping System, 1040 kPa (151 psig) and Above

High pressure compressed air (HPCA) piping systems shall conform to the following, except that factory-installed piping may conform to engine-generator set manufacturer's standards:

a. Pipe: Black steel, ASTM A 53, Type S. Screwed piping, 50 mm (2 inches) and smaller, shall be Schedule 80; remaining piping shall be Schedule 40.

b. Fittings and Flanges: Fittings, 50 mm (2 inches) and smaller, shall conform to ANSI/ASME B16.3, 1335 N (300 pound) threaded, malleable iron. Fittings, 65 mm (2 1/2 inches) and larger, shall be butt-welding type, ASTM A 234/A 234M, Grade WPA or WPB, having wall thickness same as pipe to which fitting is welded.

c. Unions: Utilize only on piping, 50 mm (2 inches) and smaller. Unions shall conform to ASME/ANSI B16.39 and shall be black, iron or steel, designed for 1335 N (300 pounds) WSP.

d. Globe Valves: For valves, 50 mm (2 inches) and smaller, provide rising stem, union bonnet type, bronze, conforming to MSS SP-80. For valves, 65 mm (2 1/2 inches) and larger, provide 1112.5 N (250 pound) class cast iron, flanged ends, bronze trim, conforming to MSS SP-85. Globe valves shall have renewable composition disc compatible with compressed air.

e. Check Valves: Lift check, suitable for horizontal installation, conforming to MSS SP-80, suitable for 2411.5 kPa (gage) (350 psig) working air pressure. For valves, 50 mm (2 inches) and smaller, provide screwed ends. For valves, 65 mm (2 1/2 inches) and larger, provide flanged ends.

f. Plug Valves: Utilize lubricated, tapered plug type in conformance with API STD 599 or MSS SP-78, 1335 N (300 pound) class. Valves, 100 mm (4 inch) and smaller, shall be wrench operated. Valves, 40 mm (1 1/2 inch) and smaller, shall have screwed ends. Valves, 50 mm (2 inch) and larger, shall have flanged ends.

g. Gaskets: Provide woven nonasbestos fibers with fluorocarbon plastic binder or compressed with nitrile or neoprene binder, minimum thickness of 1.58 mm (1/16 inch).

2.11.4 Bolts, Studs, and Nuts

a. For Temperatures up to 232 Degrees C (450 Degrees F): Material for bolts or studs shall be ASTM A 307, Grade B, and for nuts ASTM A 194/A 194M, Grade 2. Threads and dimensions for bolts or studs shall comply with ANSI B18.2.1 for square head dimensions.

b. For Temperatures over 232 Degrees C (450 Degrees F): Material for bolts or studs shall be ASTM A 193/A 193M, Grade B7, and for nuts ASTM A 194/A 194M, Grade 7. Threads and dimensions for bolts or studs shall comply with ANSI B18.2.1for square head dimensions and with ASME B1.1 coarse thread series, for 25 mm (one inch) and smaller.

2.12 ENGINE-GENERATOR SET CONTROLS

Provide an engine-generator control panel mounted on each engine-generator set subbase. Manufacturer's standard electronic control panels may be provided in lieu of those specified below if they accomplish the same functions.

2.12.1 Engine-Generator Control Panel

Provide an enclosed panel fabricated of not lighter than 14 gage sheet steel in compliance with NEMA 250, Type 3R. Construct cabinet with angle iron framework, if required, for proper stiffness and support. Size cabinet to accommodate specified equipment when arranged in an orderly and approved manner. Factory-mount panel on engine unit subbase. Provide isolation mounting material between subbase and panel to isolate the panel from engine vibrations. Provide panel-mounted devices with nameplates of laminated black gloss-finished plastic with white engraved lettering. Provide connecting piping, tubing, and wiring installed in conduit where not otherwise enclosed.

2.12.1.1 Engine Control Panel

Provide devices of the type standard with the manufacturer utilizing minimum 50 mm (2 inch) nominal diameter gages. Provide instruments subject to rapid pressure surges with damping devices to give a steady reading. Provide the following panel-mounted devices as a minimum:

a. Engine Controls: Install engine controls on generator control panel.

b. Engine Instrumentation:

(l) Fuel oil pressure gage.

(2) Lube oil pressure gage.

(3) Coolant temperature gage.

(4) Elapsed time meter.

c. Engine Safety Circuit Devices: Provide the following devices to stop engine-generator set and to simultaneously open its main circuit breaker. Stop switch may be connected to this safety circuit when recommended by the manufacturer. Source of energy for engine safety circuit devices shall be the starting or control battery.

(1) Overcranking.

(2) Overspeed.

(3) Excessive coolant temperature.

(4) Dangerously low lubricating oil pressure.

2.12.1.2 Generator Control Panel

Install controls in engine-generator control panel. Provide generator controls and instrumentation as follows:

a. Generator controls

(1) Generator circuit breaker, IEEE Device 52.

(2) Voltage regulator and associated controls.

(3) Governor remote control switch.

b. Generator instrumentation

(1) Voltmeter and control switch.

(2) Ammeter and control switch.

(3) Three current transformers.

c. Engine starting and stopping controls and protective equipment

(1) Engine starting switch.

(2) Engine cranking relay.

(3) Engine shutdown relay.

(4) Synchronizing switch to be used in conjunction with manual synchronizing panel and synchronism-check relay, IEEE Device 25.

(5) Automatic transfer and bypass isolation combination switch.

(6) Automatic synchronizing and transfer circuitry.

(7) Surge arrester and capacitor assembly.

d. Local Alarm Panel: Provide manufacturer's standard local alarm panel suitable for operation on the starting or control battery voltage. Provide with pre-shutdown and shutdown alarms in accordance with NFPA 99. Provide the following alarms with pre-shutdown alarms only for temperature and pressure conditions and shutdown alarms for all conditions:

(1) High jacket coolant temperature

(2) High lubricating oil temperature

(3) Low lubricating oil pressure

(4) Low fuel oil pressure

(5) Engine shutdown due to overspeed

(6) Engine starting failure

(7) Normal voltage supply failure

(8) Restoration of normal supply voltage

(9) Control battery summary alarm

(10) Other engine-generator set abnormal conditions as recommended by the manufacturer

2.12.2 Generator Switchboard

NEMA PB 2 free-standing, metal-enclosed, general-purpose, indoor or outdoor, low-voltage switchboard rated for 600-volts, three-phase, four-wire and provided with full-size neutral bus and continuous ground bus. Buses shall be copper. Interrupting and continuous ampere ratings as indicated.

2.12.2.1 Generator Units

Provide to switch and control electrical output of each engine-generator set.

2.12.2.2 Feeder and Bus Tie Units

Provide feeder and bus tie units to switch and control each feeder and bus tie.

2.12.2.3 Auxiliary Units

a. Manual synchronizing panel.

b. Control battery and dc service unit.

2.12.3 Remote Alarm Panel

Provide pre-shutdown alarms and shutdown alarms in accordance with paragraphs entitled "Generator Control Panel," and "Control Battery Charger" respectively.

2.12.4 Generator Control Panel Devices

2.12.4.1 Generator Circuit Breaker, IEEE Device 52

Provide circuit breaker having a solid-state tripping device with adjustable long-time and short-time tripping characteristics. Provide stored-energy closing mechanism for rapid and safe closing of circuit breaker against fault currents within the short-time rating of circuit breaker independent of operator's strength or effort in closing the handle. Size circuit breaker for the 110 percent full-load capacity of engine-generator set and provide lugs for indicated electrical connection.

a. Circuit Breaker Type:

(1) Molded-case, 100 percent rated

(a) NEMA AB 3 and UL 489

(2) Low-voltage Power Circuit Breakers

(a) ANSI/IEEE C37.13 and ANSI C37.16

(b) Provide power circuit breakers where frame size exceeds 1200 amperes

(c) All circuit breakers shall be power circuit breakers

(3) Trip ratings ANSI C37.17

b. Circuit Breaker Support Structure

(1) Switchboard

(a) NEMA PB 2

c. Operation: Circuit breakers shall be manually operated. Generator and incoming feeder circuit breakers shall be electrically operated from the control battery.

d. Circuit Breaker Test Set: Provide test set capable of performing routine calibration and maintenance tests on low-voltage power circuit breakers furnished with the switchboard. Test set shall be capable of making operational tests, internal power supply tests, pickup current and time delay tests, and trip signal output tests. Test set shall be suitable for use on a 20-ampere, 120-volt, 60-Hz circuit.

2.12.4.2 Generator Voltage Adjustment

Install manual voltage setting control system as specified under paragraph entitled "Voltage Regulator."

2.12.4.3 Governor Remote Control

Provide a governor "raise-lower" control switch to manually operate speed changer specified under paragraph entitled "Engine Speed Governing System."

2.12.4.4 Instrument and Control Switches

Utilize rotary-enclosed, rear-mounted switches having positive means of maintaining contacts, which shall be silver-to-silver type, identifying escutcheon plates, and handle targets to indicate switch position. Utilize knurled handles for instrument switches, standard pistol grip handles for circuit breaker and governor control switches. Provide red and green indicating lights for circuit breaker control switches.

2.12.4.5 Indicating Lights

Provide front removable, low drain, push-to-test, indicating lights equipped with dropping resistors suitable for 120-vac service, as required and color caps as specified.

2.12.4.6 Instruments

Provide semiflush-mounted, rectangular, switchboard instruments with rear connecting terminals, ANSI C39.1. Construct with taut-band suspension movement and 4.36 rad (250 degree) scales in a nominal 114 mm (4.5 inch) square case. Design and calibrate for vertical or horizontal mounting, as required. Elapsed time meters shall totalize engine running time to 9999.9 hours.

2.12.4.7 Watthour Meter

Provide flush or semiflush drawout, back-connected integrating switchboard type, ANSI C12.10. Provide with primary reading, pointer type, daily-reading type registers with multiplier to be a power of 10. Meter shall have built-in test facilities and indicators to show energized potential coils and conform to ANSI C12.10. Provide indicating demand registers with 15-minute intervals for feeder circuits. Meters shall be three-phase, four-wire, three-element type.

2.12.4.8 Instrument Transformers

Provide indoor, dry-type conforming to ANSI/IEEE C57.13. Coordinate mechanical and thermal ratings with circuit breakers and other apparatus in the switchboard. Provide voltage transformers as shown or as required of the nondrawout type with current-limiting primary fuses and secondary fuses.

2.12.4.9 Engine Starting Switch

Four-position rotary, enclosed rear mounting, maintained-position type. Switch positions shall be "Automatic," "Off," "Test," and "Manual" and connected to provide the following operation:

a. In "Automatic" position, engine-generator set shall start automatically in response to loss of voltage, as described in paragraph "Automatic Controls."

b. In "Off" position, engine-generator set starting circuits shall not function.

c. In "Test" position, engine may be started and brought up to speed, but engine-generator set cannot be put on line.

d. In "Manual" position, switch shall start and bring engine-generator set up to speed and then connect it to line.

2.12.4.10 Engine Cranking Relay

Provide to operate as follows:

a. When actuated, device shall close contacts to actuate engine starting system.

b. Should engine fail to start at once, cranking shall continue for 30 seconds (adjustable) after which a 120-second "off" period (adjustable) shall occur. Durations of cranking and "off" periods listed above may be modified in accordance with engine manufacturer's recommendations.

c. Repeat above described cranking cycle for four starting attempts.

d. If engine still fails to start, cranking device shall lock out further starting attempts until device is manually reset. When cranking relay locks out, an alarm light shall be energized on the panel and remain lighted until relay is manually reset.

2.12.4.11 Synchronism-Check Relay, IEEE Device 25

Provide solid-state relays for use on a dynamic system to supervise manual synchronization. Permit connection of incoming generator set to bus only when incoming generator set frequency and voltage are within a safe synchronizing zone with bus frequency and voltage. Provide a dead bus option to allow circuit breaker closure for a dead bus on either side of circuit breaker.

2.12.4.12 Engine Shutdown Relay

Provide and actuate by engine protective devices as specified in paragraph "Engine Safety Circuit Devices." Shutdown relay shall disable engine starting circuits until manually reset. Provide reset pushbutton on switchboard.

2.12.4.13 Automatic Transfer and Bypass Isolation Switch

Section 16410, Automatic Transfer and Bypass/Isolation Switches."

2.12.4.14 Automatic Synchronizing and Transfer Circuitry

Provide engine-generator sets with relays, switching, and other devices and wiring necessary for fully automatic operation.

a. Automatic Starting: When normal supply voltage in phase drops below a predetermined value, adjustable from 65 to 90 percent normal for a predetermined interval, adjustable from 0 to one minute, automatic operation shall begin. First, engine-generator set shall automatically start, accelerate to governed speed, and build up to regulated voltage. When engine-generator set voltage reaches approximately 90 percent normal, automatic transfer of load from normal source to engine-generator set shall occur. When load exceeds a predetermined value, adjustable from 50 to 100 percent of engine-generator set rating for a period of approximately 10 seconds, second engine-generator set shall automatically start, accelerate to governed speed, build up to regulated voltage, synchronize and be connected in parallel, dividing the load equally, with first set and so on for engine-generator sets provided.

b. Automatic Synchronizing: Provide each engine-generator set with an individual three-phase automatic-synchronizing relay, IEEE Device 25, having fully redundant logic and circuit breaker closure circuitry. Provide relay complete with necessary auxiliary devices arranged to close each generator circuit breaker at the correct phase angle in advance of synchronism to effect closure of a circuit breaker main contacts at approximately the instant of zero-phase angle between generator and bus voltages, when generator-synchronizing selector switch is operated. Automatic synchronizing relay shall not permit closing of a generator breaker with abnormal voltage nor with a slip frequency greater than one-third Hz and shall automatically adjust governed speed of selected generator to match frequency of bus prior to closing generator circuit breaker. Relay shall contain a pulsing circuit to "force" phase correction when frequencies are matched but improper phase relation exists. Ensure that dead bus logic operates so that before one generator circuit breaker can close, remaining generator circuit breakers have been locked out. Provide a 10- to-20 millisecond time delay compatible with logic and closure circuits. Relay shall be equipped with surge protection either by suitable devices or by component rating.

c. Automatic Stopping: When normal supply voltage is restored to a predetermined value, adjustable from 90 to 100 percent normal, for a predetermined time interval, adjustable from 0 to 2 minutes, load shall automatically transfer from engine-generator sets to normal supply, generator circuit breaker shall open, and engine-generator sets shall continue to run for a period of 5 minutes, adjustable, then automatically stop. Devices shall return to normal position, ready to repeat the automatic operation above. Complete facilities shall be provided for manual control, including test operation of each engine-generator set without load and manual operation of load transfer devices. When engine-generator sets are not required to supply connected load, unneeded sets shall be shut down.

d. Selector Switch: Provide one selector switch to permit selection of which engine-generator set first starts and permit selection of the sequential starting of other engine-generator sets.

2.12.4.15 Surge Arrester and Capacitor Assemblies

Provide surge arrester and capacitor assemblies designed for use on a three-phase, four-wire solidly grounded system and designed for engine-generator set voltage level. Provide metal-oxide type surge arresters designed for a maximum 10-kiloampere discharge. Provide surge capacitors specifically designed for use with associated surge arrester. Provide capacitors for generators with built-in resistors and designed for rotating machine protection.

2.12.5 Generator Switchboard Unit Equipment Details

Provide units with nameplates for front and rear identification and necessary auxiliary relays, small wiring, nameplates, control and instrument buses, fuses, terminal blocks, wire terminals, and accessories. Arrange cable compartments in switchboard for indicated entrance of power and control cables. For each free-standing section provide one set of phase, full-size neutral, and ground buses, splices, and connections. Buses shall be copper. Circuit breakers shall conform to paragraph "Generator Circuit Breakers."

2.12.5.1 Generator Units

Equip each unit with devices specified in paragraph "Generator Control Panel."

2.12.5.2 Feeder and Bus Tie Units

Equip each unit as follows:

a. Incoming feeder units:

[1) 1 power circuit breaker, IEEE Device 52

(2) 1 ammeter and ammeter switch

(3) 3 current transformers

(4) 3 voltage transformers

(5) 1 watthour meter demand type

(6) 1 surge arrester and capacitor assembly

b. Outgoing feeder units:

(1) 1 molded-case circuit breaker

(2) 1 ammeter and ammeter switch

(3) 3 current transformers

(4) 1 surge arrester and capacitor assembly

c. Bus tie unit:

(1) 1 [molded-case] [power] circuit breaker, IEEE Device 52

(2) 1 synchronism check relay, IEEE Device 25

(3) 2 sets of three each voltage transformers

2.12.5.3 Auxiliary Units:

a. Manual Synchronizing Panel: Provide one swinging panel located as indicated with a synchroscope, arranged to indicate synchronism of each generator by use of synchronizing switch and two white synchronizing lights. Provide one bus (run) voltmeter and frequency meter and one incoming voltmeter and frequency meter arranged to indicate voltage of source by use of its associated synchronizing switch.

b. Control Battery and dc Service Unit: Provide equipment as specified in paragraph "Control Battery."

2.13 CONTROL BATTERY

Locate as indicated.

2.13.1 Control Battery Type

Provide one heavy-duty station type battery for specified control operations and indicated requirements. Battery shall consist of 24 cells of either the lead-antimony or lead-calcium type contained in individual jars of shock- and heat-resistant clear acrylic or polystyrene plastic. Covers shall form an air-tight, acid-tight seal with the jars, and provide each with a suitable vent with removable plug designed to allow free venting of gases from the cell and to prevent escape of electrolyte. Electrolyte shall be sulfuric acid conforming to FS O-S-801 and shall have a specific gravity not exceeding 1.220 at 25 degrees C (77 degrees F) at full charge. Cells shall have adequate space below plates for accumulation of sediment under normal operation and maintenance. Provide special tools, cell-lifters, trays, racks, and maintenance equipment. Include portable hydrometer-syringe and thermometer, vent-mounted hydrometer-syringe and thermometer, one cell container and cover, and six intercell connectors.

2.13.2 Control Battery Racks

Provide battery racks constructed for the type of battery provided. Racks shall be of substantial construction and arranged as indicated, or in an approved convenient and accessible manner. Construct racks of securely braced welded steel frames. Racks shall have steel rails with a top-covering of acid- or alkali-resistant rubber or plastic. Permanently attach acid- or alkali-resistant rubber or plastic numerals not less than one inch in height to the rack in a position to readily indicate the associated cell. Structural parts of racks shall have not less than two coats of an approved acid- or alkali-resistant paint or varnish. Racks shall be designed to resist lateral forces for seismic zone involved.

2.13.3 Control Battery Charger

Provide silicon diode type, adjustable, self-regulating, current limiting, and either floor or wall mounting as shown. Charger shall comply with UL 1236. Voltage regulation of charger shall be 0.5 percent maximum from 0 to 100 percent load. Provide dual-rate charger complete with output voltage potentiometer, line switch, equalizing charge switch and timer, reverse power protection, dc ammeter, dc voltmeter, grounding terminal, and enclosing steel cabinet treated to resist corrosion. Equip charger with the following local alarm and display devices. Equip charger with white indicating lights and red alarm lights.

a. "ON" indicating light for ac power input.

b. Failure of ac power input relay and alarm light.

c. "No charge" relay to close contacts upon charger failure and alarm light.

d. Ground detector relay to close contacts upon occurrence of a dc system ground and alarm light.

e. Low dc voltage relay and indicating light.

f. High dc voltage relay and indicating light.

2.14 MOTORS

Provide continuous-duty electric motors complying with NEMA MG 1. Nameplate kW ratings shall be as required to drive associated equipment under maximum specified conditions of operation without consideration of service factor. Provide induction motors with Class B insulation. Motors shall have general purpose drip-proof or totally enclosed fan-cooled enclosures as specified or shown. Motors shall have sleeve bearings or grease-lubricated ball bearings.

2.14.1 Three-Phase Motors

Provide single- or two-speed motors as specified or shown, squirrel cage type rated at engine-generator set voltage for 373 w (1/2 hp) and larger units.

2.14.2 Single-Phase Motors

Provide motors rated 115 volts, 60-Hz for 246 w (1/3 hp) and smaller units.

2.15 MOTOR CONTROL

Comply with requirements specified in Section 16415, " Electrical Work Interior."

2.16 MISCELLANEOUS ENGINE SYSTEM REQUIREMENTS

2.16.1 Tank Construction

Construct tanks of not less than 4.76 mm (3/16 inch) steel plate with welded joints and necessary stiffeners on exterior of tank. Provide a braced structural steel framework support. Weld tank top tight and provide an access opening with dustproof, removable 610 mm (24 inch) cover.

2.16.2 Flange Connections

Where not otherwise indicated, provide piping connections in accordance with ASME/ANSI B16.1 for 556 N (125 pound) flanges.

2.16.3 Thermostatic Control Valves

Valves shall be modulating type utilizing self-contained thermostats without the use of external bulbs, and equipped with three-way valve action. Provide valves with one or more interchangeable thermostatic elements. Thermostat shall be nonadjustable and operating temperature shall be factory-set at temperature recommended by engine manufacturer. Provide valve designed to fail-safe, permitting flow through engine.

2.17 WIRE AND CABLE

Provide wire and cable required for a complete electrical system as shown. Comply with requirements specified in Section 16415, " Electrical Work Interior."

2.18 WEATHER RESISTANT ENCLOSURE

Provide a weather resistant enclosure for generator sets as required. Fabricate from zinc-coated phosphatized and shop primed 16 gage minimum sheet steel in accordance with manufacturer's standard design. Provide enclosure for engine, generator, control panel, excitation equipment, voltage regulator, engine safety control, and accessories. Enclosure shall have sufficient louvered openings to allow entrance of outside air for engine and generator cooling at full load. Louvered openings shall be designed to exclude driving rain and snow. Provide properly arranged and sized hinged panels in the enclosure to allow convenient access to engine, generator, and control equipment for maintenance and operation. Provide lockable, hinged panels with spring latches to hold panels closed securely and not allow panels to vibrate. Brace housing internally to prevent excessive vibration when generator set is in operation.

2.19 VIBRATION ISOLATION SYSTEM

The isolation system shall reduce the vibration transmitted to the adjacent floor slab to a maximum of 0.038 mm (0.0015 inch) total amplitude throughout the frequency range down to 65 CPS. The manufacturer shall certify that the vibration isolation system will reduce the vibration to the limits specified.

2.20 IDENTIFICATION OF EQUIPMENT

Each major component of equipment shall have the manufacturer's name, address, and model and serial number on a nameplate securely affixed in a conspicuous place; nameplate of the distributing agent will not be acceptable. Nameplates shall not be painted.

2.21 SOURCE QUALITY CONTROL

Perform and report on factory tests prior to shipment. Provide certified copies of manufacturer's test data and results. Notify Contracting Officer before performing tests. Contracting Officer or Contracting Officer's representative reserves the right to witness tests. Test procedures shall conform to ASME, IEEE, IEC, and ANSI Standards, and to SAE requirements on testing, as appropriate and applicable. Ensure that measuring and indicating devices are certified correct. Tests shall indicate satisfactory operation and specified performance. When satisfactory, equipment tested will be given a tentative approval. Equipment shall not be shipped before approval of factory test reports for the following tests:

2.21.1 Engine-Generator Set Tests

Perform customary commercial factory tests on each engine-generator set, including, but not necessarily limited to, the following:

a. Perform hydrostatic test on engine water jackets and piping to ensure that water seals and water jackets are water tight. Test report shall indicate pressure at which test was made and the results.

b. Place engine-generator set in continuous operation without stoppage for a period of not less than 8 hours. Operate not less than one hour at each load point, that is 1/2, 3/4, and full load. Include 2 hours at 110 percent of rated load at either 0.80 or 1.0 power factor. When stoppage becomes necessary during this period, repeat the 8-hour run. Record the following data for sets at the start, at 15-minute intervals, and at end of each load run: Fuel consumption (correct fuel consumption results to guarantee conditions); exhaust temperatures; engine coolant temperatures; lubricating oil temperatures and pressures; and any other data of importance.

2.21.1.1 Generator Tests

Ensure that temperature tests on one generator's windings are performed by manufacturer of generator in manufacturer's own plant. Temperature tests shall be in accordance with IEEE 115 and IEC 34. Generator tests shall include insulation resistance and dielectric resistance. Prototype tests for generators that are physically and electrically identical to those provided under the Contract are acceptable. Calculations of subtransient reactance shall be included in the test report.

2.21.1.2 Radio Frequency Interference (RFI) Tests

Conduct test in accordance with MIL-S-16165 and MIL-STD-461.Furnish testing equipment, instruments, personnel for conducting tests, a test location reasonably free from radiated and conducted interference, and other necessary facilities. Tests for RFI will not be required for items that are physically and electrically identical to those that have previously met requirements of the specifications.

PART 3 EXECUTION

3.1 PREPARATION

Use cribbing and shoring as required to protect construction from moving-in damage. Protect flooring and finished surfaces with heavy planking. Obtain approval of methods and materials from the Contracting Officer or the Contracting Officer's authorized representative before moving equipment across shored floors.

3.2 INSTALLATION

Installation shall be in strict accordance with manufacturer's instructions. Unload, move, and erect equipment under direct supervision of a competent and experienced erecting engineer. Provide labor, tools, equipment, and other necessities for erection and installation of equipment. After equipment has been installed, remove shoring and repair damage to floors and other parts of the building. Furnish the services of one or more Diesel-Generator representative or technicians, experienced in installation and operation of the type of systems being provided, to supervise the installation.

3.2.1 Installation of Engine-Generator Sets

Install engine-generator sets on a concrete foundation as indicated. Provide vibration isolators to isolate vibrations from engine-generator set to the foundation.

3.2.2 Equipment Supports and Installation

Provide devices to support equipment not supported on engine-generator structural steel subbase as required. Fabricate required supports of structural steel sections, plates or rods, and arrange to provide rigid and sturdy support. Provide connections and fasteners required between equipment supports and building structures.

a. Generator Switchboard: Provide floor mounting channels and install in concrete floor slab in accordance with switchboard manufacturer's drawings and instructions and as indicated. Install floor channels flat rather than on edge. Align, level, and bolt or weld switchboard units to floor channels to allow easy withdrawal or insertion of removable elements, and to permit proper operation of component devices. Splice the main bus and insulate bus joints in accordance with switchboard manufacturer's recommendations. Connect control wiring as required at shipping splits.

b. Batteries and Chargers: When batteries are to be stored during the construction period, follow manufacturer's instructions for charging and protection from environmental damage.

3.2.3 Instruction of Operators

After equipment is ready to be placed in service, Contractor and equipment manufacturer's representative shall fully instruct plant operators in operation and maintenance of the equipment. Posted operating instructions for diesel engine-generator set shall be provided adjacent to the unit.

3.2.4 Piping

Piping connecting the engine and equipment mounted on engine-generator subbase shall be factory installed and shall conform to manufacturer's standards for set sizes involved. Piping extensions from engine-generator and subbase to remote cooling and fuel systems shall conform to ASME/ANSI B31.9 and NFPA 30. Arrange piping to provide a workable arrangement, with convenient access to valves and specialty items. Maintain adequate clearance between runs of piping to permit access around adjacent pipe for dismantling, repair, and maintenance of valves. Piping shall be straight, plumb, and run direct as possible. Do not install piping over electrical equipment.

3.2.4.1 Shop Fabrication

Shop fabricate pipe to greatest extent possible. Plug ends of piping and openings prior to shipment to plant site.

3.2.4.2 Welding

Preparing, bending, cleaning, and welding of piping shall conform to ASME/ANSI B31.9. Welds shall be visually examined and meet acceptance standards of ASME/ANSI B31.9.

3.2.4.3 Field Cleaning

Before placing in position, clean inside of black steel pipe by rapping along its full length to loosen sand, mill scale, and other foreign matter. Pipe 50 mm (2 inch) and larger shall have a wire brush of a diameter larger than that of the inside of the pipe drawn through its entire length several times. Before final connections are made to apparatus, wash out interior of coolant piping with water. Blow out air and fuel lines with 551 to 689 kPa (80 to 100 psi) dry air or nitrogen.

3.2.4.4 Pickled Piping

Clean steel fuel oil piping and pickle internally by chemical cleaning. Cleaning process shall remove grease, oil, dirt, mill scale, lacquer, and corrosion products. Clean piping either by circulating cleaning solution through completed piping systems or by soaking prefabricated piping sections in a tank of solution. Provide and remove after use pumps, temporary piping connections, tanks, and other equipment required to accomplish cleaning of piping. After cleaning, thoroughly flush, drain, and dry piping and take necessary precautions to prevent rerusting before pipe is used. While cleaning, remove or isolate instrumentation, valves, and equipment installed in piping which contain bronze or brass. Cleaning solution shall not come in contact with bronze or brass. Cleaning solution shall not be circulated through engine piping systems. Provide cleaning solution of the type recommended by engine manufacturer and chemical manufacturer for the specific purpose.

3.2.4.5 Provisions for Expansion

Provide for expansion of piping subject to temperature change by using suitable flexible piping connectors, expansion joints, bends, ball joints, offsets, and loops in a manner that will prohibit development of excessive stresses between anchor points or at equipment connections. Provide bends, loops, and offsets wherever practical to prevent overstressing of piping systems due to thermal expansion and to provide adequate flexibility. A piping system may be cold sprung by an amount no greater than 50 percent of the total linear expansion to alleviate end thrusts and moments. Method of cold springing shall be as approved.

3.2.4.6 Reducing Fittings

Provide for changes in pipe size except where taps are permitted. Use of bushings is prohibited. In horizontal mains containing liquids, provide eccentric reducers.

3.2.4.7 Unions or Flanges

Provide where necessary to permit easy connection of piping and apparatus. Provide unions on valves with screwed ends. In long lines inside buildings, place unions or flanges not farther apart than 30 meters (100 feet), except in pipe lines of welded construction where unions or flanges shall be placed as indicated.

3.2.4.8 Valves

Install in positions accessible for operation and repair. Install stems preferably in a vertical position with handwheels or operators on top, or install in a horizontal position. Do not install handwheels on stop valves below the valve. Install globe valves with flow direction from below the disk.

3.2.4.9 Connections to Equipment

Make piping connections to equipment shown and provide reducers, unions, and valves to make a complete installation. Make connections to equipment with unions or flanges. Provide valves the same size as piping in which they are installed.

3.2.4.10 Joints

a. Flanged Joints: Face pipe flanges true to line and thoroughly clean before assembly. Gasket faces shall be free of burrs or bruises. Make up flanged joints prior to completing the last weld in connecting piping. Coat bolt threads with a mixture of equal parts of graphite and boiled linseed oil or with an approved commercial coating.

b. Screwed Joints: Provide graphite pipe-joint compound conforming to MIL-T-5544; apply to male threads only. Antiseize zinc compound conforming to MIL-T-22361 may be provided. Piping shall be free of fins and burrs. Ream pipe ends or file out to size of bore; remove chips.

3.2.4.11 Pipe Sleeves

Provide where pipes and tubing pass through masonry or concrete walls, floors, roofs, and partitions. Sleeves in outside walls above grade, in floor, or in roof slabs shall be steel pipe. Sleeves in floor slabs shall extend 75 mm (3 inches) above the finished floor. Firmly pack space between pipe or tubing and sleeve with oakum and calk on both ends of sleeve with elastic cement, except for sleeves in plant operating floors which shall be free of packing and elastic cement. Where piping passes through steel grating, band the opening with 25 by 3 mm (one by 1/8 inch) steel edge bands welded to the grating bars.

3.2.4.12 Wall Pipes

Provide cast iron wall pipes for piping passing through underground exterior walls and install in a manner to ensure a watertight connection between the wall and casting. Provide wall pipes with flanged ends conforming to ASME/ANSI B16.1, Class 125. Extend flanged ends beyond wall to permit bolting of flanges to connecting piping.

3.2.4.13 Excavation and Backfill

Perform necessary trenching and backfill for outside piping to be furnished and installed. Excavate bottom of trenches to grade, with bell holes provided at each joint. Bottom of each length of pipe shall bear firmly against undisturbed earth for full length of barrel. Rocks larger than 75 mm (3 inches) in diameter in soil beneath the pipe shall not come into physical contact with pipe. Make changes in grade or alignment with suitable fittings. After installing and testing outside piping backfill trenches. Consolidate backfill by mechanical tamping in layers not exceeding 150 mm (6 inches). Remove excess materials from trenches and deposit as directed by the Government. Restore trench areas to original condition.

3.2.4.14 Slope, Drainage, and Ventilating

Slope piping to permit complete drainage. Install drain valves at low points in piping. Drain valves shall be 15 mm (1/2 inch) gate valves for pipe lines smaller than 75 and 20 mm (3 and 3/4 inch) gate valves for lines 75 mm (3 inches) and larger, except where specific sizes are shown. Drain valves shall be of same class as piping drained. Install vent valves at high points in piping. Vent valves shall be 15 mm (1/2 inch) globe valves.

3.2.4.15 Flashing

Flashing and counter flashing for pipes and supports passing through exterior walls above ground and through roof shall conform to details as indicated.

3.2.4.16 Anchors, Guides, and Supports

Anchor and support piping in a manner such that expansion and contraction will take place in the desired direction. Prevent vibration by use of vibration dampers and prevent undue strains on equipment served. Hangers used for supporting piping 50 mm (2 inches) and larger shall be the type permitting adequate adjustment after erection while still supporting the load. Provide supports to adequately carry weight of lines and to maintain proper alignment. Provide inserts and sleeves for supports in concrete where necessary, and in new construction place inserts and sleeves before concrete is poured.

3.3 FIELD QUALITY CONTROL

Perform and report on field tests and trial operations, and conduct field inspections, except final field inspection. Provide labor, calibrated and approved test equipment, and incidentals required for tests. Contracting

Officer will witness field tests and trial operations and will conduct final field inspections. Give Contracting Officer 5 days notice of dates and times scheduled for tests, trial operations, and inspections which require the presence of the Contracting Officer. Rectify deficiencies and retest work affected by such deficiencies.

3.3.1   Piping Tests

Test piping system after lines have been cleaned. Test piping systems at a pressure of 1.5 times the design working pressure, and in no case less than 689 kPa (gage) (100 psig). Hydrostatically test piping, except for air and fuel, using water not exceeding 38 degrees C (100 degrees F). Test air and fuel lines with clean, dry air or nitrogen. For air lines operating at pressure greater than 689 kPa (gage) (100 psig), test at design working pressure. During testing, remove gages, traps, and other apparatus which may be damaged by the test pressure, or valve off before conducting tests. Install a calibrated test pressure gage in the system to observe loss in pressure. Brush joints in piping system tested with air with a soapy water solution to check for leaks. Maintain required test pressure for a sufficient length of time to enable inspection of joints and connections. Rectify defects that develop during testing, and retest piping systems until they show no defect or weakness and are tight.

3.3.2   Preliminary Operation

Align and adjust equipment to ensure proper operation as instructed by manufacturers of equipment. Lubricate equipment prior to operation in accordance with manufacturer's instructions. Upon approval by Contracting Officer or the Contracting Officer's authorized representative, operate engine-generator sets under supervision of supervising erector at varying loads throughout the load range for a sufficient time to demonstrate that operation is proper and that pressures and temperatures are normal and within specified limits. Operate engines for a period of time sufficient to ensure that units are ready to carry test loads specified in paragraph "Engine-Generator Set Acceptance Tests" without damage to engine parts. During this preliminary operation, check operation and ensure proper functioning of auxiliary equipment. Make necessary adjustments to equipment to place auxiliary equipment in operating condition.

3.3.3   Electrical Equipment and Materials Tests

Test procedures, inspections, and sampling shall be as specified and noted below:

a. Phase Relationship Tests: Check connections to equipment for proper phase relationship. During such check, disconnect devices which could be damaged by application of voltage or reversed phase sequence.

b. Control Panel and Switchboard Tests: Test and adjust meters and relays in accordance with applicable referenced specifications.

c. Insulation Resistance Tests: Test field installed cables. Minimum acceptable values of insulation resistance of circuits shall be as recommended by the manufacturer.

3.3.4   Engine-Generator Set Acceptance Tests

When installation is complete and in operating condition, notify the Contracting Officer in writing that engine-generator sets and auxiliary equipment are ready for final field tests. The Contracting Officer or Contracting Officer's authorized representative will witness final acceptance tests. Perform tests as necessary to make certain that equipment is functioning properly. Tests shall include the following:

a. A test to determine generating unit speed regulation under a gradual change from zero to full load.

b. A test to determine generating unit instantaneous speed change with 50 percent load on or off.

c. A test to ensure proper functioning of the overspeed trip.

d. An individual test of each alarm device.

e. A 6-hour load test, 2 hours each at 50, 75, and 100 percent load at the highest ambient temperature in the area, to prove cooling system operation in the installed location.

Inspect auxiliary equipment including, but not limited to, pumps, fans, radiators, compressors, instruments, and special valves to ensure proper operation. Auxiliary equipment may be field tested at the option of the Contracting Officer. Auxiliary equipment test shall be in accordance with the latest ASME and IEEE performance test codes, when applicable. When no code exists for equipment to be tested, perform tests as prescribed by the Contracting Officer. Use plant electrical system load for loading engine-generator set under test. Check oil after tests for presence of metal particles and water. Provide and install temporary instrumentation, piping, and electrical wiring and make electrical connections required for engine-generator set tests.

3.3.4.1 Test Reruns

When specified performance is not met by these tests, make such adjustments and changes, as necessary, and conduct additional tests, as necessary, to further check performance of equipment.

3.3.4.2 Failure to Meet Requirements

In the event equipment fails to meet specified performance or fails to operate satisfactorily, the Government shall have the right to operate equipment until defects have been corrected. If engine-generator sets fail to meet the guaranteed efficiency, the Government reserves the right to assess compensatory damages against the Contractor as determined in paragraph entitled "Compensatory Damages on Performance" or to reject engine-generator sets. Equipment proved to be faulty or inadequate for service specified will be rejected, but the Government shall have the right to operate rejected equipment until such time as new equipment is provided by the Contractor to replace equipment rejected.

3.3.4.3 Manufacturer's Field Services

Furnish the services of one or more diesel-generator representative or technicians, experienced in installation and operation of the type of systems being provided, to supervise testing, adjustment of the system, and to instruct Government personnel.

SECTION 16370

ELECTRICAL DISTRIBUTION SYSTEM, AERIAL

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C29.1	(1988; R 1996) Electrical Power Insulators - Test Methods
ANSI C29.2	(1992) Insulators - Wet-Process Porcelain and Toughened Glass Suspension Type
ANSI C29.3	(1986; R 1995) Wet Process Porcelain Insulators - Spool Type
ANSI C29.4	(1989; R 1995) Wet-Process Porcelain Insulators - Strain Type
ANSI C29.5	(1984; R 1995) Wet-Process Porcelain Insulators - Low- and Medium-Voltage Types
ANSI C29.6	(1996) Wet-Process Porcelain Insulators - High-Voltage Pin Type
ANSI C29.8	(1985; R 1995) Wet-Process Porcelain Insulators - Apparatus, Cap and Pin Type
ANSI C29.9	(1983; R 1996) Wet-Process Porcelain Insulators - Apparatus, Post-Type
ANSI C37.32	(1996) High-Voltage Air Switches, Bus Supports, and Switch Accessories - Schedules of Preferred Ratings, Manufacturing Specifications, and Application Guide
ANSI C57.12.20	(1997) Overhead Type Distribution Transformers, 500 KVA and Smaller: High Voltage 34 500 Volts and Below: Low Voltage, 7970/13 800 Y Volts and Below
ANSI C135.1	(1979) Galvanized Steel Bolts and Nuts for Overhead Line Construction
ANSI C135.2	(1999) Threaded Zinc-Coated Ferrous Strand-Eye Anchor Rods and Nuts for Overhead Line Construction
ANSI C135.4	(1987) Zinc-Coated Ferrous Eyebolts and Nuts for Overhead Line Construction
ANSI C135.14	(1979) Staples with Rolled or Slash Points for Overhead Line Construction
ANSI C135.22	(1988) Zinc-Coated Ferrous Pole-Top Insulator Pins with Lead Threads for Overhead Line Construction
ANSI C135.30	(1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction

ANSI O5.1 (1992) Specifications and Dimensions for Wood Poles

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36/A 36M (2001) Carbon Structural Steel

ASTM A 123/A 123M (2001) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 153/A 153M (2001) Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A 475 (1998) Zinc-Coated Steel Wire Strand

ASTM A 575 (1996; Rev 2002) Steel Bars, Carbon, Merchant Quality, M-Grades

ASTM A 576 (1990b; R 2000) Steel Bars, Carbon, Hot-Wrought, Special Quality

ASTM B 1 (2001) Hard-Drawn Copper Wire

ASTM B 8 (1999) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM B 117 (1997) Operating Salt Spray (Fog) Apparatus

ASTM B 228 (1998) Concentric-Lay-Stranded Copper-Clad Steel Conductors

ASTM B 230/B 230M (1999) Aluminum 1350-H19 Wire for Electrical Purposes

ASTM B 231/B 231M (2001) Concentric-Lay-Stranded Aluminum 1350 Conductors

ASTM B 232/B 232M (2001) Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR)

ASTM B 398/B 398M (1999) Aluminum-Alloy 6201-T81 Wire for Electrical Purposes

ASTM B 399/B 399M (1999) Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 Conductors

ASTM B 416 (1998) Concentric-Lay-Stranded Aluminum-Clad Steel Conductors

ASTM D 923 (1997) Sampling Electrical Insulating Liquids

ASTM D 1654 (1992; Rev 2000) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D 4059 (2000) Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2002) National Electrical Safety Code

IEEE C37.34 (1994) Test Code for High-Voltage Air Switches

IEEE C37.41	(2000) Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories
IEEE C37.60	(1981; R 1992) Requirements for Overhead, Pad Mounted, Dry Vault and Submersible Automatic Circuit Reclosers and Fault Interrupters for AC Systems
IEEE C37.63	(1997) Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizer for AC Systems
IEEE C57.12.00	(2000) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13.2	(1991) IEEE Standard Conformance Test Procedures for Instrument Transformers
IEEE C57.15	(1999) Requirements, Terminology, and Test Code for Step-Voltage and Induction-Voltage Regulators
IEEE C57.19.00	(1991; R 1997) IEEE Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings
IEEE C57.19.01	(2000) Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings
IEEE C57.98	(1994) Guide for Transformer Impulse Tests
IEEE C62.1	(1989; R 1994) Surge Arresters for AC Power Circuits
IEEE C62.2	(1987; R 1994) Guide for the Application of Gapped Silicon-Carbide Surge Arresters for Alternating Current Systems
IEEE C62.11	(1999) IEEE Standard Metal-Oxide Surge Arresters for AC Power Circuits
IEEE Std 18	(1992) Shunt Power Capacitors
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)
IEEE Std 100	(2000)IEEE Standard Dictionary of Electrical and Electronics Terms
IEEE Std 242	(2001) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
IEEE Std 399	(1997)Recommended Practice for Industrial and Commercial Power Systems Analysis
IEEE Std 404	(2000)Cable Joints for Use with Extruded Dielectric Cable Rated 5000 V Through 138 000 V and Cable Joints for Use with Laminated Dielectric Cable Rated 2500 V Through 500000 V

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-70-547 (2000) Weather Resistant Polyolefin Covered Wire & Cable

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA HV 2 (1984; R 1991) Application Guide for Ceramic Suspension Insulators

NEMA ICS 6 (1993) Industrial Control and Systems, Enclosures

NEMA LA 1 (1992) Surge Arresters

NEMA SG 2 (1993) High Voltage Fuses

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2002) National Electrical Code

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS REA Bull 1728H-701 (1993) REA Specification for Wood Crossarms (Solid and Laminated), Transmission Timbers and Pole Keys

UNDERWRITERS LABORATORIES (UL)

UL 467 (1993; Rev thru Feb 2001) Grounding and Bonding Equipment

UL 486A (1997; Rev thru May 2001) Wire Connectors and Soldering Lugs for Use with Copper Conductors

UL 486B (1997; Rev May 2001) Wire Connectors for Use with Aluminum Conductors

KOREAN STANDARDS ASSOCIATION (KS)

KS F 4301 (2000) Concrete Poles, Centrifugally Reinforced

KS C 3101 (1995) Copper Wire, Electrical, Solid, Softdrawn

KS C 3102 (1998) Copper Wire, Electrical, Solid, Harddrawn

KS C 3103 (1986) Copper Wire, Electrical, Stranded, Softdrawn

KS C 3104 (1996) Copper Wire, Electrical, Stranded, Harddrawn

KS C 3113 (1986) Aluminum Conductor Steel Reinforced

KS C 3313 (2002) OW Wire

KS C 3315 (2002) DV Wire

KS C 3327 (1990) ACSR-OW Wire

KS C 4302 (1977) Transformer, 3 KV, Oil Immersed

KS C 4303 (1977) Transformer, 6 KV, Oil Immersed

KS C 4802	(1997) Capacitor
KS D 3501	(1999) Hot Rolled Milled Steel Plate Sheet and Strip
KS D 3515	(1997) Rolled Steel for Welded Structures
KS D 3555	(1991) Hot Rolled Carbon Steel Strip for Pipes And Tubes
KS D 7007	(1996) Galvanized Steel Wire Strands
KS D 8308	(2001) Zinc Coating (Hot Dipped) on Iron and Steel

1.2 RELATED REQUIREMENTS

Section 16050, "Basic Electrical Materials and Methods," applies to this section with the additions and modifications specified herein.

1.3 GENERAL REQUIREMENTS

1.3.1 Terminology

Terminology used in this specification is as defined in IEEE Std 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Electrical Distribution System;

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams and other information necessary to define the installation and enable the Government to check conformity with the requirements of the contract drawings. Detail drawings shall as a minimum include:

a. Constant current regulators.

b. Poles.

c. Calculations for steel poles and power installed screw foundations.

d. Crossarms.

e. Transformers.

f. Automatic circuit reclosers.

g. Pole top switches.

h. Conductors.

i. Insulators.

j. Surge arresters.

If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures shall be submitted with the detail drawings. Approved departures shall be made at no additional cost to the Government.

Detail drawings shall show how components are assembled, function together and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall consist of the following:

a. Detail drawings showing physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. Optional items shall be clearly identified as included or excluded.

b. Internal wiring diagrams of equipment showing wiring as actually provided for this project. External wiring connections shall be clearly identified.

As-Built Drawings; G

The as-built drawings shall be a record of the construction as installed. The drawings shall include the information shown on the contract drawings as well as deviations, modifications, and changes from the contract drawings, however minor. The as-built drawings shall be kept at the job site and updated daily. The as-built drawings shall be a full sized set of prints marked to reflect deviations, modifications, and changes. The as-built drawings shall be complete and show the location, dimensions, part identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall submit three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within ten calendar days from the time the drawings are returned to the Contractor.

SD-03 Product Data

Fault Current Analysis;
Protective Device;
Coordination Study;

The study shall be submitted along with protective device equipment submittals. No time extensions or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device settings, ratings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Nameplates; G

Catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Material and Equipment; G

A complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include the item number, the quantity of items proposed, and the name of the manufacturer of the item.

General Installation Requirements;

As a minimum, installation procedures for regulators, transformers and reclosers. Procedures shall include diagrams, instructions, and precautions required to install, adjust, calibrate, and test the devices and equipment.

SD-06 Test Reports

Factory Tests; G

Certified factory test reports shall be submitted when the manufacturer performs routine factory tests, including tests required by standards listed in paragraph REFERENCES. Results of factory tests performed shall be certified by the manufacturer, or an approved testing laboratory, and submitted within 7 days following successful completion of the tests specified in applicable publications or in these specifications.

Field Testing; G

A proposed field test plan 14 days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Operating Tests; G

Six copies of the information described below in 215.9 by 279.4 mm (8-1/2 by 11 inch) binders having a minimum of 3 rings, and including a separate section for each test. Heavy plastic dividers with tabs shall separate sections.

a. A list of equipment used, with calibration certifications.

b. A copy of measurements taken.

c. The dates of testing.

d. The equipment and values to be verified.

e. The condition specified for the test.

f. The test results, signed and dated.

g. A description of adjustments made.

SD-07 Certificates

Material and Equipment; G

Where materials or equipment are specified to conform to the standards of the Underwriters Laboratories (UL) or to be constructed or tested, or both, in accordance with the standards of the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), or the National Electrical Manufacturers Association (NEMA), or Korean Standards (KS)the Contractor shall submit proof that the items provided under this section of the specifications conform to such requirements. The label of, or listing by, UL will be acceptable as evidence that the items conform thereto. Either a certification or a published catalog specification data statement, to the effect that the item is in accordance with the referenced ANSI or IEEE standard, will be acceptable as evidence that the item conforms thereto. A similar certification or published catalog specification data statement to the effect that the item is in accordance with the referenced NEMA standard, by a company listed as a member company of NEMA, will be acceptable as evidence that the item conforms thereto. In lieu of such certification or published data, the Contractor may submit a certificate from a recognized testing agency equipped and competent to perform such services, stating that the items have been tested and that they conform to the requirements listed, including methods of testing of the specified agencies.

SD-10 Operation and Maintenance Data

Electrical Distribution System; G

Six copies of Operation and Maintenance manuals electrical distribution system shall be provided, within 7 calendar days following the completion of tests and shall include assembly, installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked. Manuals shall also include data outlining detailed procedures for system startup and operation, and a troubleshooting guide, which lists possible operational problems and corrective action to be taken. A brief description of all equipment, basic operating features, and routine maintenance requirements shall also be included. Documents shall be bound in a binder marked or identified on the spine and front cover. A table of contents page shall be included and marked with pertinent contract information and contents of the manual. Tabs shall be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare-parts data. Index sheets shall be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers. Three additional copies of the instruction manual shall be provided within 30 calendar days following the manuals.

Three additional copies of the instructions manual within 30 calendar days following the approval of the manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Oil filled transformers and switches shall be stored in accordance with the manufacturer's requirements. Metal poles shall be handled and stored in accordance with the manufacturer's instructions.

1.6 EXTRA MATERIALS

One additional spare fuse or fuse element for each furnished fuse or fuse element shall be delivered to the Contracting Officer when the electrical system is accepted. Two complete sets of all special tools required for maintenance shall be provided, complete with a suitable tool box. Special tools are those that only the manufacturer provides, for special purposes (to access compartments, or operate, adjust, or maintain special parts).

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

Products shall conform to the following requirements. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.2 STANDARD PRODUCT

Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.3 NAMEPLATES

2.3.1 General

Each major component shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a nameplate securely attached to the equipment. Equipment containing liquid-dielectrics shall have the type of dielectric on the nameplate. Nameplates shall be made of non-corrosive metal. As a minimum, nameplates shall be provided for transformers, regulators, circuit breakers, capacitors, meters and switches.

2.3.2 Liquid-Filled Transformer Nameplates

Power transformers shall be provided in accordance with IEEE C57.12.00. Nameplates shall indicate the number of liters (gallons) and composition of liquid-dielectric, and shall be permanently marked with a statement that the transformer dielectric to be supplied is non-polychlorinated biphenyl. If transformer nameplate is not so marked, the Contractor shall furnish manufacturer's certification for each transformer that the dielectric in non-PCB classified, with less than 2 ppm PCB content in accordance with paragraph

LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the 2 ppm PCB content or transformers without certification will be considered as PCB insulated and will not be accepted.

2.4 CORROSION PROTECTION

2.4.1 Aluminum Materials

Aluminum shall not be used in contact with earth or concrete. Where aluminum conductors are connected to dissimilar metal, fittings conforming to UL 486B shall be used.

2.4.2 Ferrous Metal Materials

2.4.2.1 Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M and ASTM A 123/A 123M or KS D 8308.

2.4.2.2 Equipment

Equipment and component items, including but not limited to transformers and ferrous metal luminaires not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM B 117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm (1/16 inch) from the test mark. The described test mark and test evaluation shall be in accordance with ASTM D 1654 with a rating of not less than 7 in accordance with TABLE 1, (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

2.4.3 Finishing

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be as specified in Section 09900 PAINTING, GENERAL.

2.5 CONDUCTORS, CONNECTORS, AND SPLICES

2.5.1 Aluminum-Composition Conductors

All-aluminum-conductors, AAC, shall be alloy 1350-H19 and comply with ASTM B 230/B 230M and ASTM B 231/B 231M. All-aluminum-alloy-conductors, AAAC, shall be alloy 6201-T81 and comply with ASTM B 398/B 398M and ASTM B 399/B 399M. Aluminum-conductor-steel-reinforced, ACSR, shall comply with ASTM B 232/B 232M.

2.5.2 Copper Conductors

Hard-drawn-copper conductors shall comply with ASTM B 1 and ASTM B 8 as appropriate for the conductor size.

2.5.3 Connectors and Splices

Connectors and splices shall be of copper alloys for copper conductors, aluminum alloys for aluminum-composition conductors, and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors. Aluminum-composition and aluminum-composition to copper shall comply with UL 486B, and copper-to-copper shall comply with UL 486A.

2.6 MEDIUM-VOLTAGE LINES

2.6.1 Bare Medium-Voltage Lines

Bare medium-voltage line conductors shall be all-aluminum-conductor, AAC; all-aluminum-alloy-conductor, AAAC; aluminum-conductor-steel-reinforced, ACSR; hard-drawn-copper, CU. Conductor types shall not be mixed on any project, unless specifically indicated. Conductors larger than No. 2 AWG shall be stranded.

2.6.2 Insulated Medium-Voltage Lines

Insulated medium-voltage line conductors shall be of the factory-assembled, messenger-supported type, having a rated circuit voltage as shown and a 133 percent insulation level. Conductor material shall be hard drawn copper. Insulation shall be cross-linked thermosetting polyethylene (XLP) conforming to NEMA WC 7 or ethylene-propylene-rubber (EPR) conforming to NEMA WC 8. Messengers shall be zinc-coated steel, aluminum-clad-steel, copper-clad-steel, or composite-copper and copper-clad steel.

2.7 LOW-VOLTAGE LINES

Low-voltage line conductors shall be of the neutral-supported secondary and service drop type with thermoplastic insulation in accordance with NEMA WC 5 or cross-linked thermosetting polyethylene (XLP) insulation in accordance with NEMA WC 7 or weather-resistant polyolefin-covered type conforming to ICEA S-70-547. Neutral-supported secondary and service drop conductors shall be insulated copper with bare hard-drawn-copper or copper-clad steel neutrals or insulated aluminum with bare 1350 alloy aluminum or ACSR neutrals. Conductors on secondary racks may be provided in lieu of neutral-supported cable for pole line circuits where necessary clearances are available.

2.8 POLES AND HARDWARE

Poles shall be of lengths and classes or strengths indicated.

2.8.1 Steel Poles

Steel poles shall be designed to withstand the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors, shall be hot-dip galvanized in accordance with ASTM A 123/A 123M or KS D 8308 and shall not be painted. Poles shall have tapered tubular members, either round in cross-section or polygonal, and comply with strength calculations performed by a registered professional engineer. Calculations shall be submitted in accordance with the detail drawings portion of paragraph SUBMITTALS. Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening except as specifically approved. Pole markings shall be approximately 900 to 1270 mm above grade and shall include manufacturer, year of manufacture, top and bottom diameters, length, and a loading tree. Attachment requirements shall be provided as indicated, including grounding provisions. Climbing facilities are not required. Bases shall be of the anchor-bolt-mounted type.

2.8.2 Concrete Poles

Concrete poles shall be designed to withstand the loads specified in IEEE C2 or KS F 4301 multiplied by the appropriate overload capacity factors. Poles shall be reinforced or prestressed, either cast or spun. Spun poles shall be manufactured by a centrifugal spinning process with concrete pumped into a polished round tapered metal mold. Concrete for spun poles shall have a compressive strength of at least 34.5 MPa (5000 psi) at 28 days; steel wire shall have an ultimate tensile strength of at least 827 MPa (120,00 psi); and reinforcing bars shall have an ultimate tensile strength of at least 276 MPa (40,000 psi). After the high speed spinning action is completed, a spun pole shall be cured by a suitable wet steam process. Spun poles shall have a water absorption of not greater than three percent to eliminate cracking and to prevent erosion. Concrete poles shall have hollow shafts. Poles shall have a hard, smooth, nonporous surface that is resistant to soil acids, road salts, and attacks of water and frost. Poles shall not be installed for at least 15 days after manufacture. Fittings and brackets that conform to the concrete pole design shall be provided. Poles shall conform to strength calculations performed by a registered professional engineer and submitted in accordance with detail drawings portion of paragraph SUBMITTALS.

2.8.3 Pole Line Hardware

Zinc-coated hardware shall comply with ANSI C135.1, ANSI C135.2, ANSI C135.4, ANSI C135.14 ANSI C135.22 or KS D 8308. Steel hardware shall comply with ASTM A 575 and ASTM A 576. Hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M. Pole-line hardware shall be hot-dip galvanized steel or steel, except anchor rods of the copper-molten welded-to-steel type with nonferrous corrosion-resistant fittings shall be used. Washers shall be installed under boltheads and nuts on wood surfaces and elsewhere as required. Washers used on through-bolts and double-arming bolts shall be approximately 57.2 mm square and 4.8 mm (3/16 inch) thick. The diameter of holes in washers shall be the correct standard size for the bolt on which a washer is used. Washers for use under heads of carriage-bolts shall be of the proper size to fit over square shanks of bolts. Eye bolts, bolt eyes, eyenuts, strain-load plates, lag screws, guy clamps, fasteners, hooks, shims, and clevises shall be used wherever required to support and to protect poles, brackets, crossarms, guy wires, and insulators.

2.8.4 Armless Construction

Pole mounting brackets for line-post or pin insulators and eye bolts for suspension insulators shall be as shown. Brackets shall be attached to poles with a minimum of two bolts. Brackets may be either provided integrally as part of an insulator or attached to an insulator with a suitable stud. Bracket mounting surface shall be suitable for the shape of the pole. Horizontal offset brackets shall have a 5-degree uplift angle. Pole top brackets shall conform to ANSI C135.22, except for modifications necessary to provide support for a line-post insulator. Brackets shall provide a strength exceeding that of the required insulator strength, but in no case less than a 12.5 kN (2800 pound) cantilever strength.

2.8.5 Guy Assemblies

Guy assemblies shall be or zinc-coated steel in accordance with ASTM A 475 or KS D 8308. Guy assemblies, including insulators and attachments, shall provide a strength exceeding the required guy strength. Three-eye thimbles shall be provided on anchor rods to permit attachment of individual primary, secondary, and communication down guys. Anchors shall provide adequate strength to support all loads. Guy strand shall be 7 strand. Guy material shall be Class C zinc-coated-steel high-strength with a minimum breaking strength not less than 26.7 kN (6000 pounds) except where two or more guys are used to provide the required strength. Guy rods shall be not less than 2.4 m (8 feet) in length by 25.4 mm (1 inch) in diameter.

2.9 INSULATORS

Insulators shall comply with NEMA HV 2 for general requirements. Suspension insulators shall be used at corners, angles, dead-ends, other areas where line insulators do not provide adequate strength, and as indicated. Mechanical strength of suspension insulators and hardware shall exceed the rated breaking strength of the attached conductors.

2.9.1 Medium-Voltage Line Insulators

Medium-voltage line insulators shall comply with ANSI C29.2, ANSI C29.5, and ANSI C29.6, and as applicable. Ratings shall not be lower than the ANSI classes indicated in TABLE I. Horizontal line-post insulators shall be used for armless construction and shall have the same mechanical and electrical ratings as vertical line-post insulators for the ANSI class indicated, but shall be modified to be suitable for horizontal installation. Where line-post insulators are used for angles greater than 15 degrees, clamp-top fittings shall be provided as well as for other locations shown. Conductor clamps for use with clamp-top, line-post insulators shall be hot-dip galvanized malleable iron for copper conductors and aluminum alloy for aluminum-composition conductors. Either line-post or pin insulators may be used for crossarm construction. Pin insulators for use on voltages in excess of 6 kV phase-to-phase shall be radio-interference-freed or else line-post insulators shall be used.

TABLE I

MINIMUM ANSI RATING OF MEDIUM-VOLTAGE INSULATORS BY CLASS

Voltage Level	Line-Post	Pin	Suspension
Up to 5 kV	57-1 or 11	55-3	One 52-1
	57-1 or 11	55-5	Two 52-1
6 kV to 15 kV	57-1 or 11	55-5	Two 52-2
	57-2 or 12	56-3	Two 52-3 or 4
16 kV to 25 kV	57-2 or 12	56-3	Two 52-3 or 4
	57-3 or 13	56-4	Three 52-3 or 4
26 kV to 35 kV	57-3 or 13	56-4	Three 52-3 or 4
	57-4 or 14	56-5	Four 52-3 or 4

2.9.2 Low-Voltage Line Insulators

Low-voltage line insulators shall comply with ANSI C29.2 and ANSI C29.3 as applicable. Spool insulators for use on low-voltage lines shall be mounted on clevis attachments or secondary racks and shall be not smaller than Class 53-3. For No. 4/0 AWG and larger conductors, Class 53-4 shall be used. Suspension insulators on clevis attachments used at dead-ends shall be not smaller than Class 52-1.

2.9.3 Strain Insulators for Guy Wires

Strain insulators for use in insulated guy assemblies shall comply with ANSI C29.4 for porcelain or equivalent fiberglass, and shall have a mechanical strength exceeding the rated breaking strength of the attached guy wire. Insulators shall be not smaller than Class 54-2 for lines up to 5 kV, not smaller than Class 54-3 for lines of 6 kV to 15 kV, not smaller than Class 54-4 or 54-4 with two in tandem for lines of 16 kV to 25 kV, and not smaller than Class 54-4 with two in tandem for lines of 26 kV to 35 kV.

2.9.4 Apparatus Insulators

Apparatus insulators shall comply with IEEE C57.19.00, IEEE C57.19.01, ANSI C29.8, and ANSI C29.9 as applicable.

2.10 CROSSARM ASSEMBLIES

2.10.1 Crossarms

Crossarms shall be 2.4 m (8 feet) in length, except that 3.1 m (10 foot) crossarms shall be used for crossarm-mounted banked single-phase transformers or elsewhere as indicated. Drilling shall provide required climbing space and wire clearances. Crossarms shall be straight and free of twists to within 2.5 mm per 304.8 mm (1/10 inch per foot) of length. Bend or twist shall be in one direction only.

2.11 AUTOMATIC CIRCUIT RECLOSERS

Automatic circuit reclosers shall comply with IEEE C37.60 and shall be outdoor oil or vacuum type, complete with devices, attachments, and accessories required for installation and operation and shall be suitable for mounting on a single pole. Each recloser shall have continuous current, minimum tripping current, interrupting current, and making current ratings and reclosure times as indicated and shall be rated for the voltage and phase of the system in which it is installed. Three-phase lockout shall be provided on three-phase circuits. Reclosers shall include provisions for a sequence of not less than three automatic reclosing operations unless otherwise noted, followed by lockout if the circuit fault persists, and for manual opening, closing, and lockout by use of a hookstick. Operating sequence shall be adjustable for 1, 2, 3, and 4 operations to lockout and for combinations of instantaneous operations followed by time delay openings to secure coordination with other reclosers and fuses in the medium-voltage distribution system. Reclosers shall automatically reset within a definite time interval after a successful reclosure and shall be supplied with devices needed to provide the necessary operating power. Hydraulically-controlled reclosers shall be provided with tank drains and sampling valves. Surge arrester protection shall be provided. Reclosers shall be equipped with ground fault tripping equipment.

2.12 CAPACITORS

Capacitor equipment shall comply with IEEE Std 18 or KS C 4802 and shall be of the three-phase, grounded-wye, outdoor type rated for continuous operation and automatically switched. Equipment shall be suitable for mounting on a single pole. Polychlorinated biphenyl and tetrachloroethylene (perchloroethylene) shall not be used as the dielectric. Equipment shall be rated for the system voltage. The indicated kvars shall be automatically switched by single-step or multiple-step control providing the indicated number of steps and switching the indicated kvar. Necessary transformers shall be provided for sensing circuit variations and for low-voltage control. Oil-immersed switches shall be provided for automatic switching of capacitors, and shall be electrically separate from ungrounded capacitor enclosures and metal frames. Installations shall include one primary fuse cutout and one surge arrester for each ungrounded phase conductor. Fuse link ratings shall be in accordance with the manufacturer's recommendations. Capacitor equipment, except for low-voltage control and primary fuse cutouts, shall be subassembled and coordinated by one manufacturer. Units, including metal pole-mounting supports and hardware, shall be shipped in complete sections ready for connection at the site. Low-voltage equipment shall be socket or cabinet type, mounted on the pole approximately 1.2 m (4 feet) above grade, shall be connected with the necessary wiring in conduit to capacitor equipment, and shall be provided with secondary arrester protection against switching surges when recommended by the manufacturer.

2.13 FUSES AND SWITCHES, MEDIUM-VOLTAGE

2.13.1 Fuse Cutouts

Medium-voltage fuses and cutouts shall comply with NEMA SG 2 and shall be of the enclosed or open type construction rated 5.2, 7.8, 15, 27, 38 kV and of the extra-heavy-duty type ratings and types indicated. Open-link cut-outs are not acceptable. Fuses shall be either indicating or dropout type. Fuse ratings shall be as indicated. Fuse cutouts shall be equipped with mounting brackets suitable for the indicated installations.

2.13.2 Fused Switches

Fused switches shall be single-pole, manual devices with integral power fuses of the dropout type. Fuse ratings shall be as indicated. Each switch shall have a continuous current rating as shown, a momentary asymmetrical current rating of 20 kA rms as shown and shall be rated for the voltage of the system in which it is installed.

2.13.3 Nonfused Switches

Nonfused switches shall be single-pole, manual devices with a continuous current rating as shown, a momentary asymmetrical current rating of 20 kA rms as shown, and shall be rated for the voltage of the system in which it is installed.

2.13.4 Group-Operated Load Interrupter Switches

2.13.4.1 Manually Operated Type (Switch Handle Operated)

Manually operated (switch handle operated) load interrupter switches shall comply with ANSI C37.32 and shall be of the outdoor, manually-operated, three-pole, single-throw type with either tilting or rotating insulators. Switches shall be equipped with interrupters capable of interrupting currents equal to the switch's continuous current rating. Each switch shall be preassembled for the indicated configuration and mounting. Moving contacts shall be of the high-pressure, limited-area type, designed to ensure continuous surface contact. Switches shall be fused or non-fused as indicated. Switches shall be complete with necessary operating mechanisms, handles, and other items required for manual operation from the ground. Switch operating handles shall be located approximately 1.1 meters (3 feet 6 inches) above final grade. Insulation of switch operating mechanisms shall include both insulated interphase rod sections and insulated vertical shafts. Each handle shall be provided with a padlock arranged to lock the switch in both the open and the closed position.

2.13.4.2 Remotely Operated Type (Stored-Energy Actuator)

Remotely-operated, air-insulated or SF6 insulated load interrupter switches shall be rated in accordance with and comply with the requirements of ANSI C37.32 and shall be of the outdoor, three-pole, pole-mounted or crossarm-mounted type. Interrupter devices shall be air-insulated or SF6-insulated, puffer-type switches capable of interrupting currents equal to the switch continuous current ratings indicated. Switches shall utilize an electric motor-charged, stored-energy (spring-driven) operator to simultaneously trip all phases. A switch-control unit shall be provided for push-button operation from the ground or for push-button operation from the ground and remote switch actuation via telemetry. The switch-control unit shall be pad-lockable, tamper-resistant, in a NEMA ICS 6, Type 4X (minimum) enclosure, which is connected to the switch actuator by a shielded control cable. Control power for closing and tripping shall be provided by a battery mounted in the control unit enclosure. The switch control unit shall be provided with a separate 120 volt ac circuit for the battery powered. Power for charging the operator mechanism may be 120 volt ac or battery powered. If operator mechanism charging power is from a battery, capacity shall be provided for a minimum of four sequential opening and closing operation without battery charging. The switch control unit shall be configured for supervisory, control, and data acquisition (SCADA) function, including local and remote operation. Voltage and current sensors shall be provided, one set for each phase, for monitoring of both normal and fault conditions. Switches shall be provided with visual indication of open switch contact for clearance and isolation purposes. Switch mechanisms shall be provided with provisions for grounding of nonenergized metal parts. The switch control unit shall be provided with a switch operations.

2.13.5 Group Operated Load Interrupter Switches

2.13.5.1 Remotely Operated (Stored-Energy Actuator)

Remotely-operated, group-operated, air insulated load interrupter switches shall comply with ANSI C37.32 and shall be of the outdoor, three-pole, pole or crossarm-mounted type. The electrical ratings of remotely-operated, group-operated, gas-insulated load interrupter switches shall be in accordance with the ratings of ANSI C37.32 and shall be of the outdoor, three-pole, pole-mounted or crossarm-mounted type. Interrupting devices shall be air-insulated switches or SF6 insulated, puffer-type switches capable of interrupting currents equal to the switch continuous ratings indicated.

2.13.5.2 Electric-Motor-Charged (Stored-Energy Actuator)

Switches shall utilize an electric-motor-charged, stored-energy (spring-driven) operator to simultaneously trip all phases. A switch-control unit shall be provided for push-button operation from the ground or for push-button operation from the ground and remote switch actuation via remote telemetry. The switch-control unit shall be pad-locked, tamper-resistant, NEMA ICS 6 type 4X enclosure, which is connected to the switch actuator by a shielded control cable. Control power for closing and tripping shall be provided by a battery mounted in the control unit enclosure. The switch-control unit shall be provided with separate 120 volt ac circuit for the battery charger. Power for charging the operator mechanism, may be 120 V ac power or provided from battery power. If operating mechanism charging power is battery, capacity shall be provided for a minimum of four sequential opening and closing operations, without battery charging. The switch-control unit shall be configured for supervisory control, and data acquisition (SCADA) function, including local and remote operation. Voltage and current sensors shall be provided one set for each phase, for monitoring of both normal and fault conditions. Switches shall be provided with visual indication of open switch contact for clearance and isolation purposes. Switch mechanism shall be provided with provisions for grounding of non-energized metal parts. The switch-control unit shall be provided with a switch operations counter.

2.13.5.3 Pole-Mounted Sectionalizing Switches

Pole-mounted sectionalizing switches shall comply with IEEE C37.63. Sectionalizers shall be coordinated with source side recloser as shown.

2.14 TRANSFORMERS

Transformers shall comply with IEEE C57.12.00 for general requirements and ANSI C57.12.20 for specific requirements for overhead transformers. Overhead distribution transformers shall be of the outdoor type, mineral-oil-insulated or less-flammable liquid-insulated single-phase or three-phase as indicated and have two separate windings per phase. Transformers shall be provided with necessary auxiliary mounting devices suitable for the indicated installation. Transformers shall have two 2-1/2 percent rated kVA high-voltage taps above and below rated primary voltage. Transformer installations shall include one primary fuse cutout and one surge arrester for each ungrounded phase conductor. Self-protected transformers are not acceptable. Transformer tanks shall have a standard gray finish.

2.15 SURGE ARRESTERS

Surge arresters shall comply with NEMA LA 1 and IEEE C62.1, IEEE C62.2, and IEEE C62.11, and shall be provided for protection of aerial-to-underground transitions, automatic circuit reclosers, capacitor equipment, group-operated load-interrupter switches, transformers and other indicated equipment. Arresters shall be distribution class, rated as shown. Arresters for use at elevations in excess of 1.8 km (6000 feet) above mean sea level shall be specifically rated for that purpose. Arresters shall be equipped with mounting brackets suitable for the indicated installations. Arresters shall be of the valve or metal-oxide varistor or combination valve-metal-oxide varistor type suitable for outdoor installations.

2.16 VOLTAGE REGULATOR

Voltage regulators shall comply with IEEE C57.15 and shall be of the outdoor, self-cooled, 55/65 degrees C temperature rise, single-phase type. Windings and the load-tap-changing mechanism shall be mineral-oil-immersed. When operating under load, a regulator shall provide plus and minus 10 percent automatic voltage regulation in approximately 5/8 percent steps, with 16 steps above and 16 steps below rated voltage. Automatic control equipment shall provide Class 1 accuracy. Bypass surge arresters shall be suitable for a grounded system and for the associated regulator voltage. Intermediate class surge arresters shall be mounted next to each incoming line bushing on a regulator tank-mounted bracket and connected to a surge arrester ground pad-mounted on the regulator tank.

2.16.1 Bypass and Isolation Switches

Switches shall be of the outdoor, stickhook-operated, single-pole, single-throw, vertical-break type suitable for the indicated mounting. Switches shall be of a type designed to provide bypass of a single-phase regulator circuit by an integral sequence which always occurs when each switch is opened or closed. Each opening sequence shall initially bypass the single-phase regulator circuit, then open the input and output circuits, and finally interrupt the exciting current. Opening any single-phase regulator circuit shall not be possible until after the bypass circuit is closed. Ratings at 60 Hz shall be in accordance with IEEE C37.41 and as shown.

2.16.2 Miscellaneous

Standard accessories and components in accordance with IEEE C57.15 shall be provided. Single-phase units shall be provided with additional components and accessories required by IEEE C57.15 for three-phase units.

2.17 GROUNDING AND BONDING

2.17.1 Driven Ground Rods

Ground rods shall be of copper-clad steel conforming to UL 467 not less than 19.1 mm (3/4 inch) inch in diameter by 2.4 meter (8 feet) feet in length.

2.17.2 Grounding Conductors

Grounding conductors shall be bare, except where installed in conduit with associated phase conductors. Insulated conductors shall be of the same material as the phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Bare conductors shall be ASTM B 8 soft-drawn unless otherwise indicated. Aluminum is not acceptable.

2.18 PADLOCKS

Padlocks shall comply with Section 08700 “Builders Hardware”.

2.19 WARNING SIGNS

Warning signs shall be porcelain enameled steel or approved equal.

2.20 LIQUID DIELECTRICS

Liquid dielectrics for transformers, capacitors, reclosers, and other liquid-filled electrical equipment shall be non-polychlorinated biphenyl (PCB) mineral-oil or less-flammable liquid as specified. Nonflammable fluids shall not be used. Tetrachloroethylene (perchloroethylene) and 1, 2, 4 tetrachlorobenzene fluids shall not be used. Liquid dielectrics in retrofitted equipment shall be certified by the manufacturer as having less than 2 parts-per-million (ppm) PCB content. In lieu of the manufacturer's certification, the Contractor may submit a test sample of the dielectric in accordance with ASTM D 923 and have tests performed per ASTM D 4059 at a testing facility approved by the Contracting Officer. Equipment with test results indicating PCB level exceeding 2 ppm shall be replaced.

2.21 FACTORY TESTS

Factory tests shall be performed, as follows, in accordance with the applicable publications and with other requirements of these specifications. The Contracting Officer shall be notified at least 10 days before the equipment is ready for testing.

a. Transformers: Manufacturer's standard routine tests in accordance with IEEE C57.12.00.

b. Transformers rated 200 kVA and above: Reduced full-wave, chopped-wave, and full-wave impulse test on each line terminal, in accordance with IEEE C57.98.

c. High-Voltage Air Switches: Manufacturer's standard tests in accordance with IEEE C37.34 and IEEE C37.41.

d. Instrument Current Transformers: Manufacturer's standard tests in accordance with IEEE C57.13.2.

e. Voltage Regulators: Manufacturer's standard tests in accordance with IEEE C57.15.

f. High-Voltage Fuses: Manufacturer's standard tests in accordance with IEEE C37.41.

g. Electric Power Insulators: Manufacturer's standard tests in accordance with ANSI C29.1.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions. Circuits installed in conduits or underground and splices and terminations for medium-voltage cable shall conform to the requirements of Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Secondary circuits installed in conduit on poles shall conform to the requirements of Section 16415 ELECTRICAL WORK, INTERIOR.

3.1.1 Conformance to Codes

The installation shall comply with the requirements and recommendations of IEEE C2 for medium loading districts, Grade B construction. No reduction in clearance shall be made. The installation shall also comply with the applicable parts of NFPA 70.

3.1.2 Verification of Dimensions

The Contractor shall become familiar with details of the work, shall verify dimensions in the field, and shall notify the Contracting Officer of any discrepancy before performing any work.

3.1.3 Tree Trimming

Where lines pass through trees, trees shall be trimmed at least 4.5 m (15 feet) clear on both sides horizontally and below for medium-voltage lines, and 1.5 m (5 feet) clear on both sides horizontally and below for other lines, and no branch shall overhang horizontal clearances. Where trees are indicated to be removed to provide a clear right-of-way, clearing is specified in Section 02230 CLEARING AND GRUBBING.

3.1.4 Disposal of Liquid Dielectrics

PCB-contaminated dielectric shall be marked as PCB and transported to and incinerated by an approved EPA waste disposal facility. The Contractor shall furnish certification of proper disposal. Contaminated dielectric shall not be diluted to lower the level of contamination.

3.2 POLE INSTALLATION

Joint-use electric/roadway-lighting poles for overhead electric and communication lines shall be concrete poles utilizing crossarm construction. Cluster-mounted or Cross-arm mounted banked single-phase transformer installations shall be provided. Crossarm construction shall be provided for support of other equipment, except where direct-pole mounting is indicated. Pole equipment mounts shall be used for steel and concrete poles and may be used for wood poles rather than crossarm equipment mounts. Detail drawings shall be submitted for approval. Provision for communication services is required on pole-line construction, except where specifically noted otherwise. A vertical pole space of not less than 600 mm (2 feet) all locations.

3.2.1 Aluminum, Steel, and Concrete Pole Setting

Poles shall be mounted on cast-in-place or power-installed screw foundations. Concrete poles shall be embedded in accordance with the details shown. Conduit elbows shall be provided for cable entrances into pole interiors.

3.2.1.1 Cast-In-Place Foundations

Concrete foundations, size as indicated, shall have anchor bolts accurately set in foundations using templates supplied by the pole manufacturer. Concrete work and grouting is specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. After the concrete has cured, pole anchor bases shall be set on foundations and leveled by shimming between anchor bases and foundations or by setting anchor bases on leveling nuts and grouting. Poles shall be set plumb. Anchor bolts shall be the manufacturer's standard, and not less than necessary to meet the pole wind loading specified herein and other design requirements.

3.2.1.2 Power-Installed Screw Foundations

Power-installed screw foundations may be used if they have the required strength, mounting-bolt, and top plate dimensions. Screw foundations shall be of at least 6.4 mm (1/4 inch) thick structural steel conforming to ASTM A 36/A 36M and hot-dip galvanized in accordance with ASTM A 123/A 123M or KS D 8308. Conduit slots in screw foundation shafts and top plates shall be marked to indicate orientation. Design calculations indicating adequate strength shall be approved before installation of screw foundation is permitted. Calculations shall be submitted in accordance with the detail drawings portion of paragraph SUBMITTALS.

3.3 CROSSARM MOUNTING

Crossarms shall be bolted to poles with 15.9 mm (5/8 inch) through-bolts with square washers at each end. Bolts shall extend not less than 3 mm (1/8 inch) nor more than 50 mm (2 inches) beyond nuts. On single crossarm construction, the bolt head shall be installed on the crossarm side of the pole. Metal crossarm braces shall be provided on crossarms. Flat braces may be provided for 2.4 m (8 foot) crossarms and shall be 6.4 by 31.8 mm (1/4 by 1-1/4 inches), not less than 700 mm (28 inches) in length. Flat braces shall be bolted to arms with 9.5 mm (3/8 inch) carriage bolts with round or square washers between boltheads and crossarms, and secured to poles with 50.8 by 101.6 mm (1/2 by 4 inch) lag screws after crossarms are leveled and aligned. Angle braces are required for 3.1 m (10 foot) crossarms and shall be 1.5 m (60 inch) span by 457.2 mm (18 inch) drop formed in one piece from 38.1 by 38.1 by 4.8 mm (1-1/2 by 1-1/2 by 3/16 inch) angle. Angle braces shall be bolted to crossarms with 50.8 mm (1/2 inch) bolts with round or square washers between boltheads and crossarms, and secured to poles with 15.9 mm (5/8 inch) through-bolts. Double crossarms shall be securely held in position by means of 15.9 mm (5/8 inch) double-arming bolts. Each double-arming bolt shall be equipped with four nuts and four square washers.

3.3.1 Line Arms and Buck Arms

Line arms and buck arms shall be set at right angles to lines for straight runs and for angles 45 degrees and greater; and line arms shall bisect angles of turns of less than 45 degrees. Dead-end assemblies shall be used for turns where shown. Buckarms shall be installed, as shown, at corners and junction poles. Double crossarms shall be provided at ends of joint use or conflict sections, at dead-ends, and at angles and corners to provide adequate vertical and longitudinal strength. Double crossarms shall be provided at each line-crossing structure and where lines not attached to the same pole cross each other.

3.3.2 Equipment Arms

Equipment arms shall be set parallel or at right angles to lines as required to provide climbing space. Equipment arms shall be located below line construction to provide necessary wire and equipment clearances.

3.4 GUY INSTALLATION

Guys shall be provided where shown, with loads and strengths as indicated, and wherever conductor tensions are not balanced, such as at angles, corners, and dead-ends. Where a single guy will not provide the required strength, two or more guys shall be provided. Where guys are wrapped around poles, at least two guy hooks shall be provided and pole shims shall be provided where guy tension exceeds 27 kN (6000 pounds). Guy clamps 152.4 mm (6 inches) in length with three 15.9 mm (5/8 inch) bolts, or offset-type guy clamps, or approved guy grips shall be provided at each guy terminal. Guy-strain insulators shall be provided in each guy for wood poles. Multiple-helix screw anchors shall be provided in marshy ground; rock anchors shall be installed in rock at right angles to guys, elsewhere anchors shall be of an expanding type, except that power installed screw anchors of equivalent holding power are acceptable. A half-round yellow or gray polyvinyl, fiberglass, or other suitable plastic guy marker, not less than 2.4 m (8 feet) in length, shall be provided at the anchor end of each guy shown, securely clamped to the guy or anchor at the bottom and top of the marker. Holding capacities for down guys shall be based on a lead angle of 45 degrees or as indicated.

3.5 CONDUCTOR INSTALLATION

3.5.1 Line Conductors

Unless otherwise indicated, conductors shall be installed in accordance with manufacturer's approved tables of sags and tensions. Proper care shall be taken in handling and stringing conductors to avoid abrasions, sharp bends, cuts, kinks, or any possibility of damage to insulation or conductors. Conductors shall be paid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Bend radius for any insulated conductor shall not be less than the applicable NEMA specification recommendation. Conductors shall not be drawn over rough or rocky ground, nor around sharp bends. When installed by machine power, conductors shall be drawn from a mounted reel through stringing sheaves in straight lines clear of obstructions. Initial sag and tension shall be checked by the Contractor, in accordance with the manufacturer's approved sag and tension charts, within an elapsed time after installation as recommended by the manufacturer.

3.5.2 Connectors and Splices

Connectors and splices shall be mechanically and electrically secure under tension and shall be of the nonbolted compression type. The tensile strength of any splice shall be not less than the rated breaking strength of the conductor. Splice materials, sleeves, fittings, and connectors shall be noncorrosive and shall not adversely affect conductors. Aluminum-composition conductors shall be wire brushed and an oxide inhibitor applied before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable. Inhibitors and compression tools shall be of types recommended by the connector manufacturer. Primary line apparatus taps shall be by means of hot line clamps attached to compression type bail clamps (stirrups). Low-voltage connectors for copper conductors shall be of the solderless pressure type. Noninsulated connectors shall be smoothly taped to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors. On overhead connections of aluminum and copper, the aluminum shall be installed above the copper.

3.5.3 Conductor-To-Insulator Attachments

Conductors shall be attached to insulators by means of clamps, shoes or tie wires, in accordance with the type of insulator. For insulators requiring conductor tie-wire attachments, tie-wire sizes shall be as indicated in TABLE II.

TABLE II - TIE-WIRE REQUIREMENTS

CONDUCTOR Copper (AWG)	TIE WIRE Soft-Drawn Copper (AWG)
6	8
4 and 2	6
1 through 3/0	4
4/0 and larger	2
AAC, AAAC, or ACSR (AWG)	AAAC OR AAC (AWG)
Any size	6 or 4

3.5.4 Armor Rods

Armor rods shall be provided for AAC, AAAC, and ACSR conductors. Armor rods shall be installed at supports, except armor rods will not be required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used. Lengths and methods of fastening armor rods shall be in accordance with the manufacturer's recommendations. For span lengths of less than 61 m (200 feet), flat aluminum armor rods may be used. Flat armor rods, not less than 762.0 micrometers by 6.4 mm (0.03 by 0.25 inch) shall be used on No. 1 AWG AAC and AAAC and smaller conductors and on No. 5 AWG ACSR and smaller conductors. On larger sizes, flat armor rods shall be not less than 1.3 by 7.6 mm (0.05 by 0.30 inches). For span lengths of 61 m (200 feet) or more, preformed round armor rods shall be used.

3.5.5 Medium-Voltage Insulated Cables

Medium-voltage cable messengers shall be attached to poles with clamps providing a strength exceeding the required messenger strength and with not less than 15.9 mm (5/8 inch) through-bolts. Messengers shall be dead-ended, grounded, line-guyed at corners and dead-ends, and at intervals not exceeding 305 m (1000 feet) along straight runs.

3.5.6 Low-Voltage Insulated Cables

Low-voltage cables shall be supported on clevis fittings using spool insulators. Dead-end clevis fittings and suspension insulators shall be provided where required for adequate strength. Dead-end construction shall provide a strength exceeding the rated breaking strength of the neutral messenger. Clevis attachments shall be provided with not less than 15.9 mm (5/8 inch) through-bolts. Secondary racks may be used when installed on wood poles and where the span length does not exceed 61 m (200 feet). Secondary racks shall be two-, three-, or four-wire, complete with spool insulators. Racks shall meet strength and deflection requirements for heavy-duty steel racks, and shall be either galvanized steel or aluminum alloy. Tops of insulator saddles shall be rounded and smooth to avoid damage to conductor insulation. Each insulator shall be held in place with a 15.9 mm (5/8 inch) button-head bolt equipped with a nonferrous cotter pin, or equivalent, at the bottom. Racks for dead-ending four No. 4/0 AWG or four larger conductors shall be attached to poles with three 15.9 mm (5/8 inch) through-bolts.

Other secondary racks shall be attached to poles with at least two 15.9 mm (5/8 inch) through-bolts. Minimum vertical spacing between conductors shall not be less than 200 mm (8 inches).

3.6 TRANSFORMER INSTALLATION

Transformers shall be carefully installed so as not to scratch finishes or damage bushings. Transformers shall be installed in accordance with the manufacturer's instructions. After installation, surfaces shall be inspected and scratches shall be touched up with a finish provided by the transformer manufacturer for this purpose.

3.7 CONNECTIONS TO UTILITY LINES

The Contractor shall coordinate the work with the Contracting Officer and shall provide for final connections to the installation electric lines.

3.8 CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS

Connections between aerial and underground systems shall be made as shown. Underground cables shall be extended up poles in conduit to cable terminations. Conduits shall be secured to poles by conduit supports spaced not more than 3 m (10 feet) apart and with one support not more than 300 mm (12 inches) from any bend or termination. Cables shall be supported by devices separate from the conduit or guard, near their point of exit from the riser conduit or guard. Cables guards shall be secured in accordance with the manufacturers published procedure. Risers shall be equipped with bushings to protect cables. Capnut potheads shall be used to terminate medium-voltage multiple-conductor cable.

3.9 CONNECTIONS TO BUILDINGS

3.9.1 Aerial Services

Connections to buildings shall be made at approximately the point indicated and shall be connected to the service entrance conductors. Supports at buildings shall be adequate to withstand required pulls; supports shall not be rated less than 4450 N (1000 pounds). Drip loops shall be formed on conductors at entrances to buildings, cabinets, or conduits. Service-entrance conduits with termination fittings and conductors within the building, including sufficient slack for connection to aerial service cables, shall conform to the requirements of Section 16415 ELECTRICAL WORK, INTERIOR.

3.9.2 Underground Services

Connections to buildings shall be made at the point indicated and shall be terminated at the service entrance equipment terminals. Cable pulling shall be in accordance with Section 16375, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Service entrance conduits with termination fittings and conductors within the building shall conform to the requirements of Section 16415 ELECTRICAL WORK, INTERIOR.

3.10 GROUNDING

Noncurrent-carrying metal parts of equipment and conductor assemblies, such as luminaires, medium-voltage cable terminations and messengers, metal poles, operating mechanisms of pole top switches, panel enclosures, transformers, capacitors, recloser frames (cases) and other noncurrent-carrying metal items shall be grounded. Additional grounding of equipment, neutral, and surge arrester grounding systems shall be installed at poles where indicated.

3.10.1 Grounding Electrodes

Grounding electrodes shall be installed as follows:

a. Driven rod electrodes - Unless otherwise indicated, ground rods shall be located approximately 900 mm (3 feet) out from base of the pole and shall be driven into the earth until the tops of the rods are approximately 300 mm (1 foot) below finished grade. Multiple rods shall be evenly spaced at least 3 m (10 feet) apart and connected together 600 mm (2 feet) below grade with a minimum No. 6 AWG bare copper conductor.

b. Pole butt electrodes - Pole butt electrodes shall be installed where indicated, except that this method shall not be the sole grounding electrode at transformer locations. The pole butt electrode shall consist of a coil of at least 4 m (12 feet) of minimum No. 6 AWG bare copper conductor stapled to the butt of the pole.

c. Plate electrodes - Plate electrodes shall be installed in accordance with the manufacturer's instructions and IEEE C2 and NFPA 70.

d. Ground Resistance - The maximum resistance of a driven ground rod shall not exceed 25 ohms under normally dry conditions. Whenever the required ground resistance is not met, provide additional electrodes interconnected with grounding conductors, to achieve the specified ground resistance. The additional electrodes will be up to three rods spaced a minimum of 3 m (10 feet) apart or a single extension-type rod 19.1 mm (3/4 inch) diameter, up to 9.1 m (30 feet) long, driven perpendicular to grade and coupled and driven with the first rod. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately. Connections below grade shall be fusion welded. Connections above grade shall be fusion welded or shall use UL 467 approved connectors.

3.10.2 Grounding and Bonding Connections

Connections above grade shall be made by the fusion-welding process or with bolted solderless connectors in compliance with UL 467, and those below grade shall be made by a fusion-welding process. Where grounding conductors are connected to aluminum-composition conductors, specially treated or lined copper-to-aluminum connectors suitable for this purpose shall be used.

3.10.3 Grounding Electrode Conductors

On multi-grounded circuits, as defined in IEEE C2, provide a single continuous vertical grounding electrode conductor. Neutrals, surge arresters, and equipment grounding conductors shall be bonded to this conductor. For single grounded or ungrounded systems, provide a grounding conductor for the surge arrester and equipment grounding conductors and a separate grounding conductor for the secondary neutrals. Grounding electrode conductors shall be sized as shown. Secondary system neutral conductors shall be connected directly to the transformer neutral bushings, then connected with a neutral bonding jumper between the transformer neutral bushing and the vertical grounding electrode conductor, as shown. Grounding electrode conductors shall be stapled to wood poles at intervals not exceeding 600 mm 2 feet). On metal poles, a preformed galvanized steel strap, 15.9 mm (5/8 inch) wide by 0.853 (22 gauge) minimum by length, secured by a preformed locking method standard with the manufacturer, shall be used to support a grounding electrode conductor installation on the pole and spaced at intervals not exceeding 1.5 m (5 feet) with one band not more than 75 mm (3 inches) from each end of the vertical grounding electrode conductor. Bends greater than 45 degrees in grounding electrode conductor are not permitted.

3.11 FIELD TESTING

3.11.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 7 days prior to conducting tests. The Contractor shall furnish materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field reports will be signed and dated by the Contractor.

3.11.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.11.3 Ground-Resistance Tests

The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE Std 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes shall be provided.

3.11.4 Medium-Voltage Preassembled Cable Test

After installation, prior to connection to an existing system, and before the operating test, the medium-voltage preassembled cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors at one terminal and connecting grounds or metallic shieldings or sheaths of the cable at the other terminal for each test. Prior to the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 7 or NEMA WC 8 for the particular type of cable installed, and shall not exceed the recommendations of IEEE Std 404 for cable joints unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor shall make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

3.11.5 Sag and Tension Test

The Contracting Officer shall be given prior notice of the time schedule for stringing conductors or cables serving overhead medium-voltage circuits and reserves the right to witness the procedures used for ascertaining that initial stringing sags and tensions are in compliance with requirements for the applicable loading district and cable weight.

3.11.6 Low-Voltage Cable Test

For underground secondary or service laterals from overhead lines, the low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations of conductors in the same trench, duct, or cable, with other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

R in megohms = (rated voltage in kV + 1) x 304,800/(length of cable in meters)

R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet)

Each cable failing this test shall be repaired or replaced. The repaired cable shall then be retested until failures have been eliminated.

3.11.7 Liquid-Filled Transformer Tests

The following field tests shall be performed on liquid-filled transformers 225 kVA and above. Pass-fail criteria shall be in accordance with the transformer manufacturer's specifications.

a. Insulation resistance test phase-to-ground.

b. Turns ratio test.

c. Correct phase sequence.

3.11.8 Pre-Energization Services

The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to insure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment and to ensure that packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided, but are not limited to, are the following:

Automatic circuit reclosers.

Capacitors.

Switches.

Transformers.

3.11.9 Operating Tests

After the installation is completed, and at such time as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the specified requirements. An operating test report shall be submitted in accordance with paragraph SUBMITTALS.

3.12 MANUFACTURER'S FIELD SERVICE

3.12.1 Onsite Training

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instruction shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations. A VHS format video tape of the entire training session shall be submitted.

3.13 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

SECTION 16375

ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.4	(1984; R 1996) Mechanical Demand Registers
ANSI C12.10	(1997) Electromechanical Watthour Meters
ANSI C12.11	(1987; R 1993) Instrument Transformers for Revenue metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)
ANSI C29.1	(1988; R 1996) Electrical Power Insulators - Test Methods
ANSI C37.16	(2000) Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations
ANSI C37.46	(1981; R 1992) Power Fuses and Fuse Disconnecting Switches
ANSI C37.50	(1989; R 1995) Switchgear, Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures
ANSI C37.72	(1987) Manually-Operated Dead-Front, Padmounted Switchgear with Load-Interrupting Switches and Separable Connectors for Alternating-Current Systems
ANSI C37.121	(1989; R 1995) Switchgear, Unit Substations Requirements
ANSI C57.12.13	(1982) Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations
ANSI C57.12.21	(1995) Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with High-Voltage Bushings; (High-Voltage, 34 500 Grd Y/19 920 Volts and Below; Low-Voltage, 240/120; 167 kVA and Smaller)
ANSI C57.12.26	(1993) Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors, High-Voltage, 34 500 Grd Y/19 920 Volts and Below; 2500 kVa and Smaller
ANSI C57.12.27	(1982) Conformance Requirements for Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations
ANSI C57.12.28	(1999) Switchgear and Transformers - Padmounted Equipment - Enclosure Integrity
ANSI C80.1	(1995) Rigid Steel Conduit - Zinc Coated
ANSI C119.1	(1986; R 1997) Sealed Insulated Underground Connector Systems Rated 600 Volts

ANSI C135.30	(1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction
ANSI O5.1	(1992) Specifications and Dimensions for Wood Poles

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 48	(1994ae1) Gray Iron Castings
ASTM A 48M	(1994ae1) Gray Iron Castings (Metric)
ASTM A 123/A 123M	(2001) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2001) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM B 3	(1995) Soft or Annealed Copper Wire
ASTM B 8	(1999) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM B 231/B 231M	(1999) Concentric-Lay-Stranded Aluminum 1350 Conductors
ASTM B 400	(1994) Compact Round Concentric-Lay-Stranded Aluminum 1350 Conductors
ASTM B 496	(1999) Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM B 609/B 609M	(1999) Standard Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes
ASTM B 800	(2000) 8000 Series Aluminum Alloy Wire for Electrical Purposes-Annealed and Intermediate Tempers
ASTM B 801	(1999) Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation
ASTM C 478	(1997) Precast Reinforced Concrete Manhole Sections
ASTM C 478M	(1997) Precast Reinforced Concrete Manhole Sections (Metric)
ASTM D 923	(1997) Sampling Electrical Insulating Liquids
ASTM D 1654	(1992) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 2472	(2000) Sulfur Hexafluoride
ASTM D 4059	(1996) Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS5	(1994; CS5a-1995) Cross-linked Polyethylene Insulated Shielded Power Cables Rated 5 Through 46 kV
AEIC CS6	(1996) Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 Through 69 kV

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P7825a	(1998) Approval Guide Fire Protection

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2002) National Electrical Safety Code
IEEE C37.1	(1994) IEEE Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automatic Control
IEEE C37.2	(1996) Electrical Power System Device Function Numbers and Contact Designations
IEEE C37.13	(1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.20.1	(1993) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C37.20.2	(1993; C37.20.2b) Metal-Clad and Station-Type Cubicle Switchgear
IEEE C37.20.3	(1997) Metal-Enclosed Interrupter Switchgear
IEEE C37.23	(1987; R 1991) Guide for Metal-Enclosed Bus and Calculating Losses in Isolated-Phase Bus
IEEE C37.30	(1997)Requirements for High-Voltage Switches
IEEE C37.34	(1994) Test Code for High-Voltage Air Switches
IEEE C37.41	(1994; C37.41c) Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories
IEEE C37.63	(1997) Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizer for AC Systems
IEEE C37.90	(1989; R 1994) Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C37.90.1	(1989; R 1994) IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems
IEEE C37.98	(1987; R 1991) Seismic Testing of Relays

IEEE C57.12.00	(1993) IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(1993) Instrument Transformers
IEEE C57.98	(1993) Guide for Transformer Impulse Tests
IEEE C62.1	(1989; R 1994) Surge Arresters for AC Power Circuits
IEEE C62.2	(1987; R 1994) Guide for the Application of Gapped Silicon-Carbide Surge Arresters for Alternating Current Systems
IEEE C62.11	(1999) IEEE Standard Metal-Oxide Surge Arresters for AC Power Circuits
IEEE Std 48	(1998) Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)
IEEE Std 100	(1997) IEEE Standard Dictionary of Electrical and Electronics Terms
IEEE Std 242	(1986; R 1991) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
IEEE Std 386	(1995) Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE Std 399	(1997) Recommended Practice for Industrial and Commercial Power Systems Analysis
IEEE Std 404	(1993) Cable Joints for Use with Extruded Dielectric Cable Rated 5000 V through 138 000 V and Cable Joints for Use with Laminated Dielectric Cable Rated 2500 V Through 500 000 V
IEEE Std 592	(1990; R 1996) Exposed Semiconducting Shields on Premolded High Voltage Cable Joints and Separable Insulated Connectors

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA AB 3	(2001) Molded Case Circuit Breakers and Their Application
NEMA BU 1	(1994) Busways
NEMA FB 1	(1993) Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
NEMA FU 1	(1986) Low Voltage Cartridge Fuses
NEMA LA 1	(1992) Surge Arresters
NEMA PB 1	(1995) Panelboards

NEMA PB 2	(1995) Deadfront Distribution Switchboards
NEMA SG 2	(1993) High Voltage Fuses
NEMA SG 3	(1995) Power Switching Equipment
NEMA SG 5	(1995) Power Switchgear Assemblies
NEMA TC 5	(1990) Corrugated Polyolefin Coilable Plastic Utilities Duct
NEMA TC 6	(1990) PVC and ABS Plastic Utilities Duct for Underground Installation
NEMA TC 7	(1990) Smooth-Wall Coilable Polyethylene Electrical Plastic Duct
NEMA WC 7	(1988; Rev 3 1996) Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
NEMA WC 8	(1988; Rev 3; 1996) Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2002) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 6	(1997) Rigid Metal Conduit
UL 198C	(1986; Rev thru Feb 1998) High-Interrupting-Capacity Fuses, Current-Limiting Types
UL 198D	(1995) Class K Fuses
UL 198E	(1988; Rev Jul 1988) Class R Fuses
UL 198H	(1988; Rev thru Nov 1993) Class T Fuses
UL 467	(1993; Rev thru Apr 1999) Grounding and Bonding Equipment
UL 486A	(1997; Rev thru Dec 1998) Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL 486B	(1997; Rev Jun 1997) Wire Connectors for Use with Aluminum Conductors
UL 489	(1996; Rev thru Dec 1998) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 510	(1994; Rev thru Apr 1998) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape

UL 514A	(1996; Rev Dec 1999) Metallic Outlet Boxes
UL 651	(1995; Rev thru Oct 1998) Schedule 40 and 80 Rigid PVC Conduit
UL 854	(1996; Rev Oct 1999) Service-Entrance Cables
UL 857	(1994; Rev thru Dec 1999) Busways and Associated Fittings
UL 1072	(1995; Rev Mar 1998) Medium Voltage Power Cable
UL 1242	(1996; Rev Mar 1998) Intermediate Metal Conduit
UL 1684	(2000) Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

KOREAN INDUSTRIAL STANDARDS (KS)

KS C 3101	(1995) Copper Wire, Electrical, Solid, Softdrawn
KS C 3102	(1998) Copper Wire, Electrical, Solid, Harddrawn
KS C 3103	(1986) Copper Wire, Electrical, Stranded, Softdrawn
KS C 3104	(1996) Copper Wire, Electrical, Stranded, Harddrawn
KS C 3131	(2002) High Voltage Cross Linked Polyethylene Insulate Cable
KS C 3302	(1990) 600V PVC Insulated Wire, IV
KS C 3313	(2002) OW Wire
KS C 3315	(2002) DV Wire
KS C 3323	(1999) 600V PVC Insulated and Sheathed Cable, VV
KS C 3328	(2002) 600V PVC Insulated and Sheathed Cable, HIV
KS C 8401	(1997) Rigid Steel Conduit
KS C 8431	(2001) Unplasticized Polyvinyl Chloride (UPVC) Conduit
KS C 8460	(2001) Bushing, Saddles, Locknuts, Couplings, Insulated Bushings for Rigid Metal Conduit
KS C 8461	(1997) Universal Fittings, Terminal Caps, Surface Switch Boxes, Circular Surface Boxes For Rigid Metal Conduit
KS D 8308	(2001) Zinc Coating (Hot Dipped) on Iron and Steel
KS D 9502	(1992) Salt Spray Test

1.2 RELATED REQUIREMENTS

Section 16050, "Basic Electrical Materials and Methods," applies to this section with the additions and modifications specified herein.

1.3 TERMINOLOGY

Terminology used in this specification is as defined in IEEE Std 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Electrical Distribution System;

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams, manufacturers standard installation drawings and other information necessary to define the installation and enable the Government to check conformity with the requirements of the contract drawings.

If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures shall be included with the detail drawings. Approved departures shall be made at no additional cost to the Government.

Detail drawings shall show how components are assembled, function together and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall consist of the following:

a. Detail drawings showing physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. All optional items shall be clearly identified as included or excluded.

b. Internal wiring diagrams of equipment showing wiring as actually provided for this project. External wiring connections shall be clearly identified.

Detail drawings shall as a minimum depict the installation of the following items:

a. Medium-voltage cables and accessories including cable installation plan.

b. Transformers.

c. Substations.

d. Switchgear.

e. Pad-mounted loadbreak switches.

f. Busways.

g. Surge arresters.

As-Built Drawings; G

The as-built drawings shall be a record of the construction as installed. The drawings shall include the information shown on the contract drawings as well as deviations, modifications, and changes from the contract drawings, however minor. The as-built drawings shall be a full sized set of prints marked to reflect deviations, modifications, and changes. The as-built drawings shall be complete and show the location, size, dimensions, part identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall provide three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within 10 calendar days from the time the drawings are returned to the Contractor.

SD-03 Product Data

Fault Current Analysis; G
Protective Device; G
Coordination Study; G

The study shall be submitted with protective device equipment submittals. No time extension or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Nameplates; G

Catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Material and Equipment; G

A complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include an item number, the quantity of items proposed, and the name of the manufacturer of each such item.

General Installation Requirements;

As a minimum, installation procedures for transformers, substations, switchgear, and medium-voltage cable terminations and splices.

Procedures shall include cable pulling plans, diagrams, instructions, and precautions required to install, adjust, calibrate, and test the devices and equipment.

SD-06 Test Reports

Factory Tests; G

Certified factory test reports shall be submitted when the manufacturer performs routine factory tests, including tests required by standards listed in paragraph REFERENCES. Results of factory tests performed shall be certified by the manufacturer, or an approved testing laboratory, and submitted within 7 days following successful completion of the tests. The manufacturer's pass-fail criteria for tests specified in paragraph FIELD TESTING shall be included.

Field Testing; G

A proposed field test plan, 20 days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Operating Tests; G

Six copies of the information described below in 215.9 by 279.4 mm (8-1/2 by 11 inch) binders having a minimum of three rings, including a separate section for each test. Heavy plastic dividers with tabs shall separate sections.

a. A list of equipment used, with calibration certifications.

b. A copy of measurements taken.

c. The dates of testing.

d. The equipment and values to be verified.

e. The condition specified for the test.

f. The test results, signed and dated.

g. A description of adjustments made.

Cable Installation; G

Six copies of the information described below in 215.9 by 279.4 mm (8-1/2 by 11 inch) binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Heavy plastic dividers with tabs shall separate sections, with all data sheets signed and dated by the person supervising the pull.

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

d. The dates of cable pulls, time of day, and ambient temperature.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Material and Equipment; G

Where materials or equipment are specified to conform to the standards of the Underwriters Laboratories (UL) or to be constructed or tested, or both, in accordance with the standards of the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), or the National Electrical Manufacturers Association (NEMA), or Korean Standards (KS) the Contractor shall submit proof that the items provided conform to such requirements. The label of, or listing by, UL will be acceptable as evidence that the items conform. Either a certification or a published catalog specification data statement, to the effect that the item is in accordance with the referenced ANSI or IEEE standard, will be acceptable as evidence that the item conforms. A similar certification or published catalog specification data statement to the effect that the item is in accordance with the referenced NEMA standard, by a company listed as a member company of NEMA, will be acceptable as evidence that the item conforms. In lieu of such certification or published data, the Contractor may submit a certificate from a recognized testing agency equipped and competent to perform such services, stating that the items have been tested and that they conform to the requirements listed, including methods of testing of the specified agencies. Compliance with above-named requirements does not relieve the Contractor from compliance with any other requirements of the specifications.

Cable Joints; G

A certification that contains the names and the qualifications of people recommended to perform the splicing and termination of medium-voltage cables approved for installation under this contract. The certification shall indicate that any person recommended to perform actual splicing and terminations has been adequately trained in the proper techniques and have had at least three recent years of experience in splicing and terminating the same or similar types of cables approved for installation. In addition, any person recommended by the Contractor may be required to perform a practice splice and termination, in the presence of the Contracting Officer, before being approved as a qualified installer of medium-voltage cables. If that additional requirement is imposed, the Contractor shall provide short sections of the approved types of cables along with the approved type of splice and termination kits, and detailed manufacturer's instruction for the proper splicing and termination of the approved cable types.

Cable Installer Qualifications; G

The Contractor shall provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. A resume shall be provided showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers.

SD-10 Operation and Maintenance Data

Electrical Distribution System; G

Six copies of operation and maintenance manuals, within 7 calendar days following the completion of tests and including assembly, installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked. Manuals shall also include data outlining detailed procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective action to be taken. A brief description of all equipment, basic operating features, and routine maintenance requirements shall also be included. Documents shall be bound in a binder marked or identified on the spine and front cover. A table of contents page shall be included and marked with pertinent contract information and contents of the manual. Tabs shall be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare parts data. Index sheets shall be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers.

Three additional copies of the instructions manual shall be provided within 30 calendar days following the manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Oil filled transformers and switches shall be stored in accordance with the manufacturer's requirements. Metal poles shall be handled and stored in accordance with the manufacturer's instructions.

1.6 EXTRA MATERIALS

One additional spare fuse or fuse element for each furnished fuse or fuse element shall be delivered to the contracting officer when the electrical system is accepted. Two complete sets of all special tools required for maintenance shall be provided, complete with a suitable tool box. Special tools are those that only the manufacturer provides, for special purposes (to access compartments, or operate, adjust, or maintain special parts.

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.2 NAMEPLATES

2.2.1 General

Each major component of this specification shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a nameplate securely attached to the equipment. Nameplates shall be made of noncorrosive metal. Equipment containing liquid dielectrics shall have the type of dielectric on the nameplate. Sectionalizer switch nameplates shall have a schematic with all switch positions shown and labeled. As a minimum, nameplates shall be provided for transformers, circuit breakers, meters, switches, and switchgear.

2.2.2 Liquid-Filled Transformer Nameplates

Power transformers shall be provided with nameplate information in accordance with IEEE C57.12.00. Nameplates shall indicate the number of liters gallons and composition of liquid-dielectric, and shall be permanently marked with a statement that the transformer dielectric to be supplied is non-polychlorinated biphenyl. If transformer nameplate is not so marked, the Contractor shall furnish manufacturer's certification for each transformer that the dielectric is non-PCB classified, with less than 2 ppm PCB content in accordance with paragraph LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the 2 ppm PCB content or transformers without certification will be considered as PCB insulated and will not be accepted.

2.3 CORROSION PROTECTION

2.3.1 Aluminum Materials

Aluminum shall not be used in contact with earth or concrete. Where aluminum conductors are connected to dissimilar metal, fittings conforming to UL 486B shall be used.

2.3.2 Ferrous Metal Materials

2.3.2.1 Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M and ASTM A 123/A 123M or KS D 8308.

2.3.2.2 Equipment

Equipment and component items, including but not limited to transformer stations and ferrous metal luminaries not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM B 117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm (1/16 inch) from the test mark. The scribed test mark and test evaluation shall be in accordance with ASTM D 1654 with a rating of not less than 7 in accordance with TABLE 1, procedure A. Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

2.3.3 Finishing

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be as specified in Section 09900 PAINTING, GENERAL.

2.4 CABLES

Cables shall be single conductor type unless otherwise indicated.

2.4.1 Medium-Voltage Cables

2.4.1.1 General

Cable construction shall be conforming to NFPA 70 and UL 1072. Cables shall be manufactured for use in duct or direct burial applications.

2.4.1.3 Ratings

Cables shall be rated for a circuit voltage as indicated.

2.4.1.4 Conductor Material

Underground cables shall be soft drawn copper complying with ASTM B 3 and ASTM B 8 for regular concentric and compressed stranding or ASTM B 496 for compact stranding.

2.4.1.5 Insulation

Cable insulation shall be cross-linked thermosetting polyethylene (XLP) insulation conforming to the requirements of NEMA WC 7 and AEIC CS5 or ethylene-propylene-rubber (EPR) insulation conforming to the requirements of NEMA WC 8 and AEIC CS6. A 133 percent insulation level shall be used on 5 kV, 15 kV and 25 kV rated cables.

2.4.1.6 Shielding

Cables rated for 2 kV and above shall have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper shield for each phase.

2.4.1.6 Neutrals

Neutral conductors shall be of copper, employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable.

2.4.1.7 Jackets

Cables shall be provided with a nonmetallic jacket. Direct buried cables shall be rated for direct burial.

2.4.2 Low-Voltage Cables

Cables shall be rated 600 volts and shall conform to the requirements of NFPA 70, and must be UL listed for the application or meet the applicable section of either ICEA or NEMA standards.

2.4.2.1 Conductor Material

Underground cables shall be annealed copper complying with ASTM B 3 and ASTM B 8. Intermixing of copper and aluminum conductors is not permitted.

2.4.2.2 Insulation

Insulation must be in accordance with NFPA 70, and must be UL listed for the application or meet the applicable sections of either ICEA, or NEMA standards.

2.4.2.3 Jackets

Multiconductor cables shall have an overall nonmetallic outer jacket.

2.4.2.4 Direct Buried

Single and multi-conductor cables shall be of a type identified for direct burial. Service entrance cables shall conform to UL 854 for Type USE service entrance cable.

2.4.2.5 In Duct

Cables shall be single-conductor cable, in accordance with NFPA 70. Cables in factory-installed, coilable-plastic-duct assemblies shall conform to NEMA TC 5 or NEMA TC 7.

2.5 CABLE JOINTS, TERMINATIONS, AND CONNECTORS

2.5.1 Medium-Voltage Cable Joints

Medium-voltage cable joints shall comply with IEEE Std 404 and IEEE Std 592. Medium-voltage cable terminations shall comply with IEEE Std 48. Joints shall be the standard products of a manufacturer and shall be either of the factory preformed type or of the kit type containing tapes and other required parts. Joints shall have ratings not less than the ratings of the cables on which they are installed. Splice kits may be of the heat-shrinkable type for voltages up to 15 kV, of the premolded splice and connector type, the conventional taped type, or the resin pressure-filled overcast taped type for voltages up to 35 kV; except that for voltages of 7.5 kV or less a resin pressure-filled type utilizing a plastic-tape mold is acceptable. Joints used in manholes, handholes, vaults and pull boxes shall be certified by the manufacturer for waterproof, submersible applications.

2.5.2 Medium-Voltage Separable Insulated Connectors

Separable insulated connectors shall comply with IEEE Std 386 and IEEE Std 592 and shall be of suitable construction or standard splice kits shall be used. Separable insulated connectors are acceptable for voltages up to 35 kV. Connectors shall be of the loadbreak type as indicated, of suitable construction for the application and the type of cable connected, and shall include cable shield adaptors. Separable insulated connectors shall not be used as substitutes for conventional permanent splices. External clamping points and test points shall be provided.

2.5.3 Low-Voltage Cable Splices

Low-voltage cable splices and terminations shall be rated at not less than 600 Volts. Splices in conductors No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A. Splices in conductors No. 8 AWG and larger shall be made with noninsulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A and UL 486B. Splices shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket. Splices below grade or in wet locations shall be sealed type conforming to ANSI C119.1 or shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

2.5.4 Terminations

Terminations shall be in accordance with IEEE Std 48, Class 1 or Class 2; of the molded elastomer, wet-process porcelain, prestretched elastomer, heat-shrinkable elastomer, or taped type. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations shall be of the outdoor type, except that where installed inside outdoor equipment housings which are sealed against normal infiltration of moisture and outside air, indoor, Class 2 terminations are acceptable. Class 3 terminations are not acceptable. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, and armor.

2.5.4.1 Factory Preformed Type

Molded elastomer, wet-process porcelain, prestretched, and heat-shrinkable terminations shall utilize factory preformed components to the maximum extent practicable rather than tape build-up. Terminations shall have basic impulse levels as required for the system voltage level. Leakage distances shall comply with wet withstand voltage test requirements of IEEE Std 48 for the next higher Basic Insulation Level (BIL) level. Anti-tracking tape shall be applied over exposed insulation of preformed molded elastomer terminations.

2.5.4.2 Taped Terminations

Taped terminations shall use standard termination kits providing terminal connectors, field-fabricated stress cones, and rain hoods. Terminations shall be at least 315 mm long from the end of the tapered cable jacket to the start of the terminal connector, or not less than the kit manufacturer's recommendations, whichever is greater.

2.6 CONDUIT AND DUCTS

Ducts shall be single, round-bore type, with wall thickness and fittings suitable for the application. Duct lines shall be the type as shown between manholes and for other medium-voltage lines. Communication lines run elsewhere may be direct-burial, thick-wall type. Where concrete encasement is not required, low-voltage circuits may utilize factory-installed cable in coilable plastic duct.

2.6.1 Metallic Conduit

Rigid galvanized steel conduit shall comply with UL 6 and ANSI C80.1 or KS C 8401. Metallic conduit fittings and outlets shall comply with UL 514A and NEMA FB 1.

2.6.2 Nonmetallic Ducts

2.6.2.1 Bituminized Fiber Duct

UL 1684 for Type I (Thinwall) or Type II (Thickwall).

2.6.2.2 Concrete Encased Ducts

UL 651 Schedule 40 or NEMA TC 6 Type EB.

2.6.2.3 Direct Burial

UL 651, Schedule 40 and Schedule 80 as indicated, or NEMA TC 6 Type DB.

2.6.3 Conduit Sealing Compound

Compounds for sealing ducts and conduit shall have a putty-like consistency workable with the hands at temperatures as low as 2 degrees C (35 degrees F), shall neither slump at a temperature of 150 degrees C (300 degrees F), nor harden materially when exposed to the air. Compounds shall adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds shall form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect upon the hands of workmen or upon materials.

2.7 MANHOLES, HANDHOLES, AND PULLBOXES

Manholes, handholes, and pullboxes shall be as indicated. Strength of manholes, handholes, and pullboxes and their frames and covers shall conform to the requirements of IEEE C2. Precast-concrete manholes shall have the required strength established by ASTM C 478, ASTM C 478M. Frames and covers shall be made of gray cast iron and a machine-finished seat shall be provided to ensure a matching joint between frame and cover. Cast iron shall comply with ASTM A 48M ASTM A 48, Class 30B, minimum. Handholes for low voltage cables installed in parking lots, sidewalks, and turfed areas shall be fabricated from an aggregate consisting of sand and with continuous woven glass strands having an overall compressive strength of at least 69 MPa (10,000 psi) and a flexural strength of at least 34.5 MPa (5000 psi). Pullbox and handhole covers in sidewalks, and turfed areas shall be of the same material as the box. Concrete pullboxes shall consist of precast reinforced concrete boxes, extensions, bases, and covers.

2.8 POLES AND HARDWARE

Poles and hardware shall be in accordance with Section 16370 ELECTRICAL DISTRIBUTION SYSTEM, AERIAL.

2.9 TRANSFORMERS, SUBSTATIONS, AND SWITCHGEAR

Transformers, substations, and switchgear shall be of the outdoor type having the ratings and arrangements indicated. Medium-voltage ratings of cable terminations shall be as indicated kV between phases for 133 percent insulation level.

2.9.1 Secondary Unit Substation

Secondary unit substations shall comply with ANSI C37.121 and shall be of the radial type with an outgoing section mounted integrally on the transformer. Stations shall be subassembled and coordinated by one manufacturer and shall be shipped in complete sections ready for connection at the site. Complete sections shall include incoming, transformer, and outgoing sections and, where practicable, shall be shipped as one unit.

2.9.1.1 Incoming Section

Metal-enclosed interrupter switchgear consisting of fused or air-insulated or vacuum-insulated or SF6-insulated interrupters in series with automatic, visible blade disconnects shall be provided for protection of incoming circuits. SF6 gas shall conform to ASTM D 2472. Metal-enclosed interrupter switchgear shall comply with IEEE C37.30 for load-interrupter switches, NEMA SG 2 for power fuses, and shall be of the outdoor no-aisle type that meets or exceeds the requirements of applicable publications listed. Switch construction shall be of the manually-operated, "OPEN-CLOSED" air-insulated or vacuum-insulated or SF6-insulated load interrupter type equipped with a stored energy operator for quick-make quick-break to make operating speeds independent of manual switch operations. Where indicated, suitable bus or lug connections shall be provided to mount field-installed, slip-on, medium-voltage cable terminations for cable entering via conduit from below and a flanged throat suitable for direct connection to the associated transformer and a bus throat suitable for connection to the associated metal-enclosed bus. Surge protection shall be provided in accordance with paragraph SURGE ARRESTERS. Switches shall be of the 2-position type, open-closed. Selector switches shall be of the single-compartment, 3-position type, Line 1 - Open - Line 2, consisting of an interrupter switch in series with a selector switch. Duplex switches shall be of the dual compartment type with 2 interrupter switches.

a. Ratings. Fuse continuous current ratings shall be as indicated for the transformer for an incoming line unit and for the line tie unit. Unless otherwise indicated, fuses shall be of the current limiting type. Switch ratings at 60 Hz shall be as indicated.

b. Basic Requirements. The electrical devices listed below shall be rated for the application and voltage and current indicated. Unless otherwise noted, manufacturer's standard devices shall be provided and shall include the following:

(1) A switch-operating handle with provisions for locking in either the open or closed position.

(2) A switch mechanical position indicator.

(3) A heater continuously energized to prevent condensation over an ambient temperature range of minus 29 degrees C (minus 20 degrees F) to 40 degrees C (104 degrees F) at 90% relative humidity and wired in series with a cabinet door-actuated switch, so the heater is de-energized when doors are open. High-temperature thermal protection shall be included.

(4) One-pole or 2-pole thermal-magnetic, molded-case circuit breakers suitable for the operating voltage for heater circuits.

(5) Safety devices as necessary to ensure that the load interrupter switch is in the open position whenever unit doors are in the open position.

(6) A key interlock if indicated.

(7) An interface terminal block wired for required exterior connections.

2.9.1.3 Transformer Section

Transformers shall have two separate windings per phase and shall be of the mineral oil-insulated or less-flammable, liquid-insulated type with high molecular-weight hydrocarbon or dimethyl silicone liquid. Transformers shall be suitable for outdoor use. Liquid-insulated transformers shall comply with IEEE C57.12.00, ANSI C57.12.13, and ANSI C57.12.27, and shall have two 2-1/2 percent full capacity taps above and two 2-1/2 percent full capacity taps below rated voltage. Transformers shall be of the sealed tank type construction with welded-on cover. High-voltage terminals shall be provided in an air terminal chamber for incoming top or bottom entry cables for direct connection to the incoming line section or as shown on the drawings. Low-voltage terminals shall be provided in an air terminal chamber for incoming top or bottom] entry cables for direct connection to the outgoing switchgear section or bus duct or as shown on the drawings. Low-voltage terminals shall be on the left or right or as shown on the drawings when facing the front, accessory side of the transformer. Transformers shall be equipped with forced air cooling equipment to give indicated kVA capacity. The equipment shall include the necessary fans, conduit and wiring, motor starters, and top liquid thermometer for fan control. Provision shall be made for the future addition of forced air cooling equipment to give indicated kVA capacity. The transformer bushings, leads, and other components shall be designed to carry the increased load. A top liquid thermometer for control of future fans shall be furnished. Provision for future mounting of fans, conduit, and terminal box shall be provided. Transformer accessories and ratings at 60 Hz shall be indicated as follows:

a. Drain and filter connection.

b. Filling and top filter press connection.

c. Pressure-vacuum gauge.

d. Dial type thermometer with alarm contacts.

e. Magnetic liquid level indicator with high and low level alarm contacts.

f. Pressure relief device with alarm contacts.

g. Ground connection pad.

h. Provision for jacking, lifting, and towing.

i. Diagram and rating nameplate.

2.9.1.4 Integral Outgoing Section

Integral outgoing section shall be of the busway throat compartment or dead-front distribution panelboard/switchboard or metal-enclosed switchgear type. Each circuit breaker and auxiliary compartment shall have a suitable metal or laminated plastic nameplate with white cut letters at least 6.4 mm (1/4 inch) high on contrasting backgrounds identifying the breaker unit and/or circuit number as shown on the drawings.

a. Busway Throat Compartment Type: Outgoing section shall consist of an enclosure containing metering devices on the main secondary circuit and connections from transformer terminals to suitable busway throats provided for connections to busway installations entering from above or as shown. Connection to porcelain bushings shall be made with flexible jumpers.

b. Dead-Front Distribution Panelboard/Switchboard Type: Outgoing section shall be of the panelboard/switchboard type mounted integrally with the transformer and shall consist of metering devices and main and branch circuit breakers mounted in panelboard/switchboard enclosures. Panelboards shall comply with NEMA PB 1. Switchboards shall comply with NEMA PB 2. Molded-case and low-voltage power circuit breakers shall comply with paragraph METERING AND PROTECTIVE DEVICES. Plug-in type circuit breakers are not acceptable. Directories to indicate loads served by each circuit shall be typed and mounted in holders provided on panelboard doors behind protective coverings.

c. Metal-Enclosed Switchgear Type: Outgoing section shall be of the metal-enclosed drawout circuit breaker type, in accordance with IEEE C37.20.1 and NEMA SG 5. Low-voltage power circuit breakers shall comply with the requirements of paragraph METERING AND PROTECTIVE DEVICES.

d. Metering: The main secondary bus of each outgoing section assembly shall include a watthour demand meter with the necessary instrument transformers, and VT and CT test blocks. Metering shall be as specified in paragraph METERING AND PROTECTIVE DEVICES.

e. Ground Fault Protection: Ground fault protection shall be provided utilizing sensors of the zero-sequence type or by the residual connection of phase and neutral current sensors. Ground fault settings shall be as shown or as determined by the coordination study.

2.9.1.5 Nonintegral (Cable Compartment) Outgoing Section

A cable compartment shall be provided on the transformer for cable connections as shown. Clamp type terminations for cables entering from below or above shall be provided for connection to the transformer bushings. Clamp type cable terminations, suitable for copper conductors, shall be provided for the circuit sizes shown and to match circuit breakers.

2.9.2 Pad-Mounted Transformers

Pad-mounted transformers shall comply with ANSI C57.12.26 and shall be of the radial type. Pad-mounted transformer stations shall be assembled and coordinated by one manufacturer and each transformer station shall be shipped as a complete unit so that field installation requirements are limited to mounting each unit on a concrete pad and connecting it to primary and secondary lines. Stainless steel pins and hinges shall be provided. Barriers shall be provided between high- and low-voltage compartments. High-voltage compartment doors shall be interlocked with low-voltage compartment doors to prevent access to any high-voltage section unless its associated low-voltage section door has first been opened. Compartments shall be sized to meet the specific dimensional requirements of ANSI C57.12.26. Pentahead locking bolts shall be provided with provisions for a padlock.

2.9.2.1 High-Voltage Compartments

The high-voltage compartment shall be dead-front construction. Primary switching and protective devices shall include loadbreak switching, drawout, dry-well-mounted, current-limiting fuses, medium-voltage separable loadbreak connectors, universal bushing wells and inserts or integral one piece bushings and surge arresters. Fuses shall comply with the requirements of paragraph METERING AND PROTECTIVE DEVICES. The switch shall be mounted inside transformer tank with switch operating handle located in high-voltage compartment and equipped with metal loop for hook stick operation. Fuses shall be interlocked with switches so that fuses can be removed only when the associated switch is in the "OPEN" position. Adjacent to medium-voltage cable connections, a nameplate or equivalent stencilled inscription shall be provided inscribed "DO NOT OPEN CABLE CONNECTORS UNLESS SWITCH IS OPEN." Surge arresters shall be fully insulated and configured to terminate on the same bushing as the primary cable by means of a loadbreak, feed-through bushing insert.

2.9.2.2 Transformer Tank Sections

Transformers shall comply with IEEE C57.12.00, ANSI C57.12.21, and ANSI C57.12.26 and shall be of the mineral oil-insulated type or less-flammable, liquid-insulated type with high molecular-weight hydrocarbon or dimethyl silicone liquid. Transformers shall be suitable for outdoor use and shall have 2 separate windings per phase. Standard NEMA primary taps shall be provided. Where primary taps are not specified, 4, 2-1/2 percent of rated KVA, High-voltage taps shall be provided 2 above and 2 below rated primary voltage. Operating handles for primary tap changers for de-energized operation shall be located within high-voltage compartments, externally to transformer tanks. Adjacent to the tap changer operating handle, a nameplate or equivalent stenciled inscription shall be provided and inscribed "DO NOT OPERATE UNDER LOAD." Transformer ratings at 60 Hz shall be as shown.

2.9.2.3 Low-Voltage Cable Compartments

Neutrals shall be provided with fully-insulated bushings. Clamp type cable terminations, suitable for copper conductors entering from below, shall be provided as necessary.

2.9.2.4 Accessories

High-voltage warning signs shall be permanently attached to each side of transformer stations. Voltage warning signs shall comply with IEEE C2. Copper-faced steel or stainless steel ground connection pads shall be provided in both the high- and low-voltage compartments. Dial-type thermometer, liquid-level gauge, and drain valve with built-in sampling device shall be provided for each transformer station. Insulated-bushing-type parking stands shall be provided adjacent to each separable load-break elbow to provide for cable isolation during sectionalizing operations.

2.9.3 Busways

Busways shall comply with NEMA BU 1 and UL 857 and shall be of the voltage, phase, and continuous current ratings indicated. Neutrals shall be full sized. Busways shall have short-circuit ratings not less than the maximum short-circuit currents of associated transformers, assuming primary sources of infinite capacity. Busways shall be feeder-low-impedance type and of outdoor or indoor service construction as suitable to the location. Busways shall be complete with elbows, fittings, flanges, end-closures, tees, crosses, cable-tap boxes, accessories, and other devices required for the indicated installation, and shall be coordinated for connection to the indicated equipment. For wet/damp locations, bus duct shall be heated, nonventilated enclosure, nonsegregated phase type in accordance with IEEE C37.23. Detail drawings for busway supports and bracing shall be submitted in accordance with the detail drawings portion of paragraph SUBMITTALS.

2.9.4 Pad-Mounted, Metal-Enclosed, Switchgear

The switchgear shall be configured with 2 incoming compartments for loop-feed arrangement or one incoming compartment for radial-feed, equipped with air-insulated, load-interrupter switches or oil-insulated, load-interrupter switches or SF6-insulated, load-interrupter switches, as indicated. The outgoing compartments shall be provided with fused disconnect or non-reclosing vacuum-type interrupters or circuit breakers, as indicated.

2.9.4.1 Operators, Devices, and Controls

Operators and controls shall be provided for the switchgear as follows:

a. Switches shall be provided with a manual, handle-type operator or a push-button mechanical spring tripping mechanism, utilizing a stored-energy (spring-driven) mechanism to simultaneously open or close all phases. The switchgear shall be configured so that the switch actuator is padlockable, but may be accessed without opening the switch compartment doors.

b. Fused disconnects shall be hook-stick operated.

c. Switches shall be provided with an automatic switch operator configured for local and remote opening and closing. An actuator charging motor shall be provide which operates at 12 V dc or 24 V dc or 120 V ac. Switches shall be provided with remote telemetry units (RTUs) for remote operation and integration with supervisory, control, and data acquisition systems. Systems, components, and equipment shall conform to the requirements and recommendations of IEEE C37.1.

d. Vacuum type interrupters shall be provided with an electronic controller for trip initiation. Manual trip initiation shall be provided by a push button or switch. Automatic trip shall be initiated by detection of excessive current. The electronic controller shall provide trip current selection capability according to present time-current response curves, as indicated. Each interrupter shall be provided with a 3 phase, gang-operated handle mechanism for trip and reset.

2.9.4.2 Enclosures

Switchgear enclosures shall be of freestanding, self-supporting construction provided with separate incoming and outgoing compartments configured for bottom cable entry. Enclosures shall be of deadfront construction, provided with a hinged door for access to each compartment, and conform to the requirements of ANSI C57.12.28, ANSI C37.72, and IEEE C37.20.3, Category A.

2.9.5 Pad-Mounted Sectionalizers

Pad-mounted, sectionalizing switches shall conform to the requirements of IEEE C37.63. The switchgear shall be configured with 2 incoming compartments for loop-feed arrangement or one incoming compartment for radial-feed equipped with air-insulated, load-interrupter switches or oil-insulated, load-interrupters switches or SF6-insulated load-interrupter switches or as indicated. The outgoing compartments shall be provided with non-reclosing sectionalizers.

2.9.5.1 Enclosures

Switchgear enclosures shall be of freestanding, self-supporting construction provided with separate incoming and outgoing compartments configured for bottom cable entry. Enclosures shall be of deadfront construction, provided with a hinged door for access to each compartment, and conform to the requirements of ANSI C57.12.28, ANSI C37.72, and IEEE C37.20.3, Category A.

2.9.6 Cable Terminating Cabinets

Cable terminating cabinets shall be hook-stick operable, deadfront construction conforming to the requirements of IEEE C37.20.3, Category A. Cabinets shall be provided with 200 A. loadbreak junctions and elbow-type separable loadbreak connectors, cable parking stands, and grounding lugs or with 600 A. dead-break junctions and elbow-type separable dead-break connectors, cable parking stands, and grounding lugs. The cable terminating equipment shall conform to IEEE Std 386. Ratings at 60 Hz shall be as shown.

2.10 METERING AND PROTECTIVE DEVICES

2.10.1 Circuit Breakers, Low-Voltage

2.10.1.1 Low-Voltage Power Circuit Breakers

a. Construction: Low-voltage power circuit breakers shall conform to IEEE C37.13, ANSI C37.16, and NEMA SG 3 and shall be three-pole, single-throw, stored energy, manually or electrically operated, with drawout mounting. Solid-state trip elements which require no external power connections shall be provided. Circuit breakers shall have an open/close contact indicator, primary disconnect devices, and a mechanical interlock to prevent making or breaking contact of primary disconnection when the circuit breaker is closed. Control voltage shall be as indicated. The circuit breaker enclosure shall be suitable for its intended location.

b. Ratings: Voltage ratings shall be not less than the applicable circuit voltage. Circuit breakers shall be rated for 100 percent continuous duty and shall have trip current ratings and frame sizes as shown. Nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings shall be in accordance with ANSI C37.16. Tripping features shall be as follows:

1. Long-time current pick-up, adjustable from 50 percent to 100 percent of sensor current rating.

2. Adjustable long-time delay.

3. Short-time current pick-up, adjustable from 1.6 to 9 times long-time current setting.

4. Adjustable short-time delay.

5. Short-time I^2t switch.

6. Instantaneous current pick-up, adjustable from 1.6 to 9 times long-time current setting.

7. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted.

8. Fixed or Adjustable ground-fault delay.

9. Ground-fault I^2t switch.

10. Overload and short-circuit and ground-fault trip indicators shall be provided.

2.10.1.3 Molded-Case Circuit Breakers

NEMA AB 3 and UL 489.

2.10.2 Fuses, Medium-Voltage, Including Current-Limiting

2.10.2.1 Construction

Units shall be suitable for outdoor use. Fuses shall have integral blown-fuse indicators. All ratings shall be clearly visible.

2.10.2.2 Ratings

Expulsion-type or Current-limiting power fuses shall have ratings in accordance with ANSI C37.46.

2.10.2.3 E-Rated, Current-Limiting Power Fuses

E-rated, current-limiting, power fuses shall conform to ANSI C37.46.

2.10.2.4 C-Rated, Current-Limiting Power Fuses

C-rated, current-limiting power fuses shall open in 1000 seconds at currents between 170 and 240 percent of the C rating.

2.10.3 Fuses, Low-Voltage, Including Current-Limiting

Low-voltage fuses shall conform to NEMA FU 1. Time delay and nontime delay options shall be as shown or specified. Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilizes fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current characteristics required for effective power system coordination.

2.10.3.1 Transformer Circuit Fuses

Transformer circuit fuses shall be Class RK1 or RK5, current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.10.4 Instrument Transformers

2.10.4.1 General

Instrument transformers shall comply with ANSI C12.11 and IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on drawings.

2.10.4.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. Other thermal and mechanical ratings of current transformers and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accident open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

2.10.4.3 Current Transformers for Power Transformers

Single-ratio or Multi-ratio bushing type current transformers shall be provided internally around power transformer bushings as shown. Single-ratio units shall have a minimum relaying accuracy class of 0.6B-0.5.

2.10.4.4 Current Transformers for Metal-Enclosed Switchgear

Single-ratio units, used for metering and relaying, shall have a metering accuracy class rating of B. Single-ratio units, used only for relaying, shall have a relaying accuracy class rating of either C or T classification.

2.10.4.5 Current Transformers for Kwh and Demand Metering (Low-Voltage)

Current transformers shall conform to IEEE C57.13.

2.10.4.6 Voltage Transformers

Voltage transformers shall have indicated ratios. Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.10.5 Watthour Meters

Watthour meters shall conform to ANSI C12.10, except numbered terminal wiring sequence and case size may be the manufacturer's standard. Watthour meters shall be of the drawout switchboard type or socket mounted outdoor or indoor type having a 15 minute, cumulative form, demand register meeting ANSI C12.4 and provided with not less than 2-1/2 stators. Watthour demand meters shall have factory-installed electronic pulse initiators. Pulse initiators shall be solid-state devices incorporating light-emitting diodes, phototransistors, and power transistors, except that mercury-wetted output contacts are acceptable. Initiators shall be totally contained within watthour demand meter enclosures, shall be capable of operating up to speeds of 500 pulses per minute with no false pulses, and shall require no field adjustments. Initiators shall be calibrated for a pulse rate output of 1 pulse per 1/4 disc revolution of the associated meter and shall be compatible with the indicated equipment.

2.10.6 Protective Relaying

2.10.6.1 General

Solid-state or Microprocessor-based protective relays shall be provided as shown and shall be of a type specifically designed for use on power switchgear or associated electric power apparatus. Protective relays shall conform to IEEE C37.90. Relays and auxiliaries shall be suitable for operation with the instrument transformer ratios and connections provided.

2.10.6.2 Construction

Relays shall be dustproof and moisture resistant. Necessary test devices shall be incorporated within each relay and shall provide a means for testing either from an external source of electric power or from associated instrument transformers. Each relay shall be provided with an operation indicator and an external target reset device. Relays shall have necessary auxiliaries for proper operation. Relays and auxiliaries shall be suitable for operation with the instrument transformer ratios and connections provided.

2.10.6.3 Ratings

Relays shall be the manufacturer's standard items of equipment with appropriate ranges for time dial, tap, and other settings. Relay device numbers shall correspond to the function names and descriptions of IEEE C37.2.

2.11 SURGE ARRESTERS

Surge arresters shall comply with NEMA LA 1, IEEE C62.1, IEEE C62.2, and IEEE C62.11 and shall be provided where indicated. Arresters shall be station class, rated as shown. Arresters for use at elevations in excess of 1.8 km (6000 feet) above mean sea level shall be specifically rated for that purpose. Arresters shall be equipped with mounting brackets suitable for the indicated installations. Arresters shall be of the valve or metal-oxide varistor or combination valve-metal-oxide varistor type.

2.12 GROUNDING AND BONDING

2.12.1 Driven Ground Rods

Ground rods shall be copper-clad steel conforming to UL 467 not less than 19 mm (3/4 inch) in diameter by 2.44 m (8 feet) in length. Sectional type rods may be used.

2.12.2 Grounding Conductors

Grounding conductors shall be bare, except where installed in conduit with associated phase conductors. Insulated conductors shall be of the same material as phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Bare conductors shall be ASTM B 8 soft-drawn unless otherwise indicated. Aluminum is not acceptable.

2.13 CONCRETE AND REINFORCEMENT

Concrete work shall have minimum 20 MPa (3000 psi) compressive strength and conform to the requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Concrete reinforcing shall be as specified in Section 03200 CONCRETE REINFORCEMENT.

2.14 PADLOCKS

Padlocks shall comply with Section 08700 BUILDERS HARDWARE.

2.15 CABLE FIREPROOFING SYSTEMS

Cable fireproofing systems shall be listed in FM P7825a as a fire-protective coating or tape approved for grouped electrical conductors and shall be suitable for application on the type of medium-voltage cables provided. After being fully cured, materials shall be suitable for use where exposed to oil, water, gases, salt water, sewage, and fungus and shall not damage cable jackets or insulation. Asbestos materials are not acceptable.

2.15.1 Fireproof Coating

Cable fireproofing coatings shall be compounded of water-based thermoplastic resins, flame-retardant chemicals, and inorganic noncombustible fibers and shall be suitable for the application methods used. Coatings applied on bundled cables shall have a derating factor of less than 5 percent, and a dielectric strength of 95 volts per mil minimum after curing.

2.15.2 Fireproofing Tape

Fireproofing tape shall be at least 50 mm (2 inches) wide and shall be a flexible, conformable, polymeric, elastomer tape designed specifically for fireproofing cables.

2.15.3 Plastic Tape

Preapplication plastic tape shall be pressure sensitive, 0.254 mm (10 mil) thick, conforming to UL 510.

2.16 LIQUID DIELECTRICS

Liquid dielectrics for transformers, capacitors, reclosers, and other liquid-filled electrical equipment shall be non-polychlorinated biphenyl (PCB) mineral-oil or less-flammable liquid as specified. Nonflammable fluids shall not be used. Tetrachloroethylene (perchloroethylene) and 1, 2, 4 trichlorobenzene fluids shall not be used. Liquid dielectrics in retrofitted equipment shall be certified by the manufacturer as having less than 2 parts per million (ppm) PCB content. In lieu of the manufacturer's certification, the Contractor may submit a test sample of the dielectric in accordance with ASTM D 923 and have tests performed per ASTM D 4059 at a testing facility approved by the Contracting Officer. Equipment with test results indicating PCB level exceeding 2 ppm shall be replaced.

2.17 FACTORY TESTS

Factory tests shall be performed, as follows, in accordance with the applicable publications and with other requirements of these specifications. The Contracting Officer shall be notified at least 10 days before the equipment is ready for testing. The Contracting Officer reserves the right to witness the tests.

a. Transformers: Manufacturer's standard tests in accordance with IEEE C57.12.00.

b. Transformers rated 200 kVA and above: Reduced full-wave, chopped-wave, and full-wave impulse test on each line and neutral terminal, in accordance with IEEE C57.98.

c. High-Voltage Air Switches: Manufacturer's standard tests in accordance with IEEE C37.34 and IEEE C37.41.

d. Protective Relays: Seismic tests in accordance with IEEE C37.98. Surge withstand tests in accordance with IEEE C37.90.1.

e. Relaying Current Transformers: Manufacturer's standard tests in accordance with IEEE C57.13.

f. Instrument Current Transformers: Manufacturer's standard tests in accordance with IEEE C57.13.

g. Factory Preformed Terminations: Wet withstand voltage tests in accordance with IEEE Std 48 for the next higher BIL level.

h. Outdoor Switchgear: Manufacturer's standard tests in accordance with IEEE C37.20.1, IEEE C37.20.2, and IEEE C37.20.3.

i. Electrical Power Insulators: Manufacturer's standard tests in accordance with ANSI C29.1.

2.18 FENCING

Fencing shall conform to the requirements of Section 02831 CHAIN LINK FENCE.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions. Circuits installed aerially shall conform to the requirements of Section 16370 ELECTRICAL DISTRIBUTION SYSTEM, AERIAL. Steel conduits installed underground shall be installed and protected from corrosion in conformance with the requirements of Section 16415 ELECTRICAL WORK, INTERIOR. Except as covered herein, excavation, trenching, and backfilling shall conform to the requirements of Section 02316 EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS. Concrete work shall have minimum 20 MPa (3000 psi) compressive strength and conform to the requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.1.1 Conformance to Codes

The installation shall comply with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable.

3.1.3 Verification of Dimensions

The Contractor shall become familiar with details of the work, shall verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

3.1.4 Disposal of Liquid Dielectrics

PCB-contaminated dielectrics must be marked as PCB and transported to and incinerated by an approved EPA waste disposal facility. The Contractor shall furnish certification of proper disposal. Contaminated dielectrics shall not be diluted to lower the contamination level.

3.2 CABLE AND BUSWAY INSTALLATION

The Contractor shall obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, etc. The Contractor shall then prepare a checklist of significant requirements and perform pulling calculations and prepare a pulling plan which shall be submitted along with the manufacturers instructions in accordance with SUBMITTALS.

3.2.1 Cable Installation Plan and Procedure

Cable shall be installed strictly in accordance with the cable manufacturer's recommendations. Each circuit shall be identified by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag shall contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

3.2.1.1 Cable Inspection

The cable reel shall be inspected for correct storage positions, signs of physical damage, and broken end seals. If end seal is broken, moisture shall be removed from cable in accordance with the cable manufacturer's recommendations.

3.2.1.3 Duct Cleaning

Duct shall be cleaned with an assembly that consists of a flexible mandrel (manufacturers standard product in lengths recommended for the specific size and type of duct) that is 6.4 mm (1/4 inch) less than inside diameter of duct, 2 wire brushes, and a rag. The cleaning assembly shall be pulled through conduit a minimum of 2 times or until less than a volume of 131 cubic centimeters (8 cubic inches) of debris is expelled from the duct.

3.2.1.4 Duct Lubrication

The cable lubricant shall be compatible with the cable jacket for cable that is being installed. Application of lubricant shall be in accordance with lubricant manufacturer's recommendations.

3.2.1.5 Cable Installation

The Contractor shall provide a cable feeding truck and a cable pulling winch as required. The Contractor shall provide a pulling grip or pulling eye in accordance with cable manufacturer's recommendations. The pulling grip or pulling eye apparatus shall be attached to polypropylene or manilla rope followed by lubricant front end packs and then by power cables. A dynamometer shall be used to monitor pulling tension. Pulling tension shall not exceed cable manufacturer's recommendations. The Contractor shall not allow cables to cross over while cables are being fed into duct. For cable installation in cold weather, cables shall be kept at 10 degrees C (50 degrees F) temperature for at least 24 hours before installation.

3.2.1.6 Cable Installation Plan

The Contractor shall submit a cable installation plan for all cable pulls in accordance with the detail drawings portion of paragraph SUBMITTALS. Cable installation plan shall include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall thrust pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

3.2.2 Duct Line

Cables shall be installed in duct lines where indicated. Cable splices in low-voltage cables shall be made in manholes and handholes only, except as otherwise noted. Cable joints in medium-voltage cables shall be made in manholes or approved pullboxes only. Neutral and grounding conductors shall be installed in the same duct with their associated phase conductors.

3.2.3 Direct-Burial

Cables shall be buried directly in the earth as indicated. Minimum cover from the top of a cable to finished grade shall be as shown, but not less than the depth of the frost line.

3.2.3.1 Trenching

Trenches for direct-burial cables shall be excavated to depths required to provide the minimum necessary cable cover. Bottoms of trenches shall be smooth and free of stones and sharp objects. Where bottoms of trenches comprise materials other than sand, a 75 mm (3 inches) layer of sand shall be laid first and compacted to approximate densities of surrounding firm soil.

3.2.3.2 Cable Burial

Cables shall be unreeled along the sides of or in trenches and carefully placed on sand or earth bottoms. Pulling cables into direct-burial trenches from a fixed reel position will not be permitted, except as required to pull cables through conduits under paving or railroad tracks. Where cables cross, a separation of at least 75 mm (3 inches) shall be provided, unless each cable circuit is protected by a nonmetallic conduit sleeve at the crossing. Where single-conductor cable is installed, all 3 phases and the neutral shall be installed in the same sleeve. Bend radius of any cable shall be not less than 12 times the diameter of the cable. In no case shall cables be left under longitudinal tension. The first 150 mm (6 inches) layer of backfill shall be of sand. Machine compaction shall not be used within 150 mm (6 inches) of the cable.

3.2.3.3 Other Requirements

Where direct-burial cables cross under roads or other paving exceeding 1.6 m (5 feet) in width, such cables shall be installed in concrete-encased ducts. Where direct-burial cables cross under railroad tracks, such cables shall be installed in reinforced concrete-encased ducts. Ducts shall extend at least 300 mm (1 foot) beyond each edge of any paving and at least 1.6 m (5 feet) beyond each side of any railroad tracks. Cables may be pulled into duct from a fixed reel where suitable rollers are provided in the trench. Where direct burial cable transitions to duct-enclosed cable, direct-burial cables shall be centered in duct entrances, and a waterproof nonhardening mastic compound shall be used to facilitate such centering. If paving or railroad tracks are in place where cables are to be installed, coated rigid steel conduits driven under the paving or railroad tracks may be used in lieu of concrete-encased ducts. Damage to conduit coatings shall be prevented by providing ferrous pipe jackets or by predrilling. Where cuts are made in any paving, the paving and subbase shall be restored to their original condition.

3.2.3.4 Medium-Voltage Cable Joints or Low-Voltage Cable Splices

Cable joints or splices in direct-burial cables are not permitted in runs of 305 m (1000 feet) or less, nor at intervals of less than 305 m (1000 feet) in longer runs, except as required for taps. Locations of cable joints or splices in shorter intervals, where required to avoid obstructions or damage to cables, shall be approved. Cable joints or splices in direct burial installations shall be installed in above-ground junction boxes or in cast metal splice boxes suitable for direct burial use. Cable joints or splices in duct banks shall be made only in manholes, handholes, or pullboxes.

3.2.3.5 Cable Markers

Markers shall be located near the ends of cable runs, at each cable joint or splice, at approximately every 150 m (500 feet) along cable runs, and at changes in direction of cable runs. In addition to markers, a 0.127 mm (5 mil) brightly colored plastic tape not less than 75 mm (3 inches) in width and suitably inscribed at not more than 3 m (10 feet) on centers, or other approved dig-in warning indication, shall be placed approximately 300 mm (12 inches) below finished grade levels of trenches.

3.2.4 Insect and Rodent Damage

Animal guards shall be installed as shown.

3.2.5 Electric Manholes

Cables shall be routed around the interior walls and securely supported from walls on cables racks. Cable routing shall minimize cable crossover, provide access space for maintenance and installation of additional cables, and maintain cable separation in accordance with IEEE C2.

3.2.6 Busway Installation

Busways penetrating walls shall have wall flanges installed on both surfaces of walls. Wall openings shall be approximately 6.4 mm (1/4 inch) larger than the busway on each of the 4 busway sides, and openings shall be sealed with a suitable compound. Fire barriers shall be provided when penetrating fire rated walls. Fire barriers shall have a rating equal to the fire wall rating. A weather barrier shall be used when a busway penetrates an exterior wall. Busways shall be supported at intervals not exceeding 3 m (10 feet) and shall be braced to prevent lateral movement.

3.3 CABLE JOINTS

Medium-voltage cable joints shall be made by qualified cable splicers only. Qualifications of cable splicers shall be submitted in accordance with paragraph SUBMITTALS. Shields shall be applied as required to continue the shielding system through each entire cable joint. Shields may be integrally molded parts of preformed joints. Shields shall be grounded at each joint or in accordance with manufacturer's recommended practice. Cable joints shall provide insulation and jacket equivalent to that of the associated cable. Armored cable joints shall be enclosed in compound-filled, cast-iron or alloy, splice boxes equipped with stuffing boxes and armor clamps of a suitable type and size for the cable being installed.

3.4 FIREPROOFING

Each medium-voltage cable and conductor in manholes shall be fire-proofed for their entire length within the manhole. Where cables and conductors have been lubricated to enhance pulling into ducts, the lubricant shall be removed from cables and conductors exposed in the manhole before fireproofing. Fire-stops shall be installed in each conduit entering or leaving a manhole.

3.4.1 Tape Method

Before application of fireproofing tape, plastic tape wrapping shall be applied over exposed metallic items such as the cable ground wire, metallic outer covering, or armor to minimize the possibility of corrosion from the fireproofing materials and moisture. Before applying fireproofing tape, irregularities of cables, such as at cable joints, shall be evened out with insulation putty. A flexible conformable polymeric elastomer fireproof tape shall be wrapped tightly around each cable spirally in 1/2 lapped wrapping or in 2 butt-jointed wrappings with the second wrapping covering the joints of the first.

3.4.2 Sprayable Method

Manholes shall be power ventilated until coatings are dry and dewatered and the coatings are cured. Ventilation requirements shall be in accordance with the manufacturer's instruction, but not less than 10 air changes per hour shall be provided. Cable coatings shall be applied by spray, brush, or glove to a wet film thickness that reduces to the dry film thickness approved for fireproofing by FM P7825a. Application methods and necessary safety precautions shall be in accordance with the manufacturers instructions. After application, cable coatings shall be dry to the touch in 1 to 2 hours and fully cured in 48 hours, except where the manufacturer has stated that because of unusual humidity or temperature, longer periods may be necessary.

3.5 DUCT LINES

3.5.1 Requirements

Numbers and sizes of ducts shall be as indicated. Duct lines shall be laid with a minimum slope of 100 mm per 30 m (4 inches per 100 feet). Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be 450 mm (18 inches) for ducts of less than 80 mm (3 inch) diameter, and 900 mm (36 inches) for ducts 80 mm (3 inches) or greater in diameter. Otherwise, long sweep bends having a minimum radius of 7.6 m (25 feet) shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever duct lines terminate in manholes or handholes.

3.5.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer shall be used whenever an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.5.3 Concrete Encasement

Ducts requiring concrete encasements shall comply with NFPA 70, except that electrical duct bank configurations for ducts 150 mm (6 inches) in diameter shall be determined by calculation and as shown on the drawings. The separation between adjacent electric power and communication ducts shall conform to IEEE C2. Duct line encasements shall be monolithic construction. Where a connection is made to a previously poured encasement, the new encasement shall be well bonded or doweled to the existing encasement. The Contractor shall submit proposed bonding method for approval in accordance with the detail drawing portion of paragraph SUBMITTALS. At any point, except railroad and airfield crossings, tops of concrete encasements shall be not less than the cover requirements listed in NFPA 70. At railroad and airfield crossings, duct lines shall be encased with concrete and reinforced as indicated to withstand specified surface loadings. Tops of concrete encasements shall be not less than 1.6 m (5 feet) below tops of rails or airfield paving unless otherwise indicated. Where ducts are jacked under existing pavement, rigid steel conduit will be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 15 m (50 feet) in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 1.3 m (4 feet) on centers. Ducts shall be securely anchored to prevent movement during the placement of concrete and joints shall be staggered at least 150 mm (6 inches) vertically.

3.5.4 Nonencased Direct-Burial

Top of duct lines shall be below the frost line depth below finished grade and shall be installed with a minimum of 75 mm (3 inches) of earth around each duct, except that between adjacent electric power and communication ducts, 300 mm (12 inches) of earth is required. Bottoms of trenches shall be graded toward manholes or handholes and shall be smooth and free of stones, soft spots, and sharp objects. Where bottoms of trenches comprise materials other than sand, a 75 mm (3 inch) layer of sand shall be laid first and compacted to approximate densities of surrounding firm soil before installing ducts. Joints in adjacent tiers of duct shall be vertically staggered at least1 50 mm. (6 inches). The first 150 mm (6 inch) layer of backfill cover shall be sand compacted as previously specified. The rest of the excavation shall be backfilled and compacted in 75 to 150 mm to (6 inch) layers. Duct banks may be held in alignment with earth. However, high-tiered banks shall use a wooden frame or equivalent form to hold ducts in alignment prior to backfilling.

3.5.5 Installation of Couplings

Joints in each type of duct shall be made up in accordance with the manufacturer's recommendations for the particular type of duct and coupling selected and as approved.

3.5.5.1 Bituminized-Fiber Ducts

Bituminized-fiber ducts shall be used to interface with existing bituminized-fiber duct as shown. To ensure a watertight joint, tapered ends or joints of the same material as the ducts shall be swabbed with bituminous or joint-sealing compound before couplings are applied. Plastic or nonmetallic couplings shall be tightly driven onto unswabbed ducts. Due to the brittleness of plastic couplings at low temperatures, such couplings shall not be installed when temperatures are below minus 18 degrees C (0 degrees F). Couplings shall be warmed in hot water or by another approved method when installed at temperatures below 0 degrees C (32 degrees F).

3.5.5.2 Plastic Duct

Duct joints shall be made by brushing a plastic solvent cement on insides of plastic coupling fittings and on outsides of duct ends. Each duct and fitting shall then be slipped together with a quick 1/4-turn twist to set the joint tightly.

3.5.6 Duct Line Markers

Duct line markers shall be provided at the ends of long duct line stubouts or for other ducts whose locations are indeterminate because of duct curvature or terminations at completely below-grade structures. In addition to markers, a 0.127 mm (5 mil) brightly colored plastic tape, not less than 75 mm (3 inches) in width and suitably inscribed at not more than 3 m (10 feet) on centers with a continuous metallic backing and a corrosion-resistant 0.0254 mm (1 mil) metallic foil core to permit easy location of the duct line, shall be placed approximately 300 mm (12 inches) below finished grade levels of such lines.

3.6 MANHOLES, HANDHOLES, AND PULLBOXES

3.6.1 General

Manholes shall be constructed approximately where shown. The exact location of each manhole shall be determined after careful consideration has been given to the location of other utilities, grading, and paving. The location of each manhole shall be approved by the Contracting Officer before construction of the manhole is started. Manholes shall be the type noted on the drawings and shall be constructed in accordance with the applicable details as indicated. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. The Contractor may at his option utilize monolithically constructed precast-concrete manholes having the required strength and inside dimensions as required by the drawings or specifications. In paved areas, frames and covers for manhole and handhole entrances in vehicular traffic areas shall be flush with the finished surface of the paving. In unpaved areas, the top of manhole covers shall be approximately 15 mm (1/2 inch) above the finished grade. Where existing grades that are higher than finished grades are encountered, concrete assemblies designed for the purpose shall be installed to elevate temporarily the manhole cover to existing grade level. All duct lines entering manholes must be installed on compact soil or otherwise supported when entering a manhole to prevent shear stress on the duct at the point of entrance to the manhole. Duct lines entering cast-in-place concrete manholes shall be cast in-place with the manhole. Duct lines entering precast concrete manholes through a precast knockout penetration shall be grouted tight with a portland cement mortar. PVC duct lines entering precast manholes through a PVC endbell shall be solvent welded to the endbell. A cast metal grille-type sump frame and cover shall be installed over the manhole sump. A cable-pulling iron shall be installed in the wall opposite each duct line entrance.

3.6.2 Electric Manholes

Cables shall be securely supported from walls by hot-dip galvanized cable racks with a plastic coating over the galvanizing and equipped with adjustable hooks and insulators. The number of cable racks indicated shall be installed in each manhole and not less than 2 spare hooks shall be installed on each cable rack. Insulators shall be made of high-glazed porcelain. Insulators will not be required on spare hooks.

3.6.3 Communications Manholes

The number of hot-dip galvanized cable racks with a plastic coating over the galvanizing indicated shall be installed in each telephone manhole. Each cable rack shall be provided with 2 cable hooks. Cables for the telephone and communication systems will be installed by others.

3.6.4 Handholes

Handholes shall be located approximately as shown. Handholes shall be of the type noted on the drawings and shall be constructed in accordance with the details shown.

3.6.5 Pullboxes

Pullbox tops shall be flush with sidewalks or curbs or placed 15 mm (1/2 inch) above surrounding grades when remote from curbed roadways or sidewalks. Covers shall be marked "Low-Voltage" and provided with 2 lifting eyes and 2 hold-down bolts. Each box shall have a suitable opening for a ground rod. Conduit, cable, ground rod entrances, and unused openings shall be sealed with mortar.

3.6.6 Ground Rods

A ground rod shall be installed at the manholes, handholes and pullboxes. Ground rods shall be driven into the earth before the manhole floor is poured so that approximately 100 mm (4 inches) of the ground rod will extend above the manhole floor. When precast concrete manholes are used, the top of the ground rod may be below the manhole floor and a No. 1/0 AWG ground conductor brought into the manhole through a watertight sleeve in the manhole wall.

3.7 PAD-MOUNTED EQUIPMENT INSTALLATION

Pad-mounted equipment, shall be installed on concrete pads in accordance with the manufacturer's published, standard installation drawings and procedures, except that they shall be modified to meet the requirements of this document. Units shall be installed so that they do not damage equipment or scratch painted or coated surfaces. After installation, surfaces shall be inspected and scratches touched up with a paint or coating provided by the manufacturer especially for this purpose.

3.7.1 Concrete Pads

3.7.1.1 Construction

Concrete pads for pad-mounted electrical equipment may be either pre-fabricated or poured-in-place. Pads shall be constructed as indicated, except that exact pad dimensions and mounting details are equipment specific and are the responsibility of the Contractor. Tops of concrete pads shall be level and shall project 100 mm (4 inches) above finished paving or grade and sloped to drain. Edges of concrete pads shall have 20 mm (3/4 inch) chamfer. Conduits for primary, secondary, and grounding conductors shall be set in place prior to placement of concrete pads. Where grounding electrode conductors are installed through concrete pads, PVC conduit sleeves shall be installed through the concrete to provide physical protection. To facilitate cable installation and termination, the concrete pad shall be provided with a rectangular hole below the primary and secondary compartments, sized in accordance with the manufacturer's recommended dimensions. Upon completion of equipment installation the rectangular hole shall be filled with masonry grout.

3.7.1.3 Concrete and Reinforcement

Concrete work shall have minimum 20 MPa (3000 psi) compressive strength and conform to the requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Concrete pad reinforcement shall be in accordance with Section 03200 CONCRETE REINFORCEMENT.

3.7.1.4 Sealing

When the installation is complete, the Contractor shall seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.7.2 Padlocks

Padlocks shall be provided for pad-mounted equipment and for each fence gate. Padlocks shall be keyed as directed by the Contracting Officer.

3.7.3 Fencing

Fencing shall conform to the requirement of and be installed in accordance with Section 02831 CHAIN LINK FENCE. Fences shall provide working clearances for operation and maintenance in accordance with IEEE C2. The entire space between fences and concrete pads shall be excavated to a minimum depth of 100 mm (4 inches) below finished gradelines, shall be graded to reasonably level surfaces, and filled with well-compacted clean coarse gravel or crushed stone of 15 to 40 mm (1/2 to 1-1/2 inches) graded size up to finished gradelines. Space between fences and concrete pads shall be excavated to a minimum depth of 100 mm (4 inches) below finished gradelines, shall be graded to reasonably level surfaces, and filled with well-compacted clean coarse gravel or crushed stone of 15 to 40 mm (1/2 to 1-1/2 inches) graded size up to finished gradelines.

3.8 CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS

Connections between aerial and underground systems shall be made as shown. Underground cables shall be extended up poles in conduit to cable terminations. Conduits shall be secured to the poles by 2-hole galvanized steel pipe straps spaced not more than 3 m (10 feet) apart and with 1 strap not more than 300 mm (12 inches) from any bend or termination. Cable guards shall be secured to poles in accordance with the manufacturer's published procedures. Conduits shall be equipped with bushings to protect cables and minimize water entry. Capnut potheads shall be used to terminate medium-voltage multiple-conductor cable. Cables shall be supported by devices separate from the conduit or guard, near their point of exit from the conduit or guard.

3.8.1 Pole Installation

Pole installation shall be in accordance with Section 16370 ELECTRICAL DISTRIBUTION SYSTEM, AERIAL.

3.9 CONNECTIONS TO BUILDINGS

Cables shall be extended into the various buildings as indicated, and shall be connected to the first applicable termination point in each building. Interfacing with building interior conduit systems shall be at conduit stubouts terminating 1.6 m (5 feet) outside of a building and 600 mm (2 feet) below finished grade as specified and provided under Section 16415 ELECTRICAL WORK, INTERIOR. After installation of cables, conduits shall be sealed with caulking compound to prevent entrance of moisture or gases into buildings.

3.10 GROUNDING

A ground ring consisting of the indicated configuration of bare copper conductors and driven ground rods shall be installed around pad-mounted equipment as shown. Equipment frames of metal-enclosed equipment, and other noncurrent-carrying metal parts, such as cable shields, cable sheaths and armor, and metallic conduit shall be grounded. At least 2 connections shall be provided from a transformer, a switchgear ground bus, and a unit substation to the ground mat. Metallic frames and covers of handholes and pull boxes shall be grounded by use of a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.10.1 Grounding Electrodes

Grounding electrodes shall be installed as shown on the drawings and as follows:

a. Driven rod electrodes - Unless otherwise indicated, ground rods shall be driven into the earth until the tops of the rods are approximately 300 mm (1 foot) below finished grade.

b. Ground mat - A ground mat shall be installed as shown consisting of bare copper conductors installed 600 mm (24 inches) plus or minus 75 mm (3 inches) below the finished top of soil grade. Mat conductors shall be bonded to all rod electrodes, electrolytic electrodes, and to all other intersecting mat conductors. Mat conductors shall be sized as shown on the drawings.

c. Ground ring - A ground ring shall be installed as shown consisting of bare copper conductors installed 600 mm (24 inches) plus or minus 75 mm (3 inches) below finished top of soil grade. Ground ring conductors shall be No. 2 AWG, minimum.

d. Additional electrodes - When the required ground resistance is not met, additional electrodes shall be provided interconnected with grounding conductors to achieve the specified ground resistance. The additional electrodes will be up to three 2.4 m (8 feet) rods spaced a minimum of 3 m (12 feet) apart. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately.

3.10.2 Grounding and Bonding Connections

Connections above grade shall be made by the fusion-welding process or with bolted solderless connectors, in compliance with UL 467, and those below grade shall be made by a fusion-welding process. Where grounding conductors are connected to aluminum-composition conductors, specially treated or lined copper-to-aluminum connectors suitable for this purpose shall be used.

3.10.3 Grounding and Bonding Conductors

Grounding and bonding conductors include conductors used to bond transformer enclosures and equipment frames to the grounding electrode system. Grounding and bonding conductors shall be sized as shown, and located to provide maximum physical protection. Bends greater than 45 degrees in ground conductors are not permitted. Routing of ground conductors through concrete shall be avoided. When concrete penetration is necessary, nonmetallic conduit shall be cast flush with the points of concrete entrance and exit so as to provide an opening for the ground conductor, and the opening shall be sealed with a suitable compound after installation.

3.10.4 Surge Arrester Grounding

Surge arresters and neutrals shall be bonded directly to the transformer enclosure and then to the grounding electrode system with a bare copper conductor, sized as shown. Lead lengths shall be kept as short as practicable with no kinks or sharp bends.

3.10.5 Manhole, Handhole, or Concrete Pullbox Grounding

Ground rods installed in manholes, handholes, or concrete pullboxes shall be connected to cable racks, cable-pulling irons, the cable shielding, metallic sheath, and armor at each cable joint or splice by means of a No. 4 AWG braided tinned copper wire. Connections to metallic cable sheaths shall be by means of tinned terminals soldered to ground wires and to cable sheaths. Care shall be taken in soldering not to damage metallic cable sheaths or shields. Ground rods shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 50 mm (2 inches) above and 150 mm (6 inches) below concrete penetrations. Grounding electrode conductors shall be neatly and firmly attached to manhole or handhole walls and the amount of exposed bare wire shall be held to a minimum.

3.10.6 Metal Splice Case Grounding

Metal splice cases for medium-voltage direct-burial cable shall be grounded by connection to a driven ground rod located within 600 mm (2 feet) of each splice box using a grounding electrode conductor having a current-carrying capacity of at least 20 percent of the individual phase conductors in the associated splice box, but not less than No. 6 AWG.

3.10.7 Riser Pole Grounding

A single continuous vertical grounding electrode conductor shall be installed on each riser pole and connected directly to the grounding electrodes indicated on the drawings or required by these specifications. All equipment, neutrals, surge arresters, and items required to be grounded shall be connected directly to this vertical conductor. The grounding electrode conductor shall be sized as shown. Grounding electrode conductors shall be stapled to wood poles at intervals not exceeding 600 mm (2 feet).

3.11 FIELD TESTING

3.11.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 10 days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field test reports shall be signed and dated by the Contractor.

3.11.3 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.11.4 Ground-Resistance Tests

The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE Std 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

a. Single rod electrode - 25 ohms.

b. Multiple rod electrodes – 25 ohms.

c. Ground mat - 25 ohms.

d. Ground ring - 25 ohms.

3.11.5 Ground-Mat Connection Inspection

All below-grade ground-mat connections will be visually inspected by the Contracting Officer before backfilling. The Contractor shall notify the Contracting Officer 8 hours before the site is ready for inspection.

3.11.6 Medium-Voltage Cable Test

After installation and before the operating test or connection to an existing system, the medium-voltage cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors as one terminal and connecting grounds or metallic shieldings or sheaths of the cable as the other terminal for each test. Prior to making the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The test shall be conducted with all splices, connectors, and terminations in place. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 7 or NEMA WC 8 for the particular type of cable installed, except that 28 kV and 35 kV insulation test voltages shall be in accordance with either AEIC CS5 or AEIC CS6 as applicable, and shall not exceed the recommendations of IEEE Std 404 for cable joints and IEEE Std 48 for cable terminations unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor shall make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

3.11.6 Low-Voltage Cable Test

Low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

R in megohms = (rated voltage in kV + 1) x 304,800/(length of cable in meters)

R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet

Each cable failing this test shall be repaired or replaced. The repaired cable shall be retested until failures have been eliminated.

3.11.7 Liquid-Filled Transformer Tests

The following field tests shall be performed on all liquid-filled transformers. Pass-fail criteria shall be in accordance with transformer manufacturer's specifications.

a. Insulation resistance test phase-to-ground.

b. Turns ratio test.

c. Correct phase sequence.

d. Correct operation of tap changer.

3.11.8 Dry-Type Transformer Tests

The following field tests shall be performed on all dry-type transformers. Pass-fail criteria shall be in accordance with the transformer manufacturer's specifications.

a. Insulation resistance test phase-to-ground.

b. Turns ratio test.

3.11.9 Circuit Breaker Tests

The following field tests shall be performed on circuit breakers. Pass-fail criteria shall be in accordance with the circuit breaker manufacturer's specifications.

a. Insulation resistance test phase-to-phase.

b. Insulation resistance test phase-to-ground.

c. Closed breaker contact resistance test.

d. Power factor test.

e. High-potential test.

f. Manual and electrical operation of the breaker.

3.11.10 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

3.11.11 Pre-Energization Services

Calibration, testing, adjustment, and placing into service of the installation shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of 2 years of current product experience. The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to ensure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment to ensure packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided, but are not limited to, are the following:

a. Secondary unit substation

b. Pad-mounted transformers

c. Panelboards

d. Switchboards

e. Metal-enclosed switchgear

f. Busways

g. Switches

3.11.12 Operating Tests

After the installation is completed, and at such times as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the requirements herein. An operating test report shall be submitted in accordance with paragraph SUBMITTALS.

3.12 MANUFACTURER'S FIELD SERVICE

3.12.1 Onsite Training

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instruction shall cover pertinent points involved in operating, starting, stopping, and servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations.

3.12.2 Installation Engineer

After delivery of the equipment, the Contractor shall furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of the equipment, assist in the performance of the onsite tests, initial operation, and instruct personnel as to the operational and maintenance features of the equipment.

3.13 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

SECTION 16410

AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 117 (1997) Operating Salt Spray (Fog) Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.13 (1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures

IEEE C37.90.1 (1989; R 1994) IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems

IEEE C62.41 (1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits

IEEE Std 602 (1996) Electric Systems in Health Care Facilities

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1 (1993) Industrial Controls and Systems

NEMA ICS 2 (1993) Industrial Controls and Systems Controllers, Contactors, and Overload Relays Rated Not More Than 2,000 Volts AC or 750 Volts DC

NEMA ICS 4 (1997) Industrial Control and Systems Terminal Blocks

NEMA ICS 6 (1993) Industrial Control and Systems, Enclosures

NEMA ICS 10 (1999) Industrial Control and Systems: AC Transfer Switch Equipment - Part 2: Static AC Transfer Equipment

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2002) National Electrical Code

NFPA 110 (1999) Emergency and Standby Power Systems

UNDERWRITERS LABORATORIES (UL)

UL 1008 (1996; Rev thru Feb 1999) Transfer Switch Equipment

UL 1066 (1997) Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Switches; G

Schematic, external connection, one-line schematic and wiring diagram of each ATS assembly. Interface equipment connection diagram showing conduit and wiring between ATS and related equipment. Device, nameplate, and item numbers shown in list of equipment and material shall appear on drawings wherever that item appears. Diagrams shall show interlocking provisions and cautionary notes, if any. Operating instructions shall be shown either on one-line diagram or separately. Unless otherwise approved, one-line and elementary or schematic diagrams shall appear on same drawing.

Equipment; G

Installation; G

Dimensioned plans, sections and elevations showing minimum clearances, weights, and conduit entry provisions for each ATS.

SD-03 Product Data

Material; G
Equipment; G

List of proposed equipment and material, containing a description of each separate item.

SD-06 Test Reports

Testing; G

A description of proposed field test procedures, including proposed date and steps describing each test, its duration and expected results, not less than 1 weeks prior to test date.

Certified factory and field test reports, within 14 days following completion of tests. Reports shall be certified and dated and shall demonstrate that tests were successfully completed prior to shipment of equipment.

SD-07 Certificates

Equipment; G
Material; G

Certificates of compliance showing evidence of UL listing and conformance with applicable NEMA standards. Such certificates are not required if manufacturer's published data, submitted and approved, reflect UL listing or conformance with applicable NEMA standards.

Switching Equipment; G

Evidence that ATS withstand current rating (WCR) has been coordinated with upstream protective devices as required by UL 1008. Upon request, manufacturer shall also provide notarized letter certifying compliance with requirements of this specification, including withstand current rating.

SD-10 Operation and Maintenance Data

Switching Equipment; G
Instructions; G

Six copies of operating manual outlining step-by-step procedures for system startup, operation, and shutdown. Manual shall include manufacturer's name, model number, service manual, parts list, and brief description of equipment and basic operating features. Manufacturer's spare parts data shall be included with supply source and current cost of recommended spare parts. Six copies of maintenance manual listing routine maintenance, possible breakdowns, repairs, and troubleshooting guide. Manual shall include simplified wiring and control diagrams for system as installed.

1.3 GENERAL REQUIREMENTS

1.3.1 Standard Product

Material and equipment shall be standard products of a manufacturer regularly engaged in manufacturing the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. The experience use shall include applications in similar circumstances and of same design and rating as specified ATS. Equipment shall be capable of being serviced by a manufacturer-authorized and trained organization that is, in the Contracting Officer's opinion, reasonably convenient to the site.

1.3.2 Nameplate

Nameplate showing manufacturer's name and equipment ratings shall be made of corrosion-resistant material with not less than 3 mm (1/8 inch) tall characters. Nameplate shall be mounted to front of enclosure and shall comply with nameplate requirements of NEMA ICS 2.

1.4 SERVICE CONDITIONS

Seismic requirements shall be as indicated. ATS shall be suitable for prolonged performance under following service conditions:

a. Altitude: As specified meters (feet) above mean sea level.

b. Relative Humidity: As specified percent maximum, continuous.

c. Temperature: As specified degrees C (F).

d. Seismic Parameters: As specified.

PART 2 PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCH (ATS)

ATS shall be electrically operated and mechanically held in both operating positions. ATS shall be suitable for use in emergency systems and/or standby systems described in NFPA 70. ATS shall be UL listed. ATS shall be manufactured and tested in accordance with applicable requirements of IEEE C37.90.1, IEEE C37.13, IEEE C62.41, IEEE Std 602, NEMA ICS 1, NEMA ICS 2, NEMA ICS 10, UL 1008 and UL 1066. ATS shall conform to NFPA 110. To facilitate maintenance, manufacturer's instruction manual shall provide typical maximum contact voltage drop readings under specified conditions for use during periodic maintenance. Manufacturer shall provide instructions for determination of contact integrity. ATS shall be rated for continuous duty at specified continuous current rating. ATS shall be fully compatible and approved for use with BP/IS specified. BP/IS shall be considered part of ATS system. ATS shall be provided with following characteristics:

a. Voltage

b. Number of Phases

c. Number of Wires

d. Frequency

e. Poles

f. ATS WCR

g. Nonwelding Contacts: Rated for nonwelding of contacts when used with upstream feeder overcurrent devices shown and with available fault current specified.

h. Main and Neutral Contacts: Contacts shall have silver alloy composition. Neutral contact continuous current rating shall be not less than twice the rating of main or phase contacts.

2.1.1 Override Time Delay

Time delay to override monitored source deviation shall be adjustable from 0.5 to 6 seconds and factory set at 1 second. ATS shall monitor phase conductors to detect and respond to sustained voltage drop of 15 percent or as specified percent of nominal between any two preferred source conductors and initiate transfer action to alternate or emergency source and start engine driven generator after set time period. Pickup voltage shall be adjustable from 85 to 100 percent of nominal and factory set at 90 percent. Dropout voltage shall be adjustable from 75 to 98 percent of pickup value and factory set at 80 percent of nominal.

2.1.2 Transfer Time Delay

Time delay before transfer to alternate or emergency power source shall be adjustable from 0 to 5 minutes and factory set at 0 minutes. ATS shall monitor frequency and voltage of alternate or emergency power source and transfer when frequency and voltage are stabilized. Pickup voltage shall be adjustable from 85 to 100 percent of nominal and factory set at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal and factory set at 90 percent.

2.1.3 Return Time Delay

Time delay before return transfer to normal or preferred power source shall be adjustable from 0 to 30 minutes and factory set at 30 minutes. Time delay shall be automatically defeated upon loss or sustained under voltage of alternate or emergency power source, provided that normal or preferred supply has been restored.

2.1.4 Engine Shutdown Time Delay

Time delay shall be adjustable from 0 to 30 minutes and shall be factory set at 10 minutes.

2.1.5 Exerciser

Provide a generator exerciser timer. Run times shall be user programmable. The generator exerciser shall be selectable between load transfer and exerciser run only, and shall have a fail-safe feature that will retransfer the ATS to normal or preferred during the exercise period.

2.1.6 Auxiliary Contacts

Two normally open and two normally closed auxiliary contacts rated at 10 or specified amperes at 120 or specified volts shall operate when ATS is connected to normal or preferred power source, and two normally open and two normally closed contacts shall operate when ATS is connected to alternate or emergency source.

2.1.7 Supplemental Features

ATS shall be furnished with the following:

a. Engine start contact.

b. Alternate or Emergency source monitor.

c. Test switch to simulate normal power outage.

d. Voltage sensing. Pickup voltage adjustable from 85 to 100 percent of nominal; dropout adjustable from 75 to 98 percent of pickup.

e. Time delay bypass switch to override return time delay to normal.

f. Manual return-to-normal switch.

g. Means shall be provided in the ATS to insure that motor/transformer load inrush currents do not exceed normal starting currents. This shall be accomplished with either in-phase monitoring, time-delay transition, or load voltage decay sensing methods. If manufacturer supplies an in-phase monitoring system, the manufacturer shall indicate under what conditions a transfer cannot be accomplished. If the manufacturer supplies a time-delay transition system, the manufacturer shall supply recommendations for establishing time delay. If load voltage decay sensing is supplied, the load voltage setting shall be user programmable.

2.1.8 Operator

Manual operator conforming to UL 1008 shall be provided, and shall incorporate features to prevent operation by unauthorized personnel. ATS shall be designed for safe manual operation under full load conditions. If manual operation is accomplished by opening the door, then a dead-front shall be supplied for operator safety.

2.1.9 Override Switch

Override switch shall bypass automatic transfer controls so ATS will transfer and remain connected to alternate or emergency power source, regardless of condition of normal or preferred source.

2.1.10 Green Indicating Light

A green indicating light shall supervise/provide normal or preferred power source switch position indication and shall have a nameplate engraved “NORMAL” or “PREFERRED”.

2.1.11 Red Indicating Light

A red indicating light shall supervise/provide alternate or emergency power source switch position indication and shall have a nameplate engraved “ALTERNATE” or “EMERGENCY”.

2.2 BY-PASS/ISOLATION SWITCH (BP/IS)

2.2.1 Design

Bypass/isolation switch (BP/IS) shall permit load by-pass to either normal/preferred or alternate/emergency power source and complete isolation of associated ATS, independent of ATS operating position. BP/IS and associated ATS shall be products of same manufacturer and shall be completely interconnected and tested at factory and at project site as specified. BP/IS shall be manufactured, listed, and tested in accordance with paragraph AUTOMATIC TRANSFER SWITCH (ATS) and shall have electrical ratings that exceed or equal comparable ratings specified for ATS. Operating handles shall be externally operated and arranged so that one person can perform the bypass and isolation functions through the operation of a maximum of two handles within 5 seconds. The ATS shall have provisions for locking in the isolation position. Handle for manual operation shall be permanently attached to operating mechanism. BP/IS operation shall be accomplished without disconnecting switch load terminal conductors. Isolation handle positions shall be marked with engraved plates or other approved means to indicate position or operating condition of associated ATS, as follows:

a. Indication shall be provided to show that ATS section is providing power to the load.

b. Indication shall be provided of ATS isolation. The ATS controls shall remain functional with the ATS isolated or in bypass mode to permit monitoring of the normal power source and automatic starting of the generator in the event of a loss of the normal power source. In the isolated mode, the bypass section shall be capable of functioning as a manual transfer switch to transfer the load to either power source. The ATS shall be capable of undergoing functional operation testing without service interruption. The ATS may also be completely removed from the enclosure, if required for maintenance or repair, while the bypass section continues to power the load.

2.2.2 Switch Construction

Bypass/isolation switch shall be constructed for convenient removal of parts from front of switch enclosure without removal of other parts or disconnection of external power conductors. Contacts shall be as specified for associated ATS, including provisions for inspection of contacts without disassembly of BP/IS or removal of entire contact enclosure. To facilitate maintenance, manufacturer shall provide instructions for determination of contact integrity. BP/IS and associated ATS shall be interconnected with suitably sized copper bus bars silver-plated at each connection point, and braced to withstand magnetic and thermal forces created at WCR specified for associated ATS.

2.3 ENCLOSURE

ATS and accessories shall be installed in wall-mounted or free-standing, floor-mounted, ventilated NEMA ICS 6, Type as specified, smooth sheet metal enclosure constructed in accordance with applicable requirements of UL 1066 and/or UL 1008. Intake vent shall be screened and filtered. Exhaust vent shall be screened. Door shall have suitable hinges, locking handle latch, and gasketed jamb. Thermostatically controlled heater shall be provided within enclosure to prevent condensation over temperature range stipulated in paragraph SERVICE CONDITIONS. Metal gauge shall be not less than No. 14. Enclosure shall be equipped with at least two approved grounding lugs for grounding enclosure to facility ground system with NFPA 70. Factory wiring within enclosure and field wiring terminating within enclosure shall comply with NFPA 70. If wiring is not color coded, wire shall be permanently tagged or marked near terminal at each end with wire number shown on approved detail drawing. Terminal block shall conform to NEMA ICS 4. Terminals shall be arranged for entrance of external conductors as required. Main switch terminals, including neutral terminal if used, shall be pressure type suitable for termination of external copper conductors shown.

2.3.1 Construction

Enclosure shall be constructed for ease of removal and replacement of ATS components and control devices from front without disconnection of external power conductors or removal or disassembly of major components. Enclosure of ATS with BP/IS shall be constructed to protect personnel from energized BP/IS components during ATS maintenance.

2.3.2 Cleaning and Painting

Both the inside and outside surfaces of an enclosure, including means for fastening, shall be protected against corrosion by enameling, galvanizing, plating, powder coating, or other equivalent means. Protection is not required for metal parts that are inherently resistant to corrosion, bearings, sliding surfaces of hinges, or other parts where such protection is impractical. Finish shall be manufacturer's standard material, process, and color and shall be free from runs, sags, peeling, or other defects. An enclosure marked Type 1, 3R, 4 or 12 shall be acceptable if there is no visible rust at the conclusion of a salt spray (fog) test using the test method in ASTM B 117, employing a 5 percent by weight, salt solution for 24 hours. Type 4X enclosures are acceptable following performance of the above test with an exposure time of 200 hours.

2.4 TESTING

2.4.1 Factory Testing

A prototype of specified ATS shall be factory tested in accordance with UL 1008. In addition, factory tests shall be performed on each ATS as follows:

a. Insulation resistance test to ensure integrity and continuity of entire system.

b. Main switch contact resistance test.

c. Visual inspection to verify that each ATS is as specified.

d. Mechanical test to verify that ATS sections are free of mechanical hindrances.

e. Electrical tests to verify complete system electrical operation and to set up time delays and voltage sensing settings.

2.4.2 Factory Test Reports

Manufacturer shall provide three certified copies of factory test reports.

2.5 FACTORY TESTING (MEDICAL FACILITIES)

The factory tests for ATS and By-Pass/Isolation switches used in medical facilities shall be conducted in the following sequence:

a. General
b. Normal
c. Overvoltage
d. Undervoltage
e. Overload
f. Endurance

g. Temperature Rise
h. Dielectric Voltage-Withstand
i. Contact Opening
j. Dielectric Voltage-Withstand (Repeated)
k. Withstand
l. Instrumentation and Calibration of High Capacity
m. Closing
n. Dielectric Voltage-Withstand (Repeated)
o. Strength of Insulating Base and Support

2.5.1 Viewing Ports

ATS and BP/IS switches shall be of draw-out construction. Viewing ports to inspect the contacts without requiring disassembly shall be provided.

2.5.2 Operating Handles

The operating handles shall be externally operated, and designed and constructed not to stop in an intermediate or neutral position during operation, but shall permit load by-pass and transfer switch isolation in no more than two manual operations which can be performed by one person in 5 seconds or less. The transfer speed will be independent of the operational speed of the switch handle or handles.

PART 3 EXECUTION

3.1 INSTALLATION

ATS shall be installed as shown and in accordance with approved manufacturer's instructions.

3.2 INSTRUCTIONS

Manufacturer's approved operating instructions shall be permanently secured to cabinet where operator can see them. One-line and elementary or schematic diagram shall be permanently secured to inside of front enclosure door.

3.3 SITE TESTING

Following completion of ATS installation and after making proper adjustments and settings, site tests shall be performed in accordance with manufacturer's written instructions to demonstrate that each ATS functions satisfactorily and as specified. Contractor shall advise Contracting Officer not less than 5 working days prior to scheduled date for site testing, and shall provide certified field test reports within 2 calendar weeks following successful completion of site tests. Test reports shall describe adjustments and settings made and site tests performed. Minimum operational tests shall include the following:

a. Insulation resistance shall be tested, both phase-to-phase and phase-to-ground.

b. Power failure of normal source shall be simulated by opening upstream protective device. This test shall be performed a minimum of five times.

c. Power failure of emergency source with normal source available shall be simulated by opening upstream protective device for emergency source. This test shall be performed a minimum of five times.

d. Low phase-to-ground voltage shall be simulated for each phase of normal source.

e. Operation and settings shall be verified for specified ATS features, such as override time delay, transfer time delay, return time delay, engine shutdown time delay, exerciser, auxiliary contacts, and supplemental features.

f. Manual and automatic ATS and BP/IS functions shall be verified.

SECTION 16415

ELECTRICAL WORK, INTERIOR

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (1995) Code for Electricity Metering

ANSI C12.4 (1984; R 1996) Mechanical Demand Registers

ANSI C12.10 (1997) Electromechanical Watthour Meters

ANSI C12.11 (1987; R 1993) Instrument Transformers for Revenue Metering, 10 kV BIL Through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

ANSI C37.16 (2000) Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations

ANSI C39.1 (1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ANSI C57.12.10 (1988) Safety Requirements for Transformers 230 kV and Below 833/958 Through 8333/10417 kVA, Single-Phase, and 750/862 Through 60 000/80 000/100 000 kVA, Three-Phase Without Load Tap Charging; and 3750/4687 Through 60 000/80 000/100 000 kVA With Load Tap Charging

ANSI C57.12.13 (1982) Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations

ANSI C57.12.27 (1982) Conformance Requirements for Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations

ANSI C57.12.50	(1981; R 1989) Ventilated Dry-type Distribution Transformers 1 to 500 kVA, Single-Phase; and 15 to 500 kVA, Three-Phase with High-Voltage 601 to 34 500 Volts, Low-Voltage 120 to 600 Volts
ANSI C57.12.51	(1981; R 1989) Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, with High-Voltage 601 to 34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts
ANSI C57.12.52	(1981; R 1989) Sealed Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts
ANSI C57.12.70	(1978; R 1993) Terminal Markings and Connections for Distribution and Power Transformers
ANSI C78.1	(1991; C78.1a; R 1996) Fluorescent Lamps - Rapid-Start Types - Dimensional and Electrical Characteristics
ANSI C78.20	(1995) Electric Lamps - Characteristics of Incandescent Lamps A, G, PS, and Similar Shapes with E26 Medium Screw Bases
ANSI C78.21	(1995) Physical and Electrical Characteristics - Incandescent Lamps - PAR and R Shapes
ANSI C78.1350	(1990) 400-Watt, 100-Volt, S51 Single-Ended High-Pressure Sodium Lamps
ANSI C78.1351	(1989) 250-Watt, 100-Volt S50 Single-Ended High-Pressure Sodium Lamps
ANSI C78.1352	(1990) 1000-Watt, 250-Volt, S52 Single-Ended High-Pressure Sodium Lamps
ANSI C78.1355	(1989) 150-Watt, 55-Volt S55 High-Pressure Sodium Lamps
ANSI C78.1375	(1996) 400-Watt, M59 Single-Ended Metal-Halide lamps
ANSI C78.1376	(1996) 1000-Watt, M47 Single-Ended Metal-Halide Lamps
ANSI C78.2A	(1991) 18 & 26- Watt, Compact Fluorescent Quad Tube Lamps
ANSI C78.2B	(1992) 9 & 13-Watt, Compact Fluorescent Quad Tube Lamps
ANSI C82.1	(1997) Specifications for Fluorescent Lamp Ballasts
ANSI C82.4	(1992) Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 1	(1995) Hard-Drawn Copper Wire
ASTM B 8	(1999) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM D 709 (2000) Laminated Thermosetting Materials

ASTM D 4059 (1996) Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 18 Industrial, Scientific, and Medical Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2002) National Electrical Safety Code

IEEE C37.13 (1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures

IEEE C37.20.1 (1993) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear

IEEE C57.12.00 (1993) IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

IEEE C57.12.80 (1996) Terminology for Power and Distribution Transformers

IEEE C57.12.90 (1999) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers

IEEE C57.13 (1993) Instrument Transformers

IEEE C57.98 (1993) Guide for Transformer Impulse Tests

IEEE C57.100 (1999) Test Procedure for Thermal Evaluation of Oil-Immersed Distribution Transformers

IEEE C62.41 (1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits

IEEE Std 81 (1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)

IEEE Std 242 (1986; R 1991) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

IEEE Std 399 (1997) Recommended Practice for Industrial and Commercial Power Systems Analysis

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (1997) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA AB 3 (2001) Molded Case Circuit Breakers and Their Application.

NEMA BU 1 (1994) Busways

NEMA FU 1	(1986) Low Voltage Cartridge Fuses
NEMA ICS 1	(1993) Industrial Control and Systems
NEMA ICS 2	(1993) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated Not More Than 2,000 Volts AC or 750 Volts DC
NEMA ICS 3	(1993) Industrial Control and Systems Factory Built Assemblies
NEMA ICS 6	(1993) Industrial Control and Systems Enclosures
NEMA LE 4	(1987) Recessed Luminaires, Ceiling Compatibility
NEMA MG 1	(1998) Motors and Generators
NEMA MG 10	(1994) Energy Management Guide for Selection and Use of Polyphase Motors
NEMA OS 1	(1996) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA OS 2	(1998) Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports
NEMA PB 1	(1995) Panelboards
NEMA PB 2	(1995) Deadfront Distribution Switchboards
NEMA PE 5	(1996) Utility Type Battery Chargers
NEMA RN 1	(1998) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA SG 3	(1995) Power Switching Equipment
NEMA ST 20	(1992) Dry-Type Transformers for General Applications
NEMA TC 2	(1998) Electrical Polyvinyl Chloride (PVC) Tubing (EPT) and Conduit (EPC-40 and EPC-80)
NEMA TC 13	(1993) Electrical Nonmetallic Tubing (ENT)
NEMA VE 1	(1996) Metal Cable Tray Systems
NEMA WD 1	(1999) General Requirements for Wiring Devices
NEMA WD 6	(1997) Wiring Devices - Dimensional Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2002) National Electrical Code
NFPA 101	(2000) Life Safety Code

UNDERWRITERS LABORATORIES (UL)

UL 1	(2000) Flexible Metal Conduit
UL 5	(1996) Surface Metal Raceways and Fittings
UL 6	(1997) Rigid Metal Conduit
UL 20	(1995; Rev thru Oct 1998) General-Use Snap Switches
UL 44	(1999) Thermoset-Insulated Wires and Cables
UL 50	(1995; Rev thru Nov 1999) Enclosures for Electrical Equipment
UL 67	(1993; Rev thru Oct 1999) Panelboards
UL 83	(1998; Rev thru Sep 1999) Thermoplastic-Insulated Wires and Cables
UL 98	(1994; R thru Jun 1998) Enclosed and Dead-Front Switches
UL 198B	(1995) Class H Fuses
UL 198C	(1986; Rev thru Feb 1998) High-Interrupting-Capacity Fuses, Current-Limiting Types
UL 198D	(1995) Class K Fuses
UL 198E	(1988; Rev Jul 1988) Class R Fuses
UL 198G	(1988; Rev May 1988) Fuses for Supplementary Overcurrent Protection
UL 198H	(1988; Rev thru Nov 1993) Class T Fuses
UL 198L	(1995; Rev May 1995) D-C Fuses for Industrial Use
UL 360	(1996; Rev thru Oct 1997) Liquid-Tight Flexible Steel Conduit
UL 467	(1993; Rev thru Apr 1999) Grounding and Bonding Equipment
UL 486A	(1997; Rev thru Dec 1998) Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL 486C	(1997; Rev thru Aug 1998) Splicing Wire Connectors
UL 486E	(1994; Rev thru Feb 1997) Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(1996; Rev thru Dec 1998) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 498	(1996; Rev thru Jan 1999) Attachment Plugs and Receptacles
UL 506	(1994; Rev Oct 1997) Specialty Transformers

UL 508	(1999) Industrial Control Equipment
UL 510	(1994; Rev thru Apr 1998) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 512	(1993; Rev Mar 1999) Fuseholders
UL 514A	(1996; Rev Dec 1999) Metallic Outlet Boxes
UL 514B	(1997; Rev Oct 1998) Fittings for Cable and Conduit
UL 514C	(1996; Rev thru Dec 1999) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 542	(1999) Lampholders, Starters, and Starter Holders for Fluorescent Lamps
UL 651	(1995; Rev thru Oct 1998) Schedule 40 and 80 Rigid PVC Conduit
UL 651A	(1995; Rev thru Apr 1998) Type EB and A Rigid PVC Conduit and HDPE Conduit
UL 674	(1994; Rev thru Oct 1998) Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 698	(1999)) Industrial Control Equipment for Use in Hazardous (Classified) Locations
UL 719	(1999) Nonmetallic-Sheathed Cables
UL 817	(1994; Rev thru May 1999) Cord Sets and Power-Supply Cords
UL 844	(1995; Rev thru Mar 1999) Electric Lighting Fixtures for Use in Hazardous (Classified) Locations
UL 845	(1995; Rev thru Nov 1999) Motor Control Centers
UL 854	(1996; Rev Oct 1999) Service-Entrance Cables
UL 857	(1994; Rev thru Dec 1999) Busways and Associated Fittings
UL 869A	(1998) Reference Standard for Service Equipment
UL 877	(1993; Rev thru Nov 1999) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations
UL 886	(1994; Rev thru Apr 1999) Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations
UL 891	(1994; Rev thru Jan 1995) Dead-Front Switchboards
UL 916	(1998) Energy Management Equipment

UL 924	(1995; Rev thru Oct 1997) Emergency Lighting and Power Equipment
UL 935	(1995; Rev thru Oct 1998) Fluorescent-Lamp Ballasts
UL 943	(1993; Rev thru May 1998) Ground-Fault Circuit-Interrupters
UL 1004	(1994; Rev thru Nov 1999) Electric Motors
UL 1010	(1995; Rev thru Mar 1999) Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations
UL 1022	(1998) Line Isolation Monitors
UL 1029	(1994; Rev thru Dec 1997) High-Intensity-Discharge Lamp Ballasts
UL 1047	(1995; Rev Jul 1998) Isolated Power Systems Equipment
UL 1236	(1994; Rev thru Mar 1999) Battery Chargers for Charging Engine-Starter Batteries
UL 1449	(1996; Rev thru Dec 1999) Transient Voltage Surge Suppressors
UL 1564	(1993; Rev Sep 1998) Industrial Battery Chargers
UL 1569	(1999; Rev thru Jan 2000) Metal-Clad Cables
UL 1570	(1995; Rev thru Nov 1999) Fluorescent Lighting Fixtures
UL 1571	(1995; Rev thru Nov 1999) Incandescent Lighting Fixtures
UL 1572	(1995; Rev thru Nov 1999) High Intensity Discharge Lighting Fixtures
UL 1660	(2000) Liquid-Tight Flexible Nonmetallic Conduit
UL Elec Const Dir	(1999) Electrical Construction Equipment Directory

KOREAN INDUSTRIAL STANDARDS (KS)

KS C 2302	(1986) Friction Tape
KS C 2306	(1999) Pressure Sensitive PVC Adhesive Tape
KS C 2347	(1986) Pressure Sensitive Polyester Adhesive Tape
KS C 3101	(1995) Copper Wire, Electrical, Solid, Softdrawn
KS C 3102	(1998) Copper Wire, Electrical, Solid Harddrawn
KS C 3103	(1986) Copper Wire, Electrical, Stranded, Softdrawn
KS C 3104	(1996) Copper Wire, Electrical, Stranded, Harddrawn
KS C 3302	(1990) 600V PVC Insulated Wire, IV

KS C 3323	(1999) 600V PVC Insulated and Sheathed Cable,VV
KS C 3328	(2002) 600V PVC Insulated and Sheathed Cable,HIV
KS C 8401	(1997) Rigid Steel Conduit
KS C 8422	(2002) Steel Flexible Conduit
KS C 8431	(2001) Unplasticized Polyvinyl Chloride (UPVC) Conduit
KS C 8458	(2001) Outlet Boxes, Switch Boxes, Special Outlet Boxes, Box Covers for Rigid Metal Conduit
KS C 8459	(1997) Coupling, Connector for Flexible Conduit
KS C 8460	(2001) Bushing, Saddles, Locknuts, Couplings, Insulated Bushings for Rigid Metal Conduit
KS C 8461	(1997) Universal Fittings, Terminal Caps, Surface Switch Boxes, Circular Surface Boxes For Rigid Metal Conduit
KS D 3501	(1994) Hot Rolled Milled Steel Plate Sheet And Strip
KS D 8308	(2001) Zinc Coating (Hot Dipped) on Iron and Steel

1.2 RELATED REQUIREMENTS

Section 16050, "Basic Electrical Materials and Methods," applies to this section with the additions and modifications specified herein.

1.3 GENERAL

1.3.1 Rules

The installation shall conform to the requirements of NFPA 70 and NFPA 101, unless more stringent requirements are indicated or shown.

1.3.2 Coordination

The drawings indicate the extent and the general location and arrangement of equipment, conduit, and wiring. The Contractor shall become familiar with all details of the work and verify all dimensions in the field so that the outlets and equipment shall be properly located and readily accessible. Lighting fixtures, outlets, and other equipment and materials shall be carefully coordinated with mechanical or structural features prior to installation and positioned according to architectural reflected ceiling plans; otherwise, lighting fixtures shall be symmetrically located according to the room arrangement when uniform illumination is required, or asymmetrically located to suit conditions fixed by design as shown. Raceways, junction and outlet boxes, and lighting fixtures shall not be supported from sheet metal roof decks. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change. The Contractor shall coordinate the electrical requirements of the mechanical work and provide all power related circuits, wiring, hardware and structural support, even if not shown on the drawings.

1.3.3 Special Environments

1.3.3.1 Weatherproof Locations

Wiring, fixtures, and equipment in designated locations shall conform to NFPA 70 requirements for installation in damp or wet locations.

1.3.3.2 Hazardous Locations

Wiring in locations indicated shall conform to the NFPA 70 for Class I, II and III, Division 1 and 2 hazardous locations. Equipment shall be suitable for wiring and equipment in locations indicated shall be of the classes, groups, divisions, and suitable for the operating temperature; as indicated.

1.3.3.3 Ducts, Plenums and Other Air-Handling Spaces

Wiring and equipment in ducts, plenums and other air-handling spaces shall be installed using materials and methods in conformance with NFPA 70 unless more stringent requirements are indicated in this specification or on the contract drawings.

1.3.4 Standard Products

Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.3.5 Nameplates

1.3.5.1 Identification Nameplates

Major items of electrical equipment and major components shall be permanently marked with an identification name to identify the equipment by type or function and specific unit number as indicated. Designation of motors shall coincide with their designation in the motor control center or panel. Unless otherwise specified, identification nameplates shall be made of laminated plastic in accordance with ASTM D 709 with black outer layers and a white core. Edges shall be chamfered. Plates shall be fastened with black-finished round-head drive screws, except motors, or approved nonadhesive metal fasteners. When the nameplate is to be installed on an irregular-shaped object, the Contractor shall devise an approved support suitable for the application and ensure the proper installation of the supports and nameplates. In all instances, the nameplate shall be installed in a conspicuous location. At the option of the Contractor, the equipment manufacturer's standard embossed nameplate material with black paint-filled letters may be furnished in lieu of laminated plastic. The front of each panelboard, motor control center, switchgear, and switchboard shall have a nameplate to indicate the phase letter, corresponding color and arrangement of the phase conductors. The following equipment, as a minimum, shall be provided with identification nameplates:

Minimum 6.4 mm (1/4 inch) High Letters	Minimum 3.2 mm (1/8 inch) High Letters
Panelboards	Control Power Transformers

Starters
Safety Switches
Motor Control Centers
Transformers
Equipment Enclosures
Switchgear
Switchboards
Motors
Control Devices
Instrument Transformers

Each panel, section, or unit in motor control centers, switchgear or similar assemblies shall be provided with a nameplate in addition to nameplates listed above, which shall be provided for individual compartments in the respective assembly, including nameplates which identify "future," "spare," and "dedicated" or "equipped spaces."

1.3.5.2 Liquid-Filled Transformer Nameplates

Power transformers shall be provided with Nameplate C information in accordance with IEEE C57.12.00. Nameplates shall indicate percent impedance, voltage, kVA, frequency, number of phases, cooling class, insulation class, temperature rise, the number of gallons and composition of liquid-dielectric, and shall be permanently marked with a statement that the transformer dielectric to be supplied is non-polychlorinated biphenyl. The Contractor shall furnish manufacturer's certification for each transformer that the dielectric is non-PCB classified, with less than 2 ppm PCB content in accordance with paragraph LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the 2 ppm PCB content or transformers without certification will be considered as PCB insulated and will not be accepted.

1.3.6 As-Built Drawings

Following the project completion or turnover, within 30 days the Contractor shall furnish 2 sets of as-built drawings to the Contracting Officer.

1.3.7 Recessed Light Fixtures (RLF) Option

The Contractor has the option to substitute inch-pound (I-P) RLF to metric RLF. This option shall be coordinated with Section 09510 ACOUSTICAL CEILINGS.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Interior Electrical Equipment;

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams, and other information necessary to define the installation. Detail drawings shall show the rating of items and systems and how the components of an item and system are assembled, function together, and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall show physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. Optional items shall be clearly identified as included or excluded. Detail drawings shall as a minimum include:

a. Transformers.

b. Switchgear.

c. Battery system including calculations for the battery and charger.

d. Voltage regulators.

e. Grounding resistors.

f. Motors and rotating machinery.

g. Motor control centers.

h. Busway systems.

i. Single line electrical diagrams including primary, metering, sensing and relaying, control wiring, and control logic.

j. Sway bracing for suspended luminaires.

Structural drawings showing the structural or physical features of major equipment items, components, assemblies, and structures, including foundations or other types of supports for equipment and conductors. These drawings shall include accurately scaled or dimensioned outline and arrangement or layout drawings to show the physical size of equipment and components and the relative arrangement and physical connection of related components. Weights of equipment, components and assemblies shall be provided when required to verify the adequacy of design and proposed construction of foundations or other types of supports. Dynamic forces shall be stated for switching devices when such forces must be considered in the design of support structures. The appropriate detail drawings shall show the provisions for leveling, anchoring, and connecting all items during installation, and shall include any recommendations made by the manufacturer.

Electrical drawings including single-line and three-line diagrams, and schematics or elementary diagrams of each electrical system; internal wiring and field connection diagrams of each electrical device when published by the manufacturer; wiring diagrams of cabinets, panels, units, or separate mountings; interconnection diagrams that show the wiring between separate components of assemblies; field connection diagrams that show the termination of wiring routed between separate items of equipment; internal wiring diagrams of equipment showing wiring as actually provided for this project. Field wiring connections shall be clearly identified.

If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures, including changes in related portions of the project and the reasons why, shall be submitted with the detail drawings. Approved departures shall be made at no additional cost to the Government.

SD-03 Product Data

Fault Current and Protective Device Coordination Study;

The study shall be submitted along with protective device equipment submittals. No time extensions or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study, The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Manufacturer's Catalog; G

Data composed of catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Material, Equipment, and Fixture Lists; G

A complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include an item number, the quantity of items proposed, and the name of the manufacturer of each item.

Installation Procedures;

Installation procedures for rotating equipment, transformers, switchgear, battery systems, voltage regulators, and grounding resistors. Procedures shall include diagrams, instructions, and precautions required to install, adjust, calibrate, and test devices and equipment.

As-Built Drawings; G

The as-built drawings shall be a record of the construction as installed. The drawings shall include all the information shown on the contract drawings, deviations, modifications, and changes from the contract drawings, however minor. The as-built drawings shall be kept at the job site and updated daily. The as-built drawings shall be a full-sized set of prints marked to reflect all deviations, changes, and modifications. The as-built drawings shall be complete and show the location, size, dimensions, part identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall submit three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within ten calendar days from the time the drawings are returned to the Contractor.

Onsite Tests; G

A detailed description of the Contractor's proposed procedures for on-site tests.

SD-06 Test Reports

Factory Test Reports; G

Six copies of the information described below in 216 x 280 mm (8 1/2 x 11 inch) binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

a. A list of equipment used, with calibration certifications.

b. A copy of measurements taken.

c. The dates of testing.

d. The equipment and values to be verified.

e. The conditions specified for the test.

f. The test results, signed and dated.

g. A description of adjustments made.

Field Test Plan; G

A detailed description of the Contractor's proposed procedures for onsite test submitted 20 days prior to testing the installed system. No field test will be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Field Test Reports; G

Six copies of the information described below in 216 x 280 mm (8 1/2 x 11 inch) binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

a. A list of equipment used, with calibration certifications.

b. A copy of measurements taken.

c. The dates of testing.

d. The equipment and values to be verified.

e. The conditions specified for the test.

f. The test results, signed and dated.

g. A description of adjustments made.

h. Final position of controls and device settings.

SD-07 Certificates

Materials and Equipment; G

The label or listing of the Underwriters Laboratories, Inc., will be accepted as evidence that the materials or equipment conform to the applicable standards of that agency. In lieu of this label or listing, a statement from a nationally recognized, adequately equipped testing agency indicating that the items have been tested in accordance with required procedures and that the materials and equipment comply with all contract requirements will be accepted. However, materials and equipment installed in hazardous locations must bear the UL label unless the data submitted from other testing agency is specifically approved in writing by the Contracting Officer. Items which are required to be listed and labeled in accordance with Underwriters Laboratories must be affixed with a UL label that states that it is UL listed. No exceptions or waivers will be granted to this requirement. Materials and equipment will be approved based on the manufacturer's published data.

For other than equipment and materials specified to conform to UL publications, a manufacturer's statement indicating complete compliance with the applicable standard of the American Society for Testing and Materials, National Electrical Manufacturers Association, or other commercial standard, is acceptable.

1.5 WORKMANSHIP

Materials and equipment shall be installed in accordance with NFPA 70, recommendations of the manufacturer, and as shown.

PART 2 PRODUCTS

Products shall conform to the respective publications and other requirements specified below. Materials and equipment not listed below shall be as specified elsewhere in this section. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.1 BUSWAYS

UL 857. Busses shall be copper. Enclosures shall be steel. Short-circuit ratings, except as indicated, shall be in accordance with NEMA BU 1.

2.1.1 Feeder Busways

Feeder busways shall be ventilated, except that vertical busways within 1.8 meters (6 feet) of floors shall be unventilated low-impedance busway.

2.1.3 Plug-In Busways

Plug-in busways shall be unventilated. A hook stick of suitable length shall be provided for operating plug-in units from the floor. Plug-in units shall be of the circuit-breaker type.

2.2 CABLES AND WIRES

Conductors No. 8 AWG and larger diameter shall be stranded. Conductors No. 10 AWG and smaller diameter shall be solid, except that conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3, shall be stranded unless specifically indicated otherwise. Conductor sizes and ampacities shown are based on copper, unless indicated otherwise. All conductors shall be copper.

2.2.1 Equipment Manufacturer Requirements

When manufacturer's equipment requires copper conductors at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to meet manufacturer's requirements.

2.2.2 Aluminum Conductors

Aluminum conductors shall not be used

2.2.3 Insulation

Unless indicated otherwise, or required by NFPA 70, power and lighting wires shall be 600-volt, Type THWN, THHN, or THW, conforming to UL 83 or RHW conforming to UL 44, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits shall be Type TW, THW or TF, conforming to UL 83, or conforming to applicable KS, listed in Paragraph 1.1. References of this Section. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.2.4 Bonding Conductors

ASTM B 8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.2.5 Service Entrance Cables

Service entrance (SE) and underground service entrance (USE) cables, UL 854.

2.2.6 Non-metallic Sheathed Cable

UL 719, type NM or NMC.

2.2.7 Metal-Clad Cable

UL 1569; NFPA 70, Type MC cable.

2.2.8 Armored Cable

UL 4; NFPA 70, Type AC cable.

2.2.9 Mineral-Insulated, Metal-Sheathed Cable

UL listed NFPA 70, type MI cable. Sheathing containing asbestos fibers shall not be used.

2.2.10 Flat Conductor Cable

UL listed NFPA 70, type FCC.

2.2.11 Tray Cable or Power Limited Tray Cable

UL listed; Type TC or PLTC.

2.2.12 Cord Sets and Power-Supply Cords

UL 817.

2.3 CABLE TRAYS

NEMA VE 1 cable trays shall form a wireway system, and shall be of nominal 100 mm (4 inch) depth. Cable trays shall be constructed of zinc-coated steel. Trays shall include splice and end plates, dropouts, and miscellaneous hardware. Edges, fittings, and hardware shall be finished free from burrs and sharp edges. Fittings shall have not less than the load-carrying ability of straight tray sections and shall have manufacturer's minimum standard radius. Radius of bends shall be as shown.

2.3.1 Trough

Trough-type cable trays shall be of a minimal 150 mm (6 inch) width.

2.3.2 Ladder

Ladder-type cable trays shall be of minimal 150 mm (6 inch) width.

2.3.3 Channel

Channel-type cable trays shall be minimum of 75 mm (3 inch) width. Trays shall be one-piece construction having slots spaced not more than 110 mm (4-1/2 inches) on centers.

2.3.4 Cantilever

Cantilever-type, center-hung cable trays may be provided at the Contractor's option in lieu of other cable tray types specified.

2.4 TRANSIENT VOLTAGE SURGE PROTECTION

Transient voltage surge suppressors shall be provided as indicated. Surge suppressors shall meet the requirements of IEEE C62.41 and be UL listed and labeled as having been tested in accordance with UL 1449. Surge suppressor ratings shall be as indicated. Fuses shall not be used as surge suppression.

2.5 CHARGERS, BATTERY

Battery chargers shall be general purpose, continuous current output, with solid state rectifiers. Means shall be provided to regulate and to adjust the dc output voltage. Chargers shall have continuous current ratings of 10 to 15 percent higher than battery current outputs based upon an 8-hour discharge.

2.6 CIRCUIT BREAKERS

2.6.1 MOLDED-CASE CIRCUIT BREAKERS

Molded-case circuit breakers shall conform to NEMA AB 3 and UL 489and UL 877 for circuit breakers and circuit breaker enclosures located in hazardous (classified) locations. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers.

2.6.1.1 Construction

Circuit breakers shall be suitable for mounting and operating in any position. Lug shall be listed for copper conductors only in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.6.1.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with NEMA AB 3. Ratings shall be coordinated with system X/R ratio.

2.6.1.4 Cascade System Ratings

Circuit breakers used in series combinations shall be in accordance with UL 489. Equipment, such as switchboards and panelboards, which house series-connected circuit breakers shall be clearly marked accordingly. Series combinations shall be listed in the UL Recognized Component Directory under "Circuit Breakers-Series Connected."

2.6.1.5 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 150 amperes.

2.6.2 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be torodial construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings

2.6.3 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through I square times t to a value less than the I square times t of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.6.4 SWD Circuit Breakers

Circuit breakers rated 15 amperes and intended to switch 277 volts or less fluorescent lighting loads shall be marked "SWD."

2.6.5 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

2.6.6 Low-Voltage Power

a. Construction: Low-voltage power circuit breakers shall conform to IEEE C37.13, ANSI C37.16, and NEMA SG 3 and shall be three-pole, single-throw, stored energy, manually or electrically operated, with drawout mounting. Solid-state trip elements which require no external power connections shall be provided. Circuit breakers shall have an open/close contact position indicator, charged/discharged stored energy indicator, primary disconnect devices, and a mechanical interlock to prevent making or breaking contact of the primary disconnects when the circuit breaker is closed. Control voltage shall be as indicated. The circuit breaker enclosure shall be suitable for its intended location.

b. Ratings: Voltage ratings shall be not less than the applicable circuit voltage. Circuit breakers shall be rated for 100 percent continuous duty and shall have trip current ratings and frame sizes as shown. Nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings shall be in accordance with ANSI C37.16.

2.6.7 Ground Fault Circuit Interrupters

UL 943. Breakers equipped with ground fault circuit interrupters shall have ground fault class, interrupting capacity, and voltage and current ratings as indicated.

2.7 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

Motor short-circuit protectors shall conform to UL 508 and shall be provided as shown. Protectors shall be used only as part of a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection, and shall be rated in accordance with the requirements of NFPA 70.

2.7.1 Construction

Motor short-circuit protector bodies shall be constructed of high temperature, dimensionally stable, long life, nonhygroscopic materials. Protectors shall fit special MSCP mounting clips and shall not be interchangeable with any commercially available fuses. Protectors shall have 100 percent one-way interchangeability within the A-Y letter designations. All ratings shall be clearly visible.

2.7.2 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Letter designations shall be A through Y for motor controller Sizes 0, 1, 2, 3, 4, and 5, with 100,000 amperes interrupting capacity rating. Letter designations shall correspond to controller sizes as follows:

CONTROLLER SIZE	MSCP DESIGNATION
NEMA O	A-N
NEMA 1	A-P
NEMA 2	A-S
NEMA 3	A-U
NEMA 4	A-W
NEMA 5	A-Y

2.8 CONDUIT AND TUBING

2.8.1 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797 or KS D 8308.

2.8.2 Electrical Nonmetallic Tubing (ENT)

NEMA TC 13.

2.8.3 Electrical Plastic Tubing and Conduit

NEMA TC 2 or KS C 8431.

2.8.4 Flexible Conduit, Steel and Plastic

General-purpose type, UL 1; liquid tight, UL 360, and UL 1660 or KS C 8422.

2.8.5 Intermediate Metal Conduit

UL 1242.

2.8.6 PVC Coated Rigid Steel Conduit

NEMA RN 1.

2.8.7 Rigid Aluminum Conduit

ANSI C80.5 and UL 6.

2.8.8 Rigid Metal Conduit

UL 6 or KS C 8401.

2.8.9 Rigid Plastic Conduit

NEMA TC 2, UL 651 and UL 651A or KS C 8431.

2.8.10 Surface Metal Electrical Raceways and Fittings

UL 5.

2.9 CONDUIT AND DEVICE BOXES AND FITTINGS

2.9.1 Boxes, Metallic Outlet

NEMA OS 1 and UL 514A or KS C 8461 and KS C 8458.

2.9.2 Boxes, Nonmetallic, Outlet and Flush-Device Boxes and Covers

NEMA OS 2 and UL 514C.

2.9.3 Boxes, Outlet for Use in Hazardous (Classified) Locations

UL 886.

2.9.4 Boxes, Switch (Enclosed), Surface-Mounted

UL 98 or KS C 8461.

2.9.5 Fittings for Conduit and Outlet Boxes

UL 514B or KS C 8460 or KS C 8459.

2.9.6 Fittings For Use in Hazardous (Classified) Locations

UL 886.

2.9.7 Fittings, PVC, for Use with Rigid PVC Conduit and Tubing

UL 514B or KS C 8460 or KS C 8459 or KS C 8431.

2.10 CONDUIT COATINGS PLASTIC RESIN SYSTEM

NEMA RN 1, Type A-40.

2.11 CONNECTORS, WIRE PRESSURE

2.11.1 For Use With Copper Conductors

UL 486A.

2.11.3 For Use With Aluminum Conductors

UL 486B.

2.12 ELECTRICAL GROUNDING AND BONDING EQUIPMENT

UL 467.

2.12.1 Ground Rods

Ground rods shall be of copper-clad steel conforming to UL 467 not less than 19.1 mm (3/4 inch) in diameter by 2.4 meter (8 feet) in length.

2.12.2 Ground Bus

The ground bus shall be bare conductor or flat copper in one piece, if practicable.

2.13 ENCLOSURES

NEMA ICS 6 or NEMA 250 or UL 698 for use in hazardous (classified) locations unless otherwise specified.

2.13.1 Cabinets and Boxes

Cabinets and boxes with volume greater than 0.0164 cubic meters (100 cubic inches) shall be in accordance with UL 50 or KS D 8308, hot-dip, zinc-coated, if sheet steel.

2.13.2 Circuit Breaker Enclosures

UL 489.

2.13.3 Circuit Breaker Enclosures for Use in Hazardous (Classified) Locations

UL 877.

2.14 LIGHTING FIXTURES, LAMPS, BALLASTS, EMERGENCY EQUIPMENT, CONTROLS AND ACCESSORIES

The following specifications are supported and supplemented by information and details on the drawings. Additional fixtures, if shown, shall conform to this specification. Lighting equipment installed in classified hazardous locations shall conform to UL 844. Lamps, lampholders, ballasts, transformers, electronic circuitry and other lighting system components shall be constructed according to industry standards. Equipment shall be tested and listed by a recognized independent testing laboratory for the expected installation conditions. Equipment shall conform to the standards listed below.

2.14.1 Lamps

Lamps shall be constructed to operate in the specified fixture, and shall function without derating life or output as listed in published data. Lamps shall meet the requirements of the Energy Policy Act of 1992.

a. Incandescent and tungsten halogen lamps shall be designed for 125 volt operation (except for low voltage lamps), shall be rated for minimum life of 2,000 hours, and shall have color temperature between 2,800 and 3,200 degrees Kelvin. Tungsten halogen lamps shall incorporate quartz capsule construction. Lamps shall comply with ANSI C78.20 and sections 238 and 270 of ANSI C78.21.

b. Fluorescent lamps shall be designed to operate with the ballast and circuitry of the fixtures in which they will be used. Fluorescent lamps, including spares, shall be manufactured by one manufacturer to provide for color and performance consistency. Fluorescent lamps shall comply with ANSI C78.1. Fluorescent tube lamp efficiencies shall meet or exceed the following requirements.

(1) Linear fluorescent lamps, unless otherwise indicated, shall be 1219 mm (4 feet) long 32 watt T8, 265 mA, 2800 lumens with minimum CRI of 75. Lamps of other lengths or types shall be used only where specified or shown. Lamps shall deliver rated life when operated on rapid start or instant start ballasts or as shown.

(2) Small compact fluorescent lamps shall be twin, double, or triple tube configuration as shown with bi-pin or four-pin snap-in base and shall have minimum CRI of 85. They shall deliver rated life when operated on ballasts as shown. 9 and 13 watt double tube lamps shall comply with ANSI C78.2B. 18 and 26 watt double tube lamps shall comply with ANSI C78.2A. Minimum starting temperature shall be 0 degrees C (32 degrees F) for twin tube lamps and for double and triple twin tube lamps without internal starter; and -9 degrees C (15 degrees F) for double and triple twin tube lamps with internal starter.

(3) Long compact fluorescent lamps shall be 18, 27, 39, 40, 50, or 55 watt bi-axial type as shown with four-pin snap-in base; shall have minimum CRI of 85; and shall have a minimum starting temperature of 10 degrees C (50 degrees F). They shall deliver rated life when operated on rapid start or instant start ballasts or as shown.

c. High intensity discharge lamps, including spares, shall be manufactured by one manufacturer in order to provide color and performance consistency. High intensity discharge lamps shall be designed to operate with the ballasts and circuitry of the fixtures in which they will be used and shall have wattage, shape and base as shown. High intensity discharge lamps, unless otherwise shown, shall have medium or mogul screw base and minimum starting temperature of -29 degrees C (-20 degrees F). Metal halide lamps, unless otherwise shown, shall have minimum CRI of 65; color temperature of 4,300 degrees Kelvin; shall be -BU configuration if used in base-up position; and shall be -H or high output configuration if used in horizontal position. Lamps shall comply with all applicable ANSI C78.1350, ANSI C78.1351, ANSI C78.1352, ANSI C78.1355,ANSI C78.1375, and ANSI C78.1376.

2.14.2 Ballasts and Transformers

Ballasts or transformers shall be designed to operate the designated lamps within their optimum specifications, without derating the lamps. Lamp and ballast combinations shall be certified as acceptable by the lamp manufacturer.

a. Low voltage incandescent transformers shall be Class II UL listed 120/12 volt or 120/24 volt step-down transformers as required for the lamps shown. Transformers shall be high power factor type and shall be rated for continuous operation under the specified load. Transformers shall be encased or encased and potted, and mounted integrally within the lighting fixture unless otherwise shown.

b. Fluorescent ballasts shall comply with ANSI C82.1 and shall be mounted integrally within fluorescent fixture housing unless otherwise shown. Ballasts shall have maximum current crest factor of 1.7; high power factor; Class A sound rating; maximum operating case temperature of 25 degrees C (77 degrees F) above ambient; and shall be rated Class P. Unless otherwise indicated, the minimum number of ballasts shall be used to serve each individual fixture. A single ballast may be used to serve multiple fixtures if they are continuously mounted, identically controlled and factory manufactured for that installation with an integral wireway.

(1) Compact fluorescent ballasts shall comply with IEEE C62.41 Category A transient voltage variation requirements and shall be mounted integrally within compact fluorescent fixture housing unless otherwise shown. Ballasts shall have minimum ballast factor of 0.95; maximum current crest factor of 1.6; high power factor; maximum operating case temperature of 25 degrees C (77 degrees F) above ambient; shall be rated Class P; and shall have a sound rating of Class A. Ballasts shall meet FCC Class A specifications for EMI/RFI emissions. Ballasts shall operate from nominal line voltage of 120 or 277 volts at 60 Hz and maintain constant light output over a line voltage variation of + 10%. Ballasts shall have an end-of-lamp-life detection and shut-down circuit. Ballasts shall be UL listed and shall contain no PCBs. Ballasts shall contain potting to secure PC board, provide lead strain relief, and provide a moisture barrier.

(2) Electronic fluorescent ballasts shall comply with 47 CFR 18 for electromagnetic interference. Ballasts shall withstand line transients per IEEE C62.41, Category A. Ballasts shall have total harmonic distortion between 10 and 20%; minimum frequency of 20,000Hz; filament voltage between 2.5 and 4.5 volts; maximum starting inrush current of 20 amperes; and shall comply with the minimum Ballast Efficacy Factors shown in the table below. Minimum starting temperature shall be 10 degrees C (50 degrees F) or as shown.

ELECTRONIC FLUORESCENT BALLAST EFFICACY FACTORS

LAMP TYPE	TYPE OF STARTER & LAMP	NOMINAL OPERATIONAL VOLTAGE	NUMBER OF LAMPS	MINIMUM BALLAST EFFICACY FACTOR
32W T8	rapid start linear	120 or 277 V	1	2.54
			2	1.54
			3	0.93

4	0.73

(3) Dimming fluorescent ballasts shall be electronic and shall comply with the applicable electronic ballast specifications shown above. Dimming ballasts shall be compatible with the specified dimming control equipment and shall operate the lamps shown in the range from full rated light output to minimum of 20 percent of full rated light output. Dimming ballasts shall provide smooth square law dimming such that perceived dimming action is proportionate to the motion of the dimming control. Single or two-lamp dimming ballasts shall be used. Multi-lamp dimming ballasts shall be designed to operate lamps of the same length and current rating.

(4) Dimming compact fluorescent ballasts shall be electronic and shall comply with the applicable compact fluorescent and dimming ballast specifications shown above. Ballasts shall operate the lamps shown in the range from full rated light output to 5 percent of full rated light output. Ballast power factor shall be <90% throughout dimming range. THD shall be <10% at maximum light output and <20% at minimum light output. Ballast shall ignite the lamps at any light output setting selected.

c. High intensity discharge ballasts shall comply with UL 1029 and, if multiple supply types, with ANSI C82.4. Ballasts shall have minimum ballast factor of 0.9; high power factor; Class A sound rating; and maximum operating case temperature of 25 degrees C (77 degrees F) above ambient.

(1) Electronic high intensity discharge ballasts shall be constant wattage autotransformer type; shall have less than 10% ballast loss; shall have total harmonic distortion between 10 and 20%; and shall have a minimum starting temperature of -18 degrees C (0 degrees F).

(2) Magnetic high intensity discharge ballasts shall have a minimum starting temperature of -29 degrees C (-20 degrees F).

2.14.3 Fixtures

Fixtures shall be in accordance with the size, shape, appearance, finish, and performance shown. Unless otherwise indicated, lighting fixtures shall be provided with housings, junction boxes, wiring, lampholders, mounting supports, trim, hardware and accessories for a complete and operable installation. Recessed housings shall be minimum 20 gauge cold rolled or galvanized steel as shown. Extruded aluminum fixtures shall have minimum wall thickness of 3 mm (0.125 inches). Plastic lenses shall be 100% virgin acrylic or as shown. Glass lenses shall be tempered. Heat resistant glass shall be borosilicate type. Conoid recessed reflector cones shall be Alzak with clear specular low iridescent finish.

a. Incandescent fixtures shall comply with UL 1571. Incandescent fixture specular reflector cone trims shall be integral to the cone and shall be finished to match. Painted trim finishes shall be white with minimum reflectance of 88%. Low voltage incandescent fixtures shall have integral step-down transformers.

b. Fluorescent fixtures shall comply with UL 1570. Recessed ceiling fixtures shall comply with NEMA LE 4. Fixtures shall be plainly marked for proper lamp and ballast type to identify lamp diameter, wattage, color and start type. Marking shall be readily visible to service personnel, but not visible from normal viewing angles. Fluorescent fixture lens frames on recessed and surface mounted troffers shall be one assembly with mitered corners. Parabolic louvers shall have a low iridescent finish and 45 degree cut-off. Louver intersection joints shall be hairline type and shall conceal mounting tabs or other assembly methods. Louvers shall be free from blemishes, lines or defects which distort the visual surface. Integral ballast and wireway compartments shall be easily accessible without the use of special tools. Housings shall be constructed to include grounding necessary to start the lamps. Open fixtures shall be equipped with a sleeve, wire guard, or other positive means to prevent lamps from falling. Medium bi-pin lampholders shall be twist-in type with positive locking position. Long compact fluorescent fixtures and fixtures utilizing U-bend lamps shall have clamps or secondary lampholders to support the free ends of the lamps.

c. High intensity discharge fixture shall comply with UL 1572. Recessed ceiling fixtures shall comply with NEMA LE 4. Reflectors shall be anodized aluminum. Fixtures for horizontal lamps shall have position oriented lampholders. Lampholders shall be pulse-rated to 5,000 volts. Fixtures indicated as classified or rated for hazardous locations or special service shall be designed and independently tested for the environment in which they are installed. Recessed lens fixtures shall have extruded aluminum lens frames. Ballasts shall be integral to fixtures and shall be accessible without the use of special tools. Remote ballasts shall be encased and potted. Lamps shall be shielded from direct view with a UV absorbing material such as tempered glass, and shall be circuited through a cut-off switch which will shut off the lamp circuit if the lens is not in place.

d. Emergency lighting fixtures and accessories shall be constructed and independently tested to meet the requirements of applicable codes. Batteries shall be Nicad with no required maintenance, and shall have a minimum life expectancy of five years and warranty period of three years.

e. Exit Signs: Exit signs shall be ENERGY STAR compliant, thereby meeting the following requirements. Input power shall be less than 5 watts per face. Letter size and spacing shall adhere to NFPA 101. Luminance contrast shall be greater than 0.8. Average luminance shall be greater than 15 cd/m2 measured at normal (0 degree) and 45 degree viewing angles. Minimum luminance shall be greater than 8.6 cd/m2 measured at normal and 45 degree viewing angles. Maximum to minimum luminance shall be less than 20:1 measured at normal and 45 degree viewing angles. The manufacturer warranty for defective parts shall be at least 5 years.

2.14.4 Lampholders, Starters, and Starter Holders

UL 542

2.14.5 Ultrasonic, and Passive Infrared Occupancy Sensors

UL 916

2.15 LOW-VOLTAGE FUSES AND FUSEHOLDERS

2.15.1 Fuses, Low Voltage Cartridge Type

NEMA FU 1.

2.15.2 Fuses, High-Interrupting-Capacity, Current-Limiting Type

Fuses, Class G, J, L and CC shall be in accordance with UL 198C.

2.15.3 Fuses, Class K, High-Interrupting-Capacity Type

UL 198D.

2.15.4 Fuses, Class H

UL 198B.

2.15.5 Fuses, Class R

UL 198E.

2.15.6 Fuses, Class T

UL 198H.

2.15.7 Fuses for Supplementary Overcurrent Protection

UL 198G.

2.15.8 Fuses, D-C for Industrial Use

UL 198L.

2.15.9 Fuseholders

UL 512.

2.16 INSTRUMENTS, ELECTRICAL INDICATING

ANSI C39.1.

2.17 MOTORS, AC, FRACTIONAL AND INTEGRAL

Motors, ac, fractional and integral kilowatt (horsepower), 373.0 kW (500 hp) and smaller shall conform to NEMA MG 1 and UL 1004 for motors; NEMA MG 10 for energy management selection of polyphase motors; and UL 674 for use of motors in hazardous (classified) locations. In addition to the standards listed above, motors shall be provided with efficiencies as specified in the table "MINIMUM NOMINAL EFFICIENCIES" below.

2.17.1 Rating

The kilowatt (horsepower) rating of motors should be limited to no more than 125 percent of the maximum load being served unless a NEMA standard size does not fall within this range. In this case, the next larger NEMA standard motor size should be used.

2.17.2 Motor Efficiencies

All permanently wired polyphase motors of 746 W (1 hp) or more shall meet the minimum full-load efficiencies as indicated in the following table, and as specified in this specification. Motors of 746 W (1 hp) or more with open, drip proof or totally enclosed fan cooled enclosures shall be high efficiency type, unless otherwise indicated. Motor efficiencies indicated in the tables apply to general-purpose, single-speed, polyphase induction motors. Applications which require definite purpose, special purpose, special frame, or special mounted polyphase induction motors are excluded from these efficiency requirements. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section.

MINIMUM NOMINAL MOTOR EFFICIENCIES
OPEN DRIP PROOF MOTORS

kW	1200 RPM	1800 RPM	3600 RPM
0.746	82.5	85.5	80.0
1.12	86.5	86.5	85.5
1.59	87.5	86.5	86.5
2.24	89.5	89.5	86.5
3.73	89.5	89.5	89.5
5.60	91.7	91.0	89.5
7.46	91.7	91.7	90.2
11.3	92.4	93.0	91.0
14.9	92.4	93.0	92.4
18.7	93.0	93.6	93.0
22.4	93.6	93.6	93.0
29.8	94.1	94.1	93.6
37.3	94.1	94.5	93.6
44.8	95.0	95.0	94.1
56.9	95.0	95.0	94.5
74.6	95.0	95.4	94.5
93.3	95.4	95.4	95.0
112.0	95.8	95.8	95.4
149.0	95.4	95.8	95.4
187.0	95.4	96.2	95.8
224.0	95.4	95.0	95.4
261.0	94.5	95.4	95.0
298.0	94.1	95.8	95.0
336.0	94.5	95.4	95.4
373.0	94.5	94.5	94.5

TOTALLY ENCLOSED FAN-COOLED MOTORS

kW	1200 RPM	1800 RPM	3600 RPM
0.746	82.5	85.5	78.5
1.12	87.5	86.5	85.5
1.59	88.5	86.5	86.5
2.24	89.5	89.5	88.5
3.73	89.5	89.5	89.5
5.60	91.7	91.7	91.0
7.46	91.7	91.7	91.7
11.3	92.4	92.4	91.7
14.9	92.4	93.0	92.4
18.7	93.0	93.6	93.0

22.4	93.6	93.6	93.0
29.8	94.1	94.1	93.6
37.3	94.1	94.5	94.1
44.8	94.5	95.0	94.1
56.9	95.0	95.4	94.5
74.6	95.4	95.4	95.0
93.3	95.4	95.4	95.4
112.0	95.8	95.8	95.4
149.0	95.8	96.2	95.8
187.0	95.6	96.2	95.9
224.0	95.4	96.1	95.8
261.0	94.5	96.2	94.8
298.0	94.5	95.8	94.5
336.0	94.5	94.5	94.5
373.0	94.5	94.5	94.5

MINIMUM NOMINAL MOTOR EFFICIENCIES
OPEN DRIP PROOF MOTORS

HP	1200 RPM	1800 RPM	3600 RPM
1	82.5	85.5	80.0
1.5	86.5	86.5	85.5
2	87.5	86.5	86.5
3	89.5	89.5	86.5
5	89.5	89.5	89.5
7.5	91.7	91.0	89.5
10	91.7	91.7	90.2
15	92.4	93.0	91.0
20	92.4	93.0	92.4
25	93.0	93.6	93.0
30	93.6	93.6	93.0
40	94.1	94.1	93.6
50	94.1	94.5	93.6
60	95.0	95.0	94.1
75	95.0	95.0	94.5
100	95.0	95.4	94.5
125	95.4	95.4	95.0
150	95.8	95.8	95.4
200	95.4	95.8	95.4
250	95.4	96.2	95.8
300	95.4	95.0	95.4
350	94.5	95.4	95.0
400	94.1	95.8	95.0
450	94.5	95.4	95.4
500	94.5	94.5	94.5

TOTALLY ENCLOSED FAN-COOLED MOTORS

HP	1200 RPM	1800 RPM	3600 RPM
1	82.5	85.5	78.5
1.5	87.5	86.5	85.5
2	88.5	86.5	86.5
3	89.5	89.5	88.5

5	89.5	89.5	89.5
7.5	91.7	91.7	91.0
10	91.7	91.7	91.7
15	92.4	92.4	91.7
20	92.4	93.0	92.4
25	93.0	93.6	93.0
30	93.6	93.6	93.0
40	94.1	94.1	93.6
50	94.1	94.5	94.1
60	94.5	95.0	94.1
75	95.0	95.4	94.5
100	95.4	95.4	95.0
125	95.4	95.4	95.4
150	95.8	95.8	95.4
200	95.8	96.2	95.8
250	95.6	96.2	95.9
300	95.4	96.1	95.8
350	94.5	96.2	94.8
400	94.5	95.8	94.5
450	94.5	94.5	94.5
500	94.5	94.5	94.5

2.18 MOTOR CONTROLS AND MOTOR CONTROL CENTERS

2.18.1 General

NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845. Panelboards supplying non-linear loads shall have neutrals sized for 200 percent of rated current.

2.18.2 Motor Starters

Combination starters shall be provided as indicated.

2.18.2.1 Reduced-Voltage Starters

Reduced-voltage starters shall be provided for polyphase motors 37.3 kW (40 hp) or larger. Reduced-voltage starters shall be of the single-step autotransformer, reactor, or resistor type having an adjustable time interval between application of reduced and full voltages to the motors. Wye-delta reduced voltage starter or part winding increment starter having an adjustable time delay between application of voltage to first and second winding of motor may be used in lieu of the reduced voltage starters specified above for starting of motor-generator sets, centrifugally operated equipment or reciprocating compressors provided with automatic unloaders.

2.18.3 Thermal-Overload Protection

Each motor of 93 W (1/8 hp) or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.18.4 Low-Voltage Motor Overload Relays

2.18.4.1 General

Thermal and magnetic current overload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or motor controller, and shall be rated in accordance with the requirements of NFPA 70.

2.18.4.2 Construction

Manual reset type thermal relay shall be melting alloy or bimetallic construction. Automatic reset type thermal relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

2.18.4.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device and shall not be adjustable. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than minus 10 degrees C (18 degrees F) an ambient temperature-compensated overload relay shall be provided.

2.18.5 Automatic Control Devices

2.18.5.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate kilowatt horsepower rating.

2.18.5.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.18.5.3 Manual/Automatic Selection

a. Where combination manual and automatic control is specified and the automatic-control device operates the motor directly, a double-throw, three-position tumbler or rotary switch (marked MANUAL-OFF-AUTOMATIC) shall be provided for the manual control.

b. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.

c. Connections to the selector switch shall be such that; only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the Contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.18.6 Motor Control Centers

Control centers shall conform to the requirements of NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845. Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2, Class and Type as indicated. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Motor control centers shall be provided with a full-length ground bus bar.

2.19 PANELBOARDS

Dead-front construction, NEMA PB 1 and UL 67.

2.20 RECEPTACLES

2.20.1 Hospital Grade

UL 498.

2.20.2 Heavy Duty Grade

NEMA WD 1. Devices shall conform to all requirements for heavy duty receptacles.

2.20.3 Standard Grade

UL 498.

2.20.4 Ground Fault Interrupters

UL 943, Class A or B.

2.20.5 Hazardous (Classified) Locations

UL 1010.

2.20.6 NEMA Standard Receptacle Configurations

NEMA WD 6.

a. Single and Duplex: 20-Ampere, 125 Volt: 20-ampere, non-locking: NEMA type 5-20R, locking: NEMA type L5-20R.

b. 20-Ampere, 250 Volt: Two-pole, 3-wire grounding, non-locking: NEMA type 6-20R, locking: NEMA type L6-20R. Three-pole, 4-wire grounding, non-locking: NEMA type 15-20R, locking: NEMA type L15-20R.

c. 30-Ampere, 125/250 Volt: Three-pole, 3-wire, non-locking: NEMA type 10-30R, locking: NEMA type L10-30R. Three-pole, 4-wire grounding, non-locking: NEMA type 14-30R, locking: NEMA type L14-30R.

d. 30-Ampere, 250 Volt: Two-pole, 3-wire grounding, non-locking: NEMA type 6-30R, locking: NEMA type L6-30R. Three-pole, 4-wire grounding, non-locking: NEMA type 15-30R, locking: NEMA type L15-30R.

e. 50-Ampere, 125/250 Volt: Three-pole, 3-wire: NEMA type 10-50R. Three-pole, 4-wire grounding: NEMA type 14-50R.

f. 50-Ampere, 250 Volt: Two-pole, 3-wire grounding: NEMA type 6-50R. Three-pole, 4-wire grounding: NEMA type 15-50R.

2.21 Service Entrance Equipment

UL 869A.

2.22 SPLICE, CONDUCTOR

UL 486C.

2.23 POWER-SWITCHGEAR ASSEMBLIES INCLUDING SWITCHBOARDS

Assemblies shall be metal-enclosed, freestanding general-purpose or ventilated type in accordance with NEMA PB 2, UL 891 and IEEE C37.20.1 and shall be installed to provide front and rear access. Busses shall be copper. The withstand rating and interrupting capacity shall be based on the maximum fault current available.

2.23.1 Circuit Breakers

Circuit breakers shall be stationary, drawout, medium-voltage power circuit breakers, low-voltage power circuit breakers, molded-case circuit breakers, molded-case circuit breakers coordinated with current-limiting fuses, insulated-case, systems type circuit breakers, 4-position drawout type circuit breaker compartments with cell switches for connected, test; disconnected and withdrawn positions.

2.23.2 Auxiliary Equipment

2.23.2.1 Instruments

Instruments shall be long scale, semiflush rectangular, indicating or digital switchboard type, mounted at eye level.

a. Ammeter, range 0 to specified amperes, complete with selector switch having off position and positions to read each phase current.

b. Voltmeter, range 0 to specified volts, complete with selector switch having off position and positions to read each phase to phase, to neutral voltage.

2.23.2.2 Control Switch

A control switch with indicating lights shall be provided for each electrically operated breaker.

2.23.2.3 Control Power Sources

Control power shall be as specified.

2.24 SNAP SWITCHES

UL 20.

2.25 TAPES

2.25.1 Plastic Tape

UL 510.

2.25.2 Rubber Tape

UL 510.

2.26 TRANSFORMERS

Single- and three-phase transformers shall have two windings per phase. Full-capacity standard NEMA taps shall be provided in the primary windings of transformers unless otherwise indicated. Three-phase transformers shall be configured with delta-wye or wye-delta windings, except as indicated. Transformers supplying non-linear loads shall be UL listed as suitable for supplying such loads with a total K-factor not to exceed K-9 and have neutrals sized for 200 percent of rated current.

2.26.1 Transformers, Dry-Type

Transformers shall have 220 degrees C insulation system for transformers 15 kVA and greater, and shall have 180 degrees C insulation system for transformers rated 10 kVA and less, with temperature rise not exceeding 150 degrees C under full-rated load in maximum ambient temperature of 40 degrees C.

a. 600 Volt or Less Primary: NEMA ST 20, UL 506, general purpose, dry-type, self-cooled, ventilated, unventilated, sealed, epoxy-resin cast coil. Transformers shall be provided in NEMA specified enclosure for environment. Transformers shall be quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

b. 601 to 34,500 Volt Primary:

(1) Distribution: Ventilated, epoxy-resin cast coil, 1 to 500 kVA, single phase, and 15 to 500 kVA, three-phase, low-voltage 120-600 volts: ANSI C57.12.50.

(2) Power: Ventilated, epoxy-resin cast coil, 501 kVA and larger, three-phase, low-voltage 208Y/120 to 4160 volts: ANSI C57.12.51.

(3) Power: Sealed, epoxy-resin cast coil, 501 kVA and larger, three-phase, low-voltage 208Y/120 to 4160 volts: ANSI C57.12.52.

2.26.2 Liquid-Insulated Transformers

IEEE C57.12.00, ANSI C57.12.10, ANSI C57.12.13, ANSI C57.12.27, ANSI C57.12.70, IEEE C57.12.80, IEEE C57.12.90, IEEE C57.98, and IEEE C57.100. Transformers may be the mineral-oil insulated, silicone, or the high-molecular weight hydrocarbon (HMWH) type. Voltage and KVA ratings shall be as indicated. Pressure relief valves and relays required for safe operation in an interior location or vault shall be provided. Transformers rated above 300 kVA shall be equipped with features to permit the future addition of cooling fans, controls, and wiring. Temperature rise shall not exceed 65 degrees C under full load operation in an ambient temperature of 40 degrees C. Percent voltage impedance shall be as required to limit the available fault current to less than the withstand rating of the equipment fed by the transformer. The basic impulse insulation level (BIL) rating shall be not less than 95 kV for the distribution voltage shown. Nameplates shall be provided in accordance with IEEE C57.12.00.

2.26.3 Average Sound Level

The average sound level in decibels (dB) of transformers shall not exceed the following dB level at 300 mm 12 inches for the applicable kVA rating range listed unless otherwise indicated:

kVA Range	dB Sound Level
1-50	50
51-150	55
151-300	58
301-500	60
501-700	62
701-1000	64
1001-1500	65
1501 & above	70

2.27 ISOLATED POWER SYSTEM EQUIPMENT

UL 1047, with monitor UL 1022.

2.28 WATTHOUR METERS, UTILITY REVENUE

Watthour meters shall conform to ANSI C12.1 and ANSI C12.10, except numbered terminal wiring sequence and case size may be the manufacturer's standard. Watthour meters shall be of the drawout switchboard type, socket-mounted outdoor, indoor type having a 15-minute, cumulative form, demand register meeting ANSI C12.4 and provided with not less than two and one-half stators. Watthour demand meters shall have factory-installed electronic pulse initiators meeting the requirements of ANSI C12.1. Pulse initiators shall be solid-state devices incorporating light-emitting diodes, phototransistors, and power transistors, except that mercury-wetted output contacts are acceptable. Initiators shall be totally contained within watthour demand meter enclosures, shall be capable of operating up to speeds of 500 pulses per minute with no false pulses, and shall require no field adjustments. Initiators shall be calibrated for a pulse rate output of one pulse per 1/4 disc revolution of the associated meter and shall be compatible with the indicated equipment.

2.29 INSTRUMENT TRANSFORMERS

2.29.1 General

Instrument transformers shall comply with ANSI C12.11 and IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on drawings.

2.29.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be not less than 1.0. Other thermal and mechanical ratings of current transformer and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accidental open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

2.29.2.5 Voltage Transformers

Voltage transformers shall have indicated ratios. Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.30 WIRING DEVICES

NEMA WD 1 for wiring devices, and NEMA WD 6 for dimensional requirements of wiring devices.

2.31 Liquid-Dielectrics

Liquid dielectrics for transformers, capacitors, and other liquid-filled electrical equipment shall be non-polychlorinated biphenyl (PCB) mineral oil or less flammable liquid as specified. Nonflammable fluids shall not be used. Tetrachloroethylene (perchloroethylene) and 1, 2, 4 trichlorobenzene fluids shall be certified by the manufacturer as having less than 2 parts per million (ppm) PCB content. In lieu of the manufacturer's certification, the Contractor may submit a test sample of the dielectric in accordance with ASTM D 4059 at a testing facility approved by the Contracting Officer. Equipment with test results indicating PCB level exceeding 2 ppm shall be replaced.

PART 3 EXECUTION

3.1 GROUNDING

Grounding shall be in conformance with NFPA 70, the contract drawings, and the following specifications.

3.1.1 Ground Rods

The resistance to ground shall be measured using the fall-of-potential method described in IEEE Std 81. The maximum resistance of a driven ground shall not exceed 25 ohms under normally dry conditions. If this resistance cannot be obtained with a single rod, 2 additional rods not less than 1.8 meters (6 feet) on centers. In high-ground-resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately. Connections below grade shall be fusion welded. Connections above grade shall be fusion welded or shall use UL 467 approved connectors.

3.1.3 Ground Bus

Ground bus shall be provided in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of electrical equipment shall be effectively grounded by bonding to the ground bus. The ground bus shall be bonded to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 100 mm (4 inches) above the floor. Connections and splices shall be of the brazed, welded, bolted, or pressure-connector type, except that pressure connectors or bolted connections shall be used for connections to removable equipment. For raised floor equipment rooms in computer and data processing centers, a minimum of 4, one at each corner, multiple grounding systems shall be furnished. Connections shall be bolted type in lieu of thermoweld, so they can be changed as required by additions and/or alterations.

3.1.4 Grounding Conductors

A green equipment grounding conductor, sized in accordance with NFPA 70 shall be provided, regardless of the type of conduit. Equipment grounding bars shall be provided in all panelboards. The equipment grounding conductor shall be carried back to the service entrance grounding connection or separately derived grounding connection. All equipment grounding conductors, including metallic raceway systems used as such, shall be bonded or joined together in each wiring box or equipment enclosure. Metallic raceways and grounding conductors shall be checked to assure that they are wired or bonded into a common junction. Metallic boxes and enclosures, if used, shall also be bonded to these grounding conductors by an approved means per NFPA 70. When switches, or other utilization devices are installed, any designated grounding terminal on these devices shall also be bonded to the equipment grounding conductor junction with a short jumper.

3.2 WIRING METHODS

Wiring shall conform to NFPA 70, the contract drawings, and the following specifications. Unless otherwise indicated, wiring shall consist of insulated conductors installed in rigid zinc-coated steel conduit. Where cables and wires are installed in cable trays, they shall be of the type permitted by NFPA 70 for use in such applications. Nonmetallic-sheathed cables or metallic-armored cables may be installed in areas permitted by NFPA

70. Wire fill in conduits shall be based on NFPA 70 for the type of conduit and wire insulation specified. Wire fill in conduits located in Class I or II hazardous areas shall be limited to 25 percent of the cross sectional area of the conduit.

3.2.1 Conduit Systems

Conduit systems shall be installed as indicated. Conduit sizes shown are based on use of copper conductors with insulation types as described in paragraph WIRING METHODS. Minimum size of raceways shall be 15 mm (1/2 inch). Only metal conduits will be permitted when conduits are required for shielding or other special purposes indicated, or when required by conformance to NFPA 70. Nonmetallic conduit may be used in damp, wet or corrosive locations when permitted by NFPA 70 and the conduit system is provided with appropriate boxes, covers, clamps, screws or other appropriate type of fittings. Bushings, manufactured fittings or boxes providing equivalent means of protection shall be installed on the ends of all conduits and shall be of the insulating type, where required by NFPA 70. Penetrations of above grade floor slabs, time-rated partitions and fire walls shall be fire-stopped in accordance with Section 07270 FIRE STOPPING. Raceways shall not be installed under the firepits of boilers and furnaces and shall be kept 150 mm (6 inches) away from parallel runs of flues, steam pipes and hot-water pipes. Raceways shall be concealed within finished walls, ceilings, and floors unless otherwise shown. Raceways crossing structural expansion joints or seismic joints shall be provided with suitable expansion fittings or other suitable means to compensate for the building expansion and contraction and to provide for continuity of grounding. Wiring installed in underfloor duct system or underfloor raceway system shall be suitable for installation in wet locations.

3.2.1.1 Pull Wires

A pull wire shall be inserted in each empty raceway in which wiring is to be installed if the raceway is more than 15 meters (50 feet) in length and contains more than the equivalent of two 90-degree bends, or where the raceway is more than 45 meters (150 feet) in length. The pull wire shall be of No. 14 AWG zinc-coated steel, or of plastic having not less than 1.5 MPa (200 psi) tensile strength. Not less than 254 mm (10 inches) of slack shall be left at each end of the pull wire.

3.2.1.3 Conduit Stub-Ups

Where conduits are to be stubbed up through concrete floors, a short elbow shall be installed below grade to transition from the horizontal run of conduit to a vertical run. A conduit coupling fitting, threaded on the inside shall be installed, to allow terminating the conduit flush with the finished floor. Wiring shall be extended in rigid threaded conduit to equipment, except that where required, flexible conduit may be used 150 mm (6 inches) above the floor. Empty or spare conduit stub-ups shall be plugged flush with the finished floor with a threaded, recessed plug.

3.2.1.4 Below Slab-on-Grade or in the Ground

Electrical wiring below slab-on-grade shall be protected by a conduit system. Conduit passing vertically through slabs-on-grade shall be rigid steel. Rigid steel conduits installed below slab-on-grade or in the earth shall be field wrapped with 0.254 mm (0.010 inch) thick pipe-wrapping plastic tape applied with a 50 percent overlay, or shall have a factory-applied polyvinyl chloride, plastic resin, or epoxy coating system.

3.2.1.5 Installing in Slabs Including Slabs on Grade

Conduit installed in slabs-on-grade shall be rigid steel or IMC. Conduits shall be installed as close to the middle of concrete slabs as practicable without disturbing the reinforcement. Outside diameter shall not exceed 1/3 of the slab thickness and conduits shall be spaced not closer than 3 diameters on centers except at cabinet locations where the slab thickness shall be increased as approved by the Contracting Officer. Where conduit is run parallel to reinforcing steel, the conduit shall be spaced a minimum of one conduit diameter away but not less than 25.4 mm (one inch) from the reinforcing steel.

3.2.1.5 Changes in Direction of Runs

Changes in direction of runs shall be made with symmetrical bends or cast-metal fittings. Field-made bends and offsets shall be made with an approved hickey or conduit-bending machine. Crushed or deformed raceways shall not be installed. Trapped raceways in damp and wet locations shall be avoided where possible. Lodgment of plaster, dirt, or trash in raceways, boxes, fittings and equipment shall be prevented during the course of construction. Clogged raceways shall be cleared of obstructions or shall be replaced.

3.2.1.6 Supports

Metallic conduits and support system to which they are attached, shall be securely and rigidly fastened in place to prevent vertical and horizontal movement at intervals of not more than 3 meters (10 feet) and within 900 mm (3 feet) of boxes, cabinets, and fittings, with approved pipe straps, wall brackets, conduit clamps, conduit hangers, threaded C-clamps, beam clamps, or ceiling trapeze. Loads and supports shall be coordinated with supporting structure to prevent damage or deformation to the structure. Loads shall not be applied to joist bridging. Attachment shall be by wood screws or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion bolts on concrete or brick; by machine screws, welded threaded studs, heat-treated or spring-steel-tension clamps on steel work. Nail-type nylon anchors or threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine screws. Raceways or pipe straps shall not be welded to steel structures. Cutting the main reinforcing bars in reinforced concrete beams or joists shall be avoided when drilling holes for support anchors. Holes drilled for support anchors, but not used, shall be filled. In partitions of light steel construction, sheet-metal screws may be used. Raceways shall not be supported using wire or nylon ties. Raceways shall be independently supported from the structure. Upper raceways shall not be used as a means of support for lower raceways. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts. Cables and raceways shall not be supported by ceiling grids. Except where permitted by NFPA 70, wiring shall not be supported by ceiling support systems. Conduits shall be fastened to sheet-metal boxes and cabinets with two locknuts where required by NFPA 70, where insulating bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, a single locknut and bushing may be used. Threadless fittings for electrical metallic tubing shall be of a type approved for the conditions encountered. Additional support for horizontal runs is not required when EMT rests on steel stud cutouts.

3.2.1.7 Exposed Raceways

Exposed raceways shall be installed parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. Raceways under raised floors and above accessible ceilings shall be considered as exposed installations in accordance with NFPA 70 definitions.

3.2.1.8 Exposed Risers

Exposed risers in wire shafts of multistory buildings shall be supported by U-clamp hangers at each floor level, and at intervals not to exceed 3 meters (10 feet).

3.2.1.9 Exposed Lengths of Conduit, Over 600 Volts

Exposed lengths of conduit containing power conductors operating at more than 600 volts shall have two red bands 50 mm (2 inches) wide spaced 200 mm (8 inches) apart painted near each coupling; the intervening space between the red bands shall be painted white, and on the white space the voltage rating shall be stenciled in black.

3.2.1.10 Communications Raceways

Communications raceways indicated shall be installed in accordance with the previous requirements for conduit and tubing and with the additional requirement that no length of run shall exceed 15 meters (50 feet) for 15 mm (1/2 inch) and 20 mm (3/4 inch) sizes, and 30 meters (100 feet) for 25 mm (1 inch) or larger sizes, and shall not contain more than two 90-degree bends or the equivalent. Additional pull or junction boxes shall be installed to comply with these limitations whether or not indicated. Inside radii of bends in conduits of 25 mm (1 inch) size or larger shall not be less than ten times the nominal diameter.

3.2.2 Busway Systems

Busway systems shall be of the voltage, capacity, and phase characteristics indicated. Vertical runs of busways within 1.8 meters (6 feet) of the floor shall have solid enclosures. Busways shall be supported at intervals not exceeding 1.5 meters (5 feet) and shall be braced properly to prevent lateral movement. Busways penetrating walls or floors shall be provided with flanges to completely close wall or floor openings.

3.2.3 Cable Trays

Cable trays shall be supported in accordance with the recommendations of the manufacturer but at no more than 1.8 meter (6 foot) intervals. Contact surfaces of aluminum connections shall be coated with an antioxidant compound prior to assembly. Adjacent cable tray sections shall be bonded together by connector plates of an identical type as the cable tray sections. The Contractor shall submit the manufacturer's certification that the cable tray system meets all requirements of Article 392 of NFPA 70. The cable tray shall be installed and grounded in accordance with the provisions of Article 392 of NFPA 70. Data submitted by the Contractor shall demonstrate that the completed cable tray systems will comply with the specified requirements. Cable trays shall terminate 250 mm (10 inches) from both sides of smoke and fire partitions. Conductors run through smoke and fire partitions shall be installed in 103 mm (4 inch) rigid steel conduits with grounding bushings, extending 300 mm (12 inches) beyond each side of the partitions. The installation shall be sealed to preserve the smoke and fire rating of the partitions. Penetrations shall be firestopped in accordance with Section 07270 FIRESTOPPING.

3.2.4 Cables and Conductors

Installation shall conform to the requirements of NFPA 70. Covered, bare or insulated conductors of circuits rated over 600 volts shall not occupy the same equipment wiring enclosure, cable, or raceway with conductors of circuits rated 600 volts or less.

3.2.4.1 Sizing

Unless otherwise noted, all sizes are based on copper conductors and the insulation types indicated. Sizes shall be not less than indicated. Branch-circuit conductors shall be not smaller than No. 12 AWG. Conductors for branch circuits of 120 volts more than 30 meters (100 feet) long and of 277 volts more than 70 meters (230 feet) long, from panel to load center, shall be no smaller than No. 10 AWG. Class 1 remote control and signal circuit conductors shall be not less than No. 14 AWG. Class 2 remote control and signal circuit conductors shall be not less than No. 16 AWG. Class 3 low-energy, remote-control and signal circuits shall be not less than No. 22 AWG.

3.2.4.2 Use of Aluminum Conductors in Lieu of Copper

Aluminum conductors shall not be used.

3.2.4.3 Cable Systems

Cable systems shall be installed where indicated. Cables shall be installed concealed behind ceiling or wall finish where practicable. Cables shall be threaded through holes bored on the approximate centerline of wood members; notching of surfaces will not be permitted. Sleeves shall be provided through bond beams of masonry-block walls for threading cables through hollow spaces. Exposed cables shall be installed parallel or at right angles to walls or structural members. In rooms or areas not provided with ceiling or wall finish, cables and outlets shall be installed so that a room finish may be applied in the future without disturbing the cables or resetting the boxes. Exposed nonmetallic-sheathed cables less than 1.3 meters (4 feet) above floors shall be protected from mechanical injury by installation in conduit.

3.2.4.4 Mineral-Insulated Cable

Mineral-insulated, metal-sheathed cable system, Type MI, may be used in lieu of exposed conduit and wiring. Conductor sizes shall be not less than those indicated for the conduit installation. Cables shall be fastened within 300 mm (12 inches) of each turn or offset and at intervals of not more than 1.8 meters (6 feet). Cable terminations shall be made in accordance with manufacturer's recommendations.

3.2.4.5 Cable Splicing

Splices shall be made in an accessible location. Crimping tools and dies shall be approved by the connector manufacturer for use with the type of connector and conductor.

a. Copper Conductors, 600 Volt and Under: Splices in conductors No. 10 AWG and smaller diameter shall be made with an insulated, pressure-type connector. Splices in conductors No. 8 AWG and larger diameter shall be made with a solderless connector and insulated with tape or heat-shrink type insulating material equivalent to the conductor insulation.

c. Greater Than 600 Volt: Cable splices shall be made in accordance with the cable manufacturer's recommendations and Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

3.2.4.6 Conductor Identification and Tagging

Power, control, and signal circuit conductor identification shall be provided within each enclosure where a tap, splice, or termination is made. Where several feeders pass through a common pull box, the feeders shall be tagged to indicate clearly the electrical characteristics, circuit number, and panel designation. Phase conductors of low voltage power circuits shall be identified by color coding. Phase identification by a particular color shall be maintained continuously for the length of a circuit, including junctions.

a. Color coding shall be provided for service, feeder, branch, and ground conductors. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in the same raceway or box, other neutral shall be white with colored (not green) stripe. The color coding for 3-phase and single-phase low voltage systems shall be as follows:

120/208-volt, 3-phase: Black(A), red(B), and blue(C).
277/480-volt, 3-phase: Brown(A), orange(B), and yellow(C).
120/240-volt, 1-phase: Black and red.

b. Conductor phase and voltage identification shall be made by color-coded insulation for all conductors smaller than No. 6 AWG. For conductors No. 6 AWG and larger, identification shall be made by color-coded insulation, or conductors with black insulation may be furnished and identified by the use of half-lapped bands of colored electrical tape wrapped around the insulation for a minimum of 75 mm (3 inches) of length near the end, or other method as submitted by the Contractor and approved by the Contracting Officer.

c. Control and signal circuit conductor identification shall be made by color-coded insulated conductors, plastic-coated self-sticking printed markers, permanently attached stamped metal foil markers, or equivalent means as approved. Control circuit terminals of equipment shall be properly identified. Terminal and conductor identification shall match that shown on approved detail drawings. Hand lettering or marking is not acceptable.

3.3 BOXES AND SUPPORTS

Boxes shall be provided in the wiring or raceway systems where required by NFPA 70 for pulling of wires, making connections, and mounting of devices or fixtures. Pull boxes shall be furnished with screw-fastened covers. Indicated elevations are approximate, except where minimum mounting heights for hazardous areas are required by NFPA 70. Unless otherwise indicated, boxes for wall switches shall be mounted 1.3 meters (48 inches) above finished floors. Switch and outlet boxes located on opposite sides of fire rated walls shall be separated by a minimum horizontal distance of 600 mm (24 inches). The total combined area of all box openings in fire rated walls shall not exceed 0.0645 square meters (100 square inches) per 9.3 square meters (100 square feet). Maximum box areas for individual boxes in fire rated walls vary with the manufacturer and shall not exceed the maximum specified for that box in UL Elec Const Dir. Only boxes listed in UL Elec Const Dir shall be used in fire rated walls.

3.3.1 Box Applications

Each box shall have not less than the volume required by NFPA 70 for number of conductors enclosed in box. Boxes for metallic raceways shall be listed for the intended use when located in normally wet locations, when flush or surface mounted on outside of exterior surfaces, or when located in hazardous areas. Boxes installed in wet locations and boxes installed flush with the outside of exterior surfaces shall be gasketed. Boxes for mounting lighting fixtures shall be not less than 102 mm (4 inches square), or octagonal, except smaller boxes may be installed as required by fixture configuration, as approved. Cast-metal boxes with 2.4 mm (3/32 inch) wall thickness are acceptable. Boxes in other locations shall be sheet steel except that nonmetallic boxes may be used with nonmetallic conduit and tubing or nonmetallic sheathed cable system, when permitted by NFPA 70. Boxes for use in masonry-block or tile walls shall be square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers.

3.3.2 Brackets and Fasteners

Boxes and supports shall be fastened to wood with wood screws or screw-type nails of equal holding strength, with bolts and metal expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screw or welded studs on steel work. Threaded studs driven in by powder charge and provided with lockwashers and nuts, or nail-type nylon anchors may be used in lieu of expansion shields, or machine screws. Penetration of more than 38.1 mm (1-1/2 inches) into reinforced-concrete beams or more than 19.1 mm (3/4 inch) into reinforced-concrete joists shall avoid cutting any main reinforcing steel. The use of brackets which depend on gypsum wallboard or plasterboard for primary support will not be permitted. In partitions of light steel construction, bar hangers with 25 mm (1 inch) long studs, mounted between metal wall studs or metal box mounting brackets shall be used to secure boxes to the building structure. When metal box mounting brackets are used, additional box support shall be provided on the side of the box opposite the brackets. This additional box support shall consist of a minimum 300 mm (12 inch) long section of wall stud, bracketed to the opposite side of the box and secured by two screws through the wallboard on each side of the stud. Metal screws may be used in lieu of the metal box mounting brackets.

3.3.3 Mounting in Walls, Ceilings, or Recessed Locations

In walls or ceilings of concrete, tile, or other non-combustible material, boxes shall be installed so that the edge of the box is not recessed more than 6 mm (1/4 inch) from the finished surface. Boxes mounted in combustible walls or ceiling material shall be mounted flush with the finished surface. The use of gypsum or plasterboard as a means of supporting boxes will not be permitted. Boxes installed for concealed wiring shall be provided with suitable extension rings or plaster covers, as required. The bottom of boxes installed in masonry-block walls for concealed wiring shall be mounted flush with the top of a block to minimize cutting of the blocks, and boxes shall be located horizontally to avoid cutting webs of block. Separate boxes shall be provided for flush or recessed fixtures when required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided.

3.3.4 Installation in Overhead Spaces

In open overhead spaces, cast-metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast-metal boxes having threadless connectors and sheet metal boxes shall be supported directly from the building structure or by bar hangers. Hangers shall not be fastened to or supported from joist bridging. Where bar hangers are used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported with an approved type fastener not more than 600 mm (24 inches) from the box.

3.4 DEVICE PLATES

One-piece type device plates shall be provided for all outlets and fittings. Plates on unfinished walls and on fittings shall be of zinc-coated sheet steel, cast-metal, or impact resistant plastic having rounded or beveled edges. Plates on finished walls shall be of steel with baked enamel finish or impact-resistant plastic and shall be ivory or as indicated or satin finish corrosion resistant steel or satin finish chromium plated brass. Screws shall be of metal with countersunk heads, in a color to match the finish of the plate. Plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1.6 mm (1/16 inch). The use of sectional-type device plates will not be permitted. Plates installed in wet locations shall be gasketed and provided with a hinged, gasketed cover, unless otherwise specified.

3.5 RECEPTACLES

3.5.1 Single and Duplex, 20-ampere, 125 volt

Single and duplex receptacles shall be rated 20 amperes, 125 volts, two-pole, three-wire, grounding type with polarized parallel slots. Bodies shall be to match color of switch handles in the same room or to harmonize with the color of the respective wall, and supported by mounting strap having plaster ears. Contact arrangement shall be such that contact is made on two sides of an inserted blade. Receptacle shall be side- or back-wired with two screws per terminal. The third grounding pole shall be connected to the metal mounting yoke. Switched receptacles shall be the same as other receptacles specified except that the ungrounded pole of each suitable receptacle shall be provided with a separate terminal. Only the top receptacle of a duplex receptacle shall be wired for switching application. Receptacles with ground fault circuit interrupters shall have the current rating as indicated, and shall be UL Class A type unless otherwise shown. Ground fault circuit protection shall be provided as required by NFPA 70 and as indicated on the drawings.

3.5.2 Clock Outlet

Clock outlet, for use in other than a wired clock system, shall consist of an outlet box, a plaster cover where required, and a single receptacle with clock-outlet plate. The receptacle shall be recessed sufficiently within the box to allow the complete insertion of a standard cap, flush with the plate. A suitable clip or support for hanging the clock shall be secured to the top of the plate. Material and finish of the plate shall be as specified in paragraph DEVICE PLATES.

3.5.3 Floor Outlets

Floor outlets shall be adjustable and each outlet shall consist of a cast-metal body with threaded openings for conduits and cover plate with 15 mm (1/2 inch) or 20 mm (3/4 inch) threaded flush plug. Each telephone outlet shall consist of a horizontal cast housing with a receptacle as specified. Gaskets shall be used where necessary to ensure a watertight installation. Plugs with installation instructions shall be delivered to the Contracting Officer at the job site for capping outlets upon removal of service fittings.

3.5.4 Weatherproof Applications

Weatherproof receptacles shall be suitable for the environment, damp or wet as applicable, and the housings shall be labeled to identify the allowable use. Receptacles shall be marked in accordance with UL 514A for the type of use indicated; "Damp locations", "Wet Locations", "Wet Location Only When Cover Closed". Assemblies shall be installed in accordance with the manufacturer's recommendations.

3.5.4.1 Damp Locations

Receptacles in damp locations shall be mounted in an outlet box with a gasketed, weatherproof, cast-metal cover plate (device plate, box cover) and a gasketed cap (hood, receptacle cover) over each receptacle opening. The cap shall be either a screw-on type permanently attached to the cover plate by a short length of bead chain or shall be a flap type attached to the cover with a spring loaded hinge.

3.5.4.2 Wet Locations

Receptacles in wet locations shall be installed in an assembly rated for such use whether the plug is inserted or withdrawn, unless otherwise indicated. In a duplex installation, the receptacle cover shall be configured to shield the connections whether one or both receptacles are in use. Assemblies which utilize a self-sealing boot or gasket to maintain wet location rating shall be furnished with a compatible plug at each receptacle location and a sign notifying the user that only plugs intended for use with the sealing boot shall be connected during wet conditions.

3.5.5 Receptacles, 20-Ampere, 250-Volt

Receptacles, single, 20-ampere, 250-volt, shall be ivory or as indicated molded plastic, two-pole, three-wire or three-pole, four-wire, grounding type complete with appropriate mating cord-grip plug.

3.5.6 Receptacles, 30-Ampere, 125/250-Volt

Receptacles, single, 30-ampere, 125/250-volt, shall be molded-plastic, three-pole, four-wire, grounding type, complete with appropriate mating cord-grip type attachment plug. Each dryer receptacle shall be furnished with a non-detachable power supply cord for connection to the electric clothes dryer. The cord shall be an angle-type 900 mm (36 inch) length of Type SRD, SRDE or SRDT range and dryer cable with three No. 10 AWG conductors.

3.5.7 Receptacles, 30-Ampere, 250-Volt

Receptacles, single, 30-ampere, 250-volt, shall be molded-plastic, three-pole, three-wire type, complete with appropriate mating cord-grip plug.

3.5.9 Receptacles, 50-Ampere, 125/250-Volt

Receptacles, single 50-ampere, 125/250-volt, shall be flush, molded plastic, three-pole, four-wire, grounding type. Each range receptacle shall be furnished with a nondetachable power supply cord for connection to the electric range. The cord shall be an angle-type 900 mm (36 inch) length of SRD, SRDE or SRDT range and dryer cable with one No. 8 and two No. 6 AWG conductors.

3.5.10 Receptacles, 50-Ampere, 250-Volt

Receptacles, single, 50-ampere, 250-volt, shall be flush molded plastic, three-pole, three-wire type, complete with appropriate mating cord-grip plug.

3.5.11 Special-Purpose or Heavy-Duty Receptacles

Special-purpose or heavy-duty receptacles shall be of the type and of ratings and number of poles indicated or required for the anticipated purpose. Contact surfaces may be either round or rectangular. One appropriate straight or angle-type plug shall be furnished with each receptacle. Locking type receptacles, rated 30 amperes or less, shall be locked by rotating the plug. Locking type receptacles, rated more than 50 amperes, shall utilize a locking ring.

3.6 WALL SWITCHES

Wall switches shall be of the totally enclosed tumbler type. The wall switch handle and switch plate color shall be ivory or as indicated. Wiring terminals shall be of the screw type or of the solderless pressure type having suitable conductor-release arrangement. Not more than one switch shall be installed in a single-gang position. Switches shall be rated 20-ampere 120 or 277 volt for use on alternating current only. Pilot lights indicated shall consist of yoke-mounted candelabra-base sockets rated at 75 watts, 125 volts, and fitted with glass or plastic jewels. A clear 6-watt lamp shall be furnished and installed in each pilot switch. Jewels for use with switches controlling motors shall be green, and jewels for other purposes shall be red. Dimming switches shall be solid-state flush mounted, sized for the loads.

3.7 SERVICE EQUIPMENT

Service-disconnecting means shall be of the type indicated with an external handle for manual operation. When service disconnecting means is a part of an assembly, the assembly shall be listed as suitable for service entrance equipment. Enclosures shall be sheet metal with hinged cover for surface mounting unless otherwise indicated.

3.8 PANELBOARDS AND LOADCENTERS

Circuit breakers and switches used as a motor disconnecting means shall be capable of being locked in the open position. Door locks shall be keyed alike. Nameplates shall be as approved. Directories shall be typed to indicate loads served by each circuit and mounted in a holder behind a clear protective covering. Busses shall be copper.

3.8.1 Loadcenters

Loadcenters shall be circuit breaker equipped.

3.8.2 Panelboards

Panelboards shall be circuit breaker or fusible switch equipped as indicated on the drawings

3.9 FUSES

Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilize fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current characteristics required for effective power system coordination. Time-delay and non-time-delay options shall be as specified.

3.9.1 Cartridge Fuses; Noncurrent-Limiting Type

Cartridge fuses of the noncurrent-limiting type shall be Class H, nonrenewable, dual element, time lag type and shall have interrupting capacity of 10,000 amperes. At 500 percent current, cartridge fuses shall not blow in less than 10 seconds.

3.9.2 Cartridge Fuses; Current-Limiting Type

Cartridge fuses, current-limiting type, Class G, J, K, L, RK1, RK5, RK9, T, or CC shall have tested interrupting capacity not less than 100,000 amperes. Fuse holders shall be the type that will reject all Class H fuses.

3.9.5 Motor and Transformer Circuit Fuses

Motor, motor controller, transformer, and inductive circuit fuses shall be Class RK1 or RK5, current-limiting, time-delay with 200,000 amperes interrupting capacity.

3.10 UNDERGROUND SERVICE

Unless otherwise indicated, interior conduit systems shall be stubbed out 1.5 m (5 feet) beyond the building wall and 600 mm (2 feet) below finished grade, for interface with the exterior service lateral conduits and exterior communications conduits. Outside conduit ends shall be bushed when used for direct burial service lateral conductors. Outside conduit ends shall be capped or plugged until connected to exterior conduit systems. Underground service lateral conductors will be extended to building service entrance and terminated in accordance with the requirements of Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND and NFPA 70.

3.11 AERIAL SERVICE

Services shall conform to the requirements of Section 16370 ELECTRICAL DISTRIBUTION SYSTEM, AERIAL, IEEE C2, and NFPA 70. The service drop conductors shall be continuous from the point of connection on the last pole to the service mast or structural support, connected to the service entrance conductors, and shall be routed to a weatherhead, or weatherproof conduit fitting, before entry into an enclosing conduit. A drip loop shall be formed in each service conductor below the entrance to the weatherhead or the weatherproof conduit fitting. The weatherhead or weatherproof service entrance conduit fitting shall be securely fastened to a rigid galvanized steel (RGS) conduit that shall be terminated in the meter enclosure or service entrance equipment which penetrates the exterior wall or roof. Penetration of the conduit through an exterior wall shall be sealed to prevent the entrance of moisture and the escape of conditioned air. A roof penetration fitting shall be provided for the conduit to prevent the entrance of rain. Service entrance conductors shall be routed in RGS in the exterior wall, or in the interior of the building or facility that contains the meter enclosure or service entrance equipment. Aerial service drop conductors will be extended to building service entrance and terminated.

3.12 MOTORS

Each motor shall conform to the kW (hp) and voltage ratings indicated, and shall have a service factor and other characteristics that are essential to the proper application and performance of the motors under conditions shown or specified. Three-phase motors for use on 3-phase 208-volt systems shall have a nameplate rating of 200 volts. Unless otherwise specified, all motors shall have open frames, and continuous-duty classification based on a 40 degree C ambient temperature reference. Polyphase motors shall be squirrel-cage type, having normal-starting-torque and low-starting-current characteristics, unless other characteristics are specified in other sections of these specifications or shown on contract drawings. The Contractor shall be responsible for selecting the actual kilowatt (horsepower) ratings and other motor requirements necessary for the applications indicated. When electrically driven equipment furnished under other sections of these specifications materially differs from the design, the Contractor shall make the necessary adjustments to the wiring, disconnect devices and branch-circuit protection to accommodate the equipment actually installed.

3.13 MOTOR CONTROL

Each motor or group of motors requiring a single control and not controlled from a motor-control center shall be provided under other sections of these specifications with a suitable controller and devices that will perform the functions as specified for the respective motors. Each motor of 93 W (1/8 hp) or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as thermostats, float or pressure switches may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have an adequate kilowatt (horsepower) rating. When the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit. When combination manual and automatic control is specified and the automatic-control device operates the motor directly, a double-throw, three-position tumbler or rotary switch shall be provided for the manual control; when the automatic-control device actuates the pilot control circuit of a magnetic starter, the latter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC. Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position; all safety control devices, such as low- or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the Contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

3.13.1 Reduced-Voltage Controllers

Reduced-voltage controllers shall be provided for polyphase motors 37.5 kW (40 hp) or larger. Reduced-voltage starters shall be of the single-step autotransformer, reactor, or resistor type having an adjustable time interval between application of reduced and full voltages to the motors. Wye-delta reduced voltage starters or part winding increment starters having an adjustable time delay between application of voltage to first and second winding of motor may be used in lieu of the reduced voltage starters specified above for starting of motor-generator sets, centrifugally operated equipment or reciprocating compressors provided with automatic unloaders.

3.13.2 Motor Control Centers

Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2, Class and Type as indicated. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Combination starters shall be provided with circuit breakers equipped with high-interrupting-capacity current-limiting fuses. Motor control centers shall be provided with a full-length ground bus bar.

3.13.3 Contacts

Unless otherwise indicated, contacts in miscellaneous control devices such as float switches, pressure switches, and auxiliary relays shall have current and voltage ratings in accordance with NEMA ICS 2 for rating designation B300.

3.13.4 Safety Controls

Safety controls for boilers shall be connected to a 2-wire, 120 volt grounded circuit supplied from the associated boiler-equipment circuit. Where the boiler circuit is more than 120 volts to ground, safety controls shall be energized through a two-winding transformer having its 120 volt secondary winding grounded. Overcurrent protection shall be provided in the ungrounded secondary conductor and shall be sized for the load encountered.

3.14 MOTOR-DISCONNECT MEANS

Each motor shall be provided with a disconnecting means when required by NFPA 70 even though not indicated. For single-phase motors, a single or double pole toggle switch, rated only for alternating current, will be acceptable for capacities less than 30 amperes, provided the ampere rating of the switch is at least 125 percent of the motor rating. Switches shall disconnect all ungrounded conductors.

3.15 TRANSFORMER INSTALLATION

Three-phase transformers shall be connected only in a delta-wye or wye-delta configuration as indicated except isolation transformers having a one-to-one turns ratio. "T" connections may be used for transformers rated at 15 kVA or below. Dry-type transformers shown located within 1.5 meters (5 feet) of the exterior wall shall be provided in a weatherproof enclosure. Transformers to be located within the building or building and vault may be provided in the manufacturer's standard, ventilated indoor enclosure designed for use in 40 degrees C ambient temperature, unless otherwise indicated.

3.16 LIGHTING FIXTURES, LAMPS AND BALLASTS

This paragraph shall cover the installation of lamps, lighting fixtures and ballasts in interior or building mounted applications.

3.16.1 Lamps

Lamps of the type, wattage, and voltage rating indicated shall be delivered to the project in the original cartons and installed just prior to project completion. Lamps installed and used for working light during construction shall be replaced prior to turnover to the Government if more than 15% of their rated life has been used. Lamps shall be tested for proper operation prior to turn-over and shall be replaced if necessary with new lamps from the original manufacturer. 10% spare lamps of each type, from the original manufacturer, shall be provided.

3.16.2 Lighting Fixtures

Fixtures shall be as shown and shall conform to the following specifications and shall be as detailed on the drawings. Illustrations shown on the drawings are indicative of the general type desired and are not intended to restrict selection to fixtures of any particular manufacturer. Fixtures of similar designs and equivalent energy efficiency, light distribution and brightness characteristics, and of equal finish and quality will be acceptable if approved. In suspended acoustical ceilings with fluorescent fixtures, the fluorescent emergency light fixtures shall be furnished with self-contained battery packs.

3.16.2.1 Accessories

Accessories such as straps, mounting plates, nipples, or brackets shall be provided for proper installation.

3.16.2.2 Ceiling Fixtures

Ceiling fixtures shall be coordinated with and suitable for installation in, on or from the ceiling as shown. Installation and support of fixtures shall be in accordance with NFPA 70 and manufacturer's recommendations. Where seismic requirements are specified herein, fixtures shall be supported as shown or specified. Recessed fixtures shall have adjustable fittings to permit alignment with ceiling panels. Recessed fixtures installed in fire-resistive ceiling construction shall have the same fire rating as the ceiling or shall be provided with fireproofing boxes having materials of the same fire rating as the ceiling, in conformance with UL Elec Const Dir. Surface-mounted fixtures shall be suitable for fastening to the ceiling panel structural supports.

3.16.2.3 Fixtures for Installation in Grid Type Ceilings

Fixtures for installation in grid type ceilings which are smaller than a full tile shall be centered in the tile. 305 by 1219 mm (1 by 4 foot) fixtures shall be mounted along the grid rail as shown. Work above the ceiling shall be coordinated among the trades to provide the lighting layout shown. Fixtures mounted to the grid shall have trim exactly compatible with the grid. Contractor shall coordinate trims with ceiling trades prior to ordering fixtures. Metric fixtures shall be designed to fit the metric grid specified. Fixtures in continuous rows shall be coordinated between trades prior to ordering. Fixtures shall be mounted using independent supports capable of supporting the entire weight of the fixture. No fixture shall rest solely on the ceiling grid. Recessed fixtures installed in seismic areas should be installed utilizing specially designed seismic clips. Junction boxes shall be supported at four points.

3.16.2.4 Suspended Fixtures

Suspended fixtures shall be provided with swivel hangers or hand-straights so that they hang plumb. Pendants, rods, or chains 1.3 meters (4 feet) or longer excluding fixture shall be braced to prevent swaying using three cables at 120 degrees of separation. Suspended fixtures in continuous rows shall have internal wireway systems for end to end wiring and shall be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Aligning splines shall be used on extruded aluminum fixtures to assure hairline joints. Steel fixtures shall be supported to prevent "oil-canning" effects. Fixture finishes shall be free of scratches, nicks, dents, and warps, and shall match the color and gloss specified. Pendants shall be finished to match fixtures. Aircraft cable shall be stainless steel. Canopies shall be finished to match the ceiling and shall be low profile unless otherwise shown. Maximum distance between suspension points shall be 3.1 meters (10 feet) or as recommended by the manufacturer, whichever is less.

Suspended fixtures installed in seismic areas shall have 45% swivel hangers and shall be located with no obstructions within the 45% range in all directions. The stem, canopy and fixture shall be capable of 45% swing.

3.16.3 Ballasts

Remote type ballasts or transformers, where indicated, shall be mounted in a well ventilated, easily accessible location, within the maximum operating distance from the lamp as designated by the manufacturer.

3.16.4 Emergency Light Sets

Emergency light sets shall conform to UL 924 with the number of heads as indicated. Sets shall be permanently connected to the wiring system by conductors installed in short lengths of flexible conduit.

3.17 BATTERY CHARGERS

Battery chargers shall be installed in conformance with NFPA 70.

3.18 EQUIPMENT CONNECTIONS

Wiring not furnished and installed under other sections of the specifications for the connection of electrical equipment as indicated on the drawings shall be furnished and installed under this section of the specifications. Connections shall comply with the applicable requirements of paragraph WIRING METHODS. Flexible conduits 2 m (6 feet) or less in length shall be provided to all electrical equipment subject to periodic removal, vibration, or movement and for all motors. All motors shall be provided with separate grounding conductors. Liquid-tight conduits shall be used in damp or wet locations.

3.18.1 Motors and Motor Control

Motors, motor controls, and motor control centers shall be installed in accordance with NFPA 70, the manufacturer's recommendations, and as indicated. Wiring shall be extended to motors, motor controls, and motor control centers and terminated.

3.18.2 Installation of Government-Furnished Equipment

Wiring shall be extended to the equipment and terminated.

3.18.3 Food Service Equipment Provided Under Other Sections

Wiring shall be extended to the equipment and terminated.

3.19 CIRCUIT PROTECTIVE DEVICES

The Contractor shall calibrate, adjust, set and test each new adjustable circuit protective device to ensure that they will function properly prior to the initial energization of the new power system under actual operating conditions.

3.20 PAINTING AND FINISHING

Field-applied paint on exposed surfaces shall be provided under Section 09900 PAINTING, GENERAL.

3.21 REPAIR OF EXISTING WORK

The work shall be carefully laid out in advance, and where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceiling, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, this work shall be carefully done, and any damage to building, piping, or equipment shall be repaired by skilled mechanics of the trades involved at no additional cost to the Government.

3.22 FIELD TESTING

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 7 days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspection recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. All field test reports will be signed and dated by the Contractor.

3.22.1 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.22.2 Ground-Resistance Tests

The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE Std 81. Soil resistivity in the area of the grid shall be measured concurrently with the grid measurements. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

a. Single rod electrode - 25 ohms

b. Grid electrode - 25 ohms.

3.22.3 Ground-Grid Connection Inspection

All below-grade ground-grid connections will be visually inspected by the Contracting Officer before backfilling. The Contractor shall notify the Contracting Officer 48 hours before the site is ready for inspection.

3.22.4 Cable Tests

The Contractor shall be responsible for identifying all equipment and devices that could be damaged by application of the test voltage and ensuring that they have been properly disconnected prior to performing insulation resistance testing. An insulation resistance test shall be performed on all low and medium voltage cables after the cables are installed in their final configuration and prior to energization. The test voltage shall be 500 volts DC applied for one minute between each conductor and ground and between all possible combinations of conductors. The minimum value of resistance shall be:

R in megohms = (rated voltage in kV + 1) x 304.8/(length of cable in meters)

R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet)

Each cable failing this test shall be repaired or replaced. The repaired cable system shall then be retested until failures have been eliminated.

3.22.5 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. These tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to insure proper calibration and operation. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

3.23 OPERATING TESTS

After the installation is completed, and at such time as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the specified requirements. An operating test report shall be submitted in accordance with paragraph FIELD TEST REPORTS.

3.24 FIELD SERVICE

3.24.1 Onsite Training

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instruction shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations.

3.24.2 Installation Engineer

After delivery of the equipment, the Contractor shall furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of equipment, assist in the performance of the onsite tests, oversee initial operations, and instruct personnel as to the operational and maintenance features of the equipment.

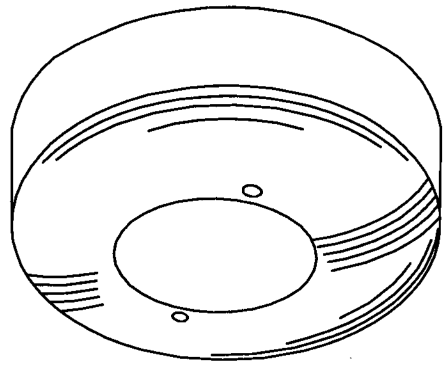
3.25 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: C1



FEATURES

PATTERN: 360 DEGREES
COVERAGE: 46–186 SQ M (500–2000 SF)
TIME DELAY: ADJUSTABLE 15 SECONDS TO 15 MINUTES

OPTIONS

PATTERN: CORRIDOR

NOM. DIMENSIONS 114 mm X 32 mm (4 1/2 " DIA. X 1 1/4 " D)

GENERAL DESCRIPTION

HOUSING: IMPACT RESISTANT INJECTION MOLDED ABS

MOUNTING: CEILING BETWEEN 2440–3050 mm (8–10') H

ELECTRICAL: 24 VOLT DC (FROM POWER PACK), 120 OR 277 VOLT AC

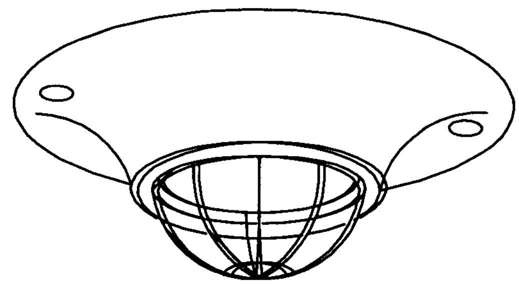
FINISH: WHITE

CEILING MOUNTED ULTRASONIC OCCUPANCY SENSOR

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: C2



FEATURES

PATTERN: 360 DEGREES
COVERAGE: 46–186 SQ M (500–2000 SF)
TIME DELAY: ADJUSTABLE 30 SECONDS TO 15 MINUTES

OPTIONS

PATTERN: CORRIDOR

NOM. DIMENSIONS 121 mm X 102 mm (4 3/4 " DIA x 4"D)

GENERAL DESCRIPTION

HOUSING: IMPACT RESISTANT INJECTION MOLDED ABS

MOUNTING: CEILING BETWEEN 2440–3050 mm (8–10') H

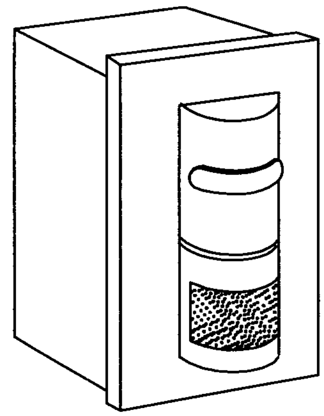
ELECTRICAL: 24 VOLT DC (FROM POWER PACK), 120 OR 277 VOLT AC

FINISH: WHITE

CEILING MOUNTED INFRARED OCCUPANCY SENSOR

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



TYPE: C3

FEATURES

PATTERN: 170 DEGREES
COVERAGE: 28–93 SQ M (300–1000 SF)
TIME DELAY: ADJUSTABLE 15 SECONDS TO 30 MINUTES

OPTIONS

FINISH: DESIGNER COLORS
CONTROL: MANUAL OFF, TWO LEVEL LIGHTING CONTROL

NOM. DIMENSIONS 114 mm X 24 mm X 118 mm (4 1/2 " H X 15/16 " D X 4 5/8 " W)

GENERAL DESCRIPTION

HOUSING: MEDIUM IMPACT INJECTION MOLDED ABS

MOUNTING: WALL MOUNTED AT NORMAL SWITCH HEIGHT, BETWEEN 915–1525 MM (3–5')

ELECTRICAL: 120 OR 277 VOLT

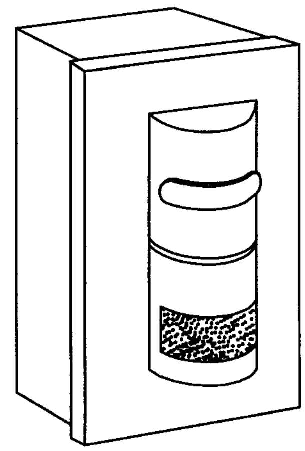
FINISH: WHITE STANDARD

WALL MOUNTED INFRARED OCCUPANCY SENSOR

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: C4



FEATURES

PATTERN: 170 DEGREE
COVERAGE: 28–140 SQ M (300–1500 SF)
TIME DELAY: ADJUSTABLE 15 SECONDS TO 30 MINUTES

OPTIONS

NOM. DIMENSIONS 114 mm X 24 mm X 118 mm (4 1/ 2" H X 15/16" D X 4 5/8" W)

GENERAL DESCRIPTION

HOUSING: IMPACT RESISTANT INJECTION MOLDED ABS

MOUNTING: WALL MOUNTED BETWEEN TOP OF OBSTRUCTIONS AND CEILING

ELECTRICAL: 120 OR 277 VOLT

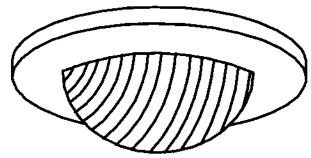
FINISH: WHITE

WALL MOUNTED ULTRASONIC AND INFRARED OCCUPANCY SENSOR

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: C5



FEATURES

PATTERN: 60 DEGREES
COVERAGE: 1 SQ M (10 SF)
TIME DELAY: ADJUSTABLE 3 TO 15 MINUTES

OPTIONS

NOM. DIMENSIONS 76 mm X 121 mm X 10 mm (3" x 4 3/4 " x 0.4")

GENERAL DESCRIPTION

HOUSING: HIGH IMPACT, UL LISTED MATERIAL WITH METAL BASE TO COMPLY WITH FLAMMABILITY RATING STANDARDS.

MOUNTING: CEILING

ELECTRICAL: 24 VOLT DC

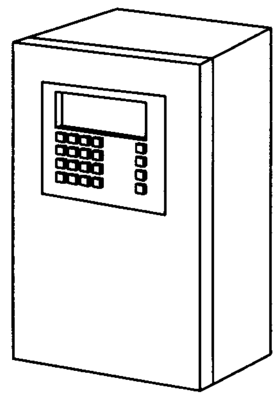
FINISH: WHITE

CEILING MOUNTED DAYLIGHT PHOTOCELL SENSOR

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: C6



FEATURES

TECHNOLOGY: PROGRAMMABLE NETWORK TIME CLOCK, 16 PROGRAMMABLE EVENTS PER DAY

OPTIONS

NOM. DIMENSIONS 197 mm X 127 mm X 76 mm
(7 3/4 " H X 5" W X 3" D)

GENERAL DESCRIPTION

HOUSING: CASE, NEMA 3R DRAWN STEEL, SIDE HINGED DOOR WITH LOCK AND KEY

MOUNTING: WALL MOUNTED

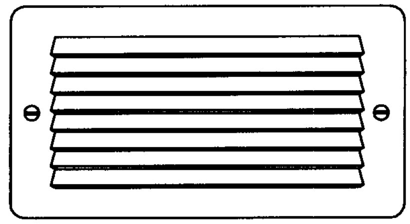
ELECTRICAL: 120 OR 277 VOLT

FINISH: PAINTED GRAY

WALL MOUNTED TIME CLOCK

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: EF1



FEATURES

LAMP TYPE: F13TT/RS
PROFILE: 1 LAMP
SHIELDING: TEMPERED OPAL GLASS
BALLAST: ELECTRONIC

OPTIONS

MOUNTING: SURFACE
BALLAST: HIGH POWER FACTOR
MAGNETIC

NOM. DIMENSIONS 260 mm X 133 mm X 113 mm
(10 1/4 " L X 5 1/4 " H X 4 7/16 " D)

GENERAL DESCRIPTION

HOUSING: CAST, HEAVY DUTY ALUMINUM

REFLECTORS: HIGHLY REFLECTIVE WHITE ENAMEL

ELECTRICAL: 120 OR 277 VOLT BALLAST

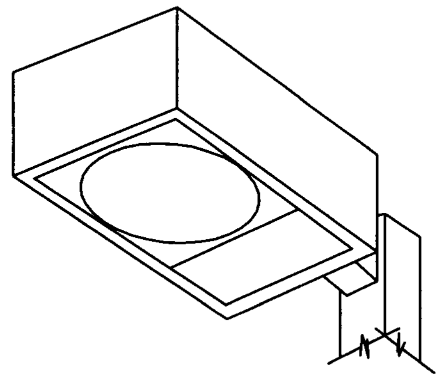
FINISH: POLYESTER POWDER COAT

RECESSED STEP LIGHT FLUORESCENT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: EH1



FEATURES

LAMP TYPE: 250W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: 5 mm (3/16") CLEAR TEMPERED GLASS
REFLECTOR: FACETED SPECULAR ALUMINUM
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA
OTHER: TYPE I DISTRIBUTION

OPTIONS

LAMP TYPE: MH: 175W, 400W
HPS: 250W, 400W
OTHER: TYPE II, III, IV AND V DISTRIBUTIONS.

NOM. DIMENSIONS 642 mm X 470 mm X 143 mm
(25 5/16 " L X 18 1/2 " W X 5 5/8 " D)

GENERAL DESCRIPTION

HOUSING: ONE PIECE EXTRUDED ALUMINUM, WELDED JOINTS. LENS HINGED & HELD IN PLACE BY CAPTIVE SCREWS.

MOUNTING: SQ. EXTRUDED MOUNTING ARM AND POLE WITH ANCHOR TYPE BASE, ANCHOR BOLTS & MOUNTING HARDWARE.

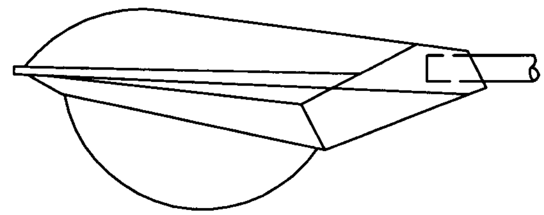
ELECTRICAL: 120, 277 OR 480 VOLT BALLAST.

FINISH: FIXTURE MOUNTING ARM, HOUSING, DOOR FRAMES, POLE & BASE TO BE PAINTED DARK BRONZE FINISH.

POLE MOUNTED METAL HALIDE CUTOFF LUMINAIRE

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: EH2



FEATURES

LAMP TYPE: 250W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: TEMPERED PRISMATIC FORMED GLASS
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA
OTHER: TYPE I DISTRIBUTION

OPTIONS

LAMP TYPE: MH: 400W
HPS: 250W, 400W
OTHER: TYPE II, III, IV AND V DISTRIBUTIONS.

NOM. DIMENSIONS 699 mm X 292 mm X 337 mm
(27 1/2 " L X 11 1/2 " H X 13 1/4 " W)

GENERAL DESCRIPTION

HOUSING: DIE-CAST ALUMINUM, BOTTOM PLATE HINGED TO TOP OF HOUSING.

MOUNTING: SLIP FITTER TO DAVIT ARM POLE

REFLECTORS: SPECULAR ALUMINUM

ELECTRICAL: 120, 277 OR 480 VOLT BALLAST

FINISH: PAINTED BAKED ENAMEL

POLE MOUNTED METAL HALIDE COBRA HEAD

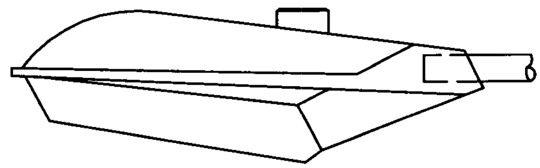
CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: EH3

FEATURES

LAMP TYPE: 100W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: CLEAR POLYCARBONATE
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA
OTHER: TYPE I DISTRIBUTION



OPTIONS

LAMP TYPE: MH: 175W, 250W
HPS: 150W, 250W
SHIELDING: TEMPERED CLEAR GLASS
OTHER: PHOTOCELL CONTROL, BIRD GUARD, TYPE II AND III DISTRIBUTIONS

NOM. DIMENSIONS 699 mm X 165 mm X 337 mm
(27 1/2 " L X 6 1/2 " H X 13 1/4 " W)

GENERAL DESCRIPTION

HOUSING: DIE CAST ALUMINUM WITH BOTTOM PLATE HINGED TO TOP OF HOUSING.

MOUNTING: UNIVERSAL FOUR-BOLT SLIP FITTER TO POLE

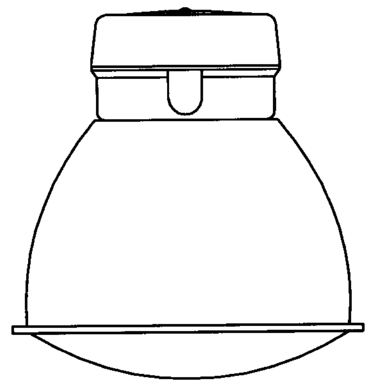
REFLECTORS: FACETED SPECULAR ALUMINUM

ELECTRICAL: 120, 277 OR 480 VOLT BALLAST

FINISH: PAINTED BAKED ENAMEL

POLE MOUNTED METAL HALIDE COBRA HEAD

TYPE: EH4



FEATURES

LAMP TYPE: 400W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: CLEAR TEMPERED GLASS
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA
OTHER: TYPE I DISTRIBUTION

OPTIONS

LAMP TYPE: HPS: 750W, 1000W
MH: 1000W
DISTRIBUTION: TYPE II, III, IV AND V

NOM. DIMENSIONS 635 mm X 584 mm (25" H X 23" DIA.)

GENERAL DESCRIPTION

HOUSING: FORMED ALUMINUM OPTICAL HOUSING

MOUNTING: POLE MOUNTED W/CAST ALUMINUM BALLAST COVER AND SLIP FITTER MOUNT

REFLECTORS: FORMED, FACETED, SPECULAR ALUMINUM

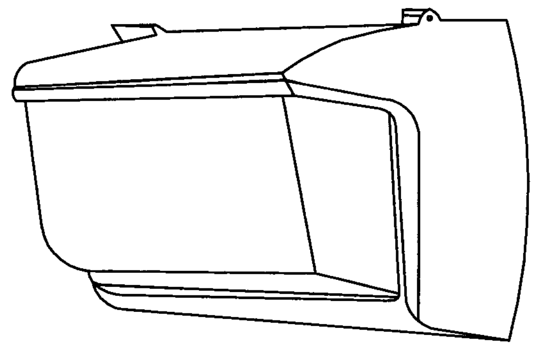
ELECTRICAL: 120, 208, 240, 277, 347, & 480 VOLT MULTI TAP BALLAST

FINISH: GRAY PAINT

POLE MOUNTED METAL HALIDE HIGH MAST LUMINAIRE

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: EH5



FEATURES

LAMP TYPE: 70W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: PRISMATIC BOROSILICATE GLASS
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 100W, 175W
HPS: 70W, 100W, 150W
SHIELDING: POLYCARBONATE
OTHER: PHOTOCELL CONTROL

NOM. DIMENSIONS 311 mm X 241 mm X 184 mm
(12 1/4 " L X 9 1/2 " H X 7 1/4 " D)

GENERAL DESCRIPTION

HOUSING: DIE CAST ALUMINUM HOUSING, DOOR ASSEMBLY AND BACKPLATE

MOUNTING: DIE CAST ALUMINUM BACKPLATE WITH CAST-IN KNOCKOUTS FOR MOUNTING HOLE ALIGNMENT.

REFLECTORS: SPECULAR ANODIZED ALUMINUM

ELECTRICAL: 120, 277, 208, 240, 347 & 480 VOLT MULTI TAP BALLAST

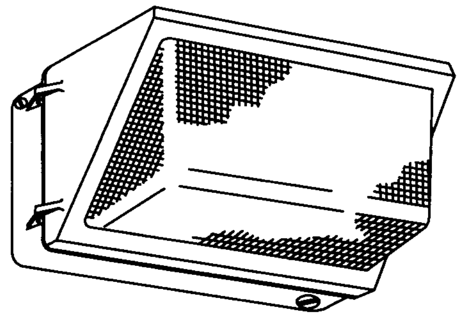
FINISH: BAKED-ON POLYURETHANE POWDER COAT PAINT

METAL HALIDE WALL PAK

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: EH6



FEATURES

LAMP TYPE: 250W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: TEMPERED PRISMATIC BOROSILICATE GLASS
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 400W
HPS: 250W, 400W
OTHER: KNUCKLE WALL MOUNT OR SLIP FITTER. FIELD INSTALLED PHOTO-CELL CONTROL KIT, THREADED TOP CONDUIT ENTRANCE.

NOM. DIMENSIONS 394 mm X 305 mm X 252 mm
(15 1/2 " L X 12" D X 9 15/16 " H)

GENERAL DESCRIPTION

HOUSING: DIE CAST ALUMINUM HOUSING, HINGED DOOR

REFLECTORS: FACETED ALUMINUM

ELECTRICAL: 120, 277, 208, 240, 347 & 480 VOLT MULTI TAP BALLAST

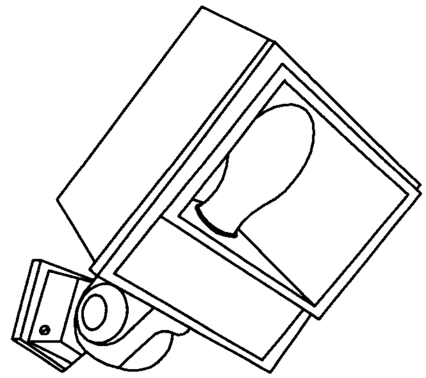
FINISH: PAINTED DARK BRONZE FINISH

METAL HALIDE WALL PAK

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: EH8



FEATURES

LAMP TYPE:	400W METAL HALIDE
PROFILE:	1 LAMP
SHIELDING:	IMPACT RESISTANT TEMPERED GLASS
BALLAST:	HIGH POWER FACTOR, CORE & COIL, CWA
OTHER:	NEMA TYPE 4X5H DISTRIBUTION

OPTIONS

LAMP TYPE:	MH: 175W, 250W HPS: 150W, 250W, 400W
OTHER:	VARIOUS DISTRIBUTIONS, PHOTOCELL CONTROL

NOM. DIMENSIONS 470 mm X 178 mm (18 1/2 " SQ. X 7" D)

GENERAL DESCRIPTION

HOUSING: HEAVY DUTY CAST ALUMINUM

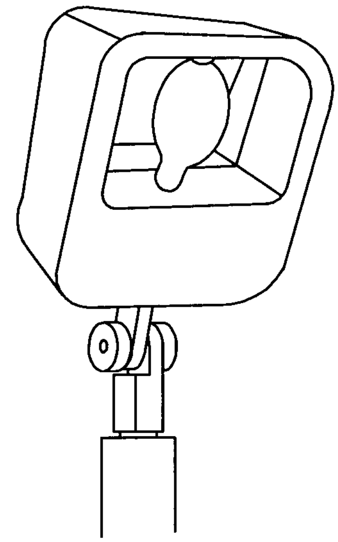
REFLECTORS: FACETED SPECULAR ALUMINUM

ELECTRICAL: 120, 277 OR 480 VOLT BALLAST

FINISH: PAINTED DARK BRONZE FINISH

WALL MOUNTED METAL HALIDE FLOODLIGHT

TYPE: EH9



FEATURES

LAMP TYPE: 400W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: IMPACT RESISTANT CLEAR TEMPERED GLASS
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA
OTHER: NEMA TYPE 4X5H DISTRIBUTION

OPTIONS

LAMP TYPE: MH: 175W, 250W
HPS: 150W, 250W, 400W
OTHER: VARIOUS DISTRIBUTIONS, PHOTO-CELL CONTROL

NOM. DIMENSIONS 470 mm X 178 mm
(18 1/2 " SQ. X 7" H)

GENERAL DESCRIPTION

HOUSING: HEAVY DUTY CAST ALUMINUM

REFLECTORS: FACETED SPECULAR ALUMINUM

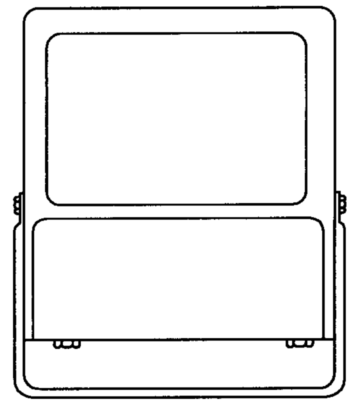
ELECTRICAL: 120, 277 OR 480 VOLT BALLAST

FINISH: PAINTED DARK BRONZE FINISH

POLE MOUNTED METAL HALIDE FLOODLIGHT

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: EH10



FEATURES

LAMP TYPE: 250W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: CLEAR TEMPERED GLASS
REFLECTOR: SPECULAR ALUMINUM
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 400W
HPS: 250W, 400W
OTHER: GLARE GUARD, MESH GUARD, POLYCARBONATE SHIELD

NOM. DIMENSIONS 416 mm X 511 mm X 229 mm
(16 3/8 " W X 20 1/8 " L X 9" D)

GENERAL DESCRIPTION

HOUSING: ONE-PIECE DIE-CAST COPPER-FREE ALUMINUM, FULLY GASKETED

MOUNTING: VARIOUS

ELECTRICAL: 120, 277, 208, 240, 347 & 408 VOLT MULTI TAP BALLAST

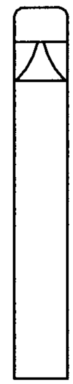
FINISH: PAINTED DARK BRONZE FINISH

OTHER: NEC CLASS 1, DIV 2

METAL HALIDE HAZARDOUS LOCATION FLOODLIGHT, CLASS 1/ DIV 2

CORPS OF ENGINEERS — DEPARTMENT OF THE ARMY

TYPE: EH11



FEATURES

LAMP TYPE: 70W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: 6 mm (1/4") SEAMLESS 100% VIRGIN ACRYLIC
REFLECTORS: HYDRO-FORMED FLUTED ANODIZED ALUMINUM UPPER REFLECTOR AND SPUN ANODIZED ALUMINUM FLARE CONE
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 100W
HPS: 70W, 100W
REFLECTOR: CYLINDRICAL LOWER REFLECTOR
SHIELDING: CAST ALUMINUM LOUVERS

NOM. DIMENSIONS 203 mm X 1067 mm (8" DIA. X 42" H)

GENERAL DESCRIPTION

HOUSING: 4 mm (.156") EXTRUDED ALUMINUM ONE PIECE HOUSING AND CAST ALUMINUM TOP COVER

MOUNTING: (4) 12 mm X 280 mm (1/2" X 11") ANCHOR BOLTS WITH DOUBLE NUTS AND WASHERS

ELECTRICAL: 120 OR 277 VOLT BALLAST

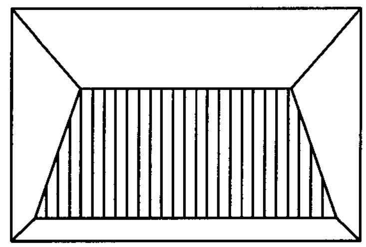
FINISH: PAINTED DARK BRONZE FINISH

METAL HALIDE BOLLARD

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: EH12



FEATURES

LAMP TYPE: 70W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: FLAT TEMPERED CLEAR GLASS WITH NEOPRENE GASKET
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA
DISTRIBUTION: SYMMETRIC

OPTIONS

LAMP TYPE: MH: 100W
HPS: 70W, 100W
SHIELDING: INJECTION MOLDED POLYCARBONATE
DISTRIBUTION: ASYMMETRIC (LEFT OR RIGHT)

NOM. DIMENSIONS 295 mm X 197 mm X 327 mm
(11 5/8 " W X 7 3/4 " D X 12 7/8 " H)

GENERAL DESCRIPTION

HOUSING: HEAVY DUTY CAST ALUMINUM

REFLECTORS: HIGHLY SPECULAR ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

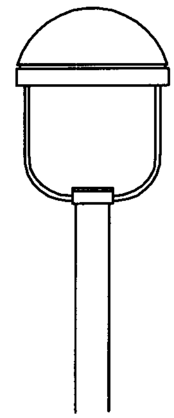
FINISH: PAINTED DARK BRONZE FINISH

RECESSED METAL HALIDE STEP LIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: EH13



FEATURES

LAMP TYPE: 175W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: CLEAR TEMPERED GLASS
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 70W, 250W
HPS: 70W, 150W, 250W
OTHER: PHOTOCELL CONTROL, VANDAL RESISTANT POLYCARBONATE SHIELD

NOM. DIMENSIONS 610 mm X 381 mm (24" DIA. X 15" H)

GENERAL DESCRIPTION

HOUSING: ONE PIECE HEAVY GAUGE SPUN ALUMINUM WITH NO VISIBLE SEAMS OR WELD BEADS

MOUNTING: YOKE MOUNTED TO POLE, 4.27 M (14') MAX

REFLECTORS: SEGMENTED HIGHLY REFLECTIVE SPECULAR ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

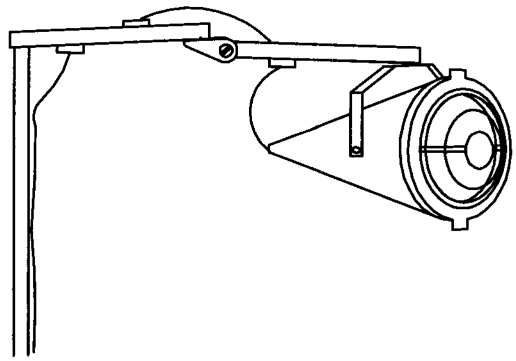
FINISH: PAINTED DARK BRONZE FINISH

LOW HEIGHT METAL HALIDE PEDESTRIAN POLE

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: EI1



FEATURES

LAMP TYPE: 90W PAR38
PROFILE: 1 LAMP
SHIELDING: DIE CAST ALUMINUM HOOD WITH WIRE GUARD
OTHER: 24" ARM LENGTH

OPTIONS

LAMP TYPE: 60W PAR38
MOUNTING: 1015 OR 1525 mm (40" OR 60") ARM

NOM. DIMENSIONS 194 mm X 137 mm x 610 mm
(7 5/8 " DIA X 5 3/8 " H X 24" ARM)

GENERAL DESCRIPTION

HOUSING: DIE CAST ALUMINUM

MOUNTING: ARM MOUNT WITH 180 HORIZONTAL FREEDOM ON BASE JOINT, 360 ON REFLECTOR, 300 HORIZONTALLY AND 180 VERTICALLY ON CENTER JOINT

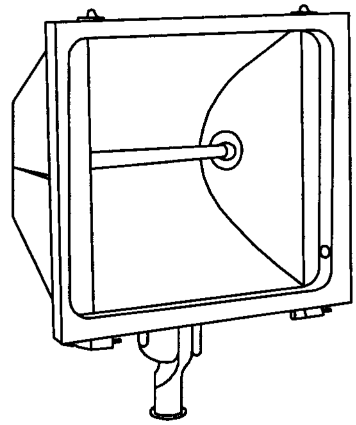
ELECTRICAL: 120 VOLT

FINISH: BLACK LEKTROKOTE• FINISH

WALL MOUNTED INCANDESCENT ARM DOCK LIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



TYPE: EI2

FEATURES

LAMP TYPE: 500W T3 HALOGEN
PROFILE: 1 LAMP
SHIELDING: CLEAR TEMPERED GLASS

OPTIONS

LAMP TYPE: 300W, 425W, 1500W T3

NOM. DIMENSIONS 241 mm L X 197 mm H X 98 mm
(9 1/2 " L X 7 3/4 " H X 3 7/8 " W)

GENERAL DESCRIPTION

HOUSING: CAST ALUMINUM

REFLECTORS: SPECULAR ALUMINUM

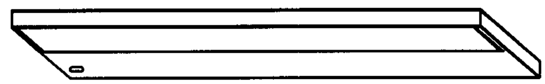
ELECTRICAL: 120 VOLT

FINISH: PAINTED DARK BRONZE FINISH

TUNGSTEN HALOGEN FLOODLIGHT

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: FF1



FEATURES

LAMP TYPE: F32T8/RS
PROFILE: 1 LAMP
SHIELDING: PRISMATIC #12 ACRYLIC
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F25T8/RS
SHIELDING: OPAQUE FRONT LENS
BALLAST: HIGH POWER FACTOR MAGNETIC

NOM. DIMENSIONS 135 mm X 30 mm X 1219 mm
(5 5/16 " W X 1 3/16 " D X 4' L)

GENERAL DESCRIPTION

HOUSING: 20 GAUGE PRIME COLD ROLLED STEEL

REFLECTORS: HIGHLY REFLECTIVE WHITE FORMED REFLECTOR

ELECTRICAL: 120 OR 277 VOLT BALLAST

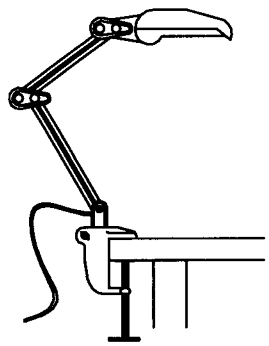
FINISH: WHITE URETHANE POWDER COAT

FLUORESCENT UNDER CABINET TASK LIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: FF2



FEATURES

LAMP TYPE: F13TT/RS
PROFILE: 2 LAMP
SHIELDING: PARABOLIC LOUVER
BALLAST: HIGH POWER FACTOR MAGNETIC

OPTIONS

LAMP TYPE: F9TT/RS
PROFILE: 1 LAMP
BALLAST: ELECTRONIC

NOM. DIMENSIONS 264 mm X 213 mm X 60 mm
(10 3/8 " L X 8 3/8 " W 2 3/8 " D)

GENERAL DESCRIPTION

HOUSING: NON-REFLECTIVE ABS MATERIAL, 180 DEG. HORIZONTAL MOVEMENT

MOUNTING: DESK CLAMP

REFLECTORS: SPECULAR ALUMINUM

ELECTRICAL: 120 VOLT BALLAST, 1829 mm (6'-0") CORD AND PLUG, ON/OFF ROCKER SWITCH.

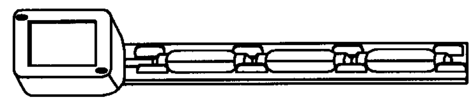
FINISH: BAKED ENAMEL

CLAMP ON COMPACT FLUORESCENT TASK LIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: FI1



FEATURES

LAMP TYPE: 5W FESTOON HALOGEN
PROFILE: 50 mm (2") ON CENTER

OPTIONS

LAMP TYPE: 3.5W, 10W, XENON, OR
INCANDESCENT FESTOON
20 W MR-16, 20W MR-11
PROFILE: 4" O.C.
FINISH: BLACK
CONNECTORS: FUSED PLUG, MOLDED PLUG, INTEGRAL JUNCTION BOX,
CRIMP ON SPADE; CLEAR ACRYLIC LENS COVER.

NOM. DIMENSIONS 25 mm X 13 mm X 1219 mm
(1" W X 1/2 " H X 4' L)

GENERAL DESCRIPTION

HOUSING: EXTENDED HOUSING NOMINAL INCREMENTS UP TO 4.9 M (16')

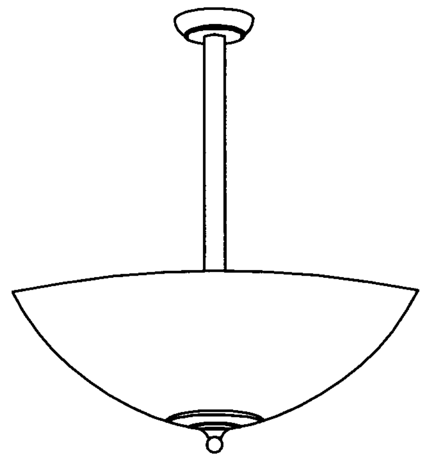
REFLECTORS: GLOSS WHITE

ELECTRICAL: 12 VOLT OR 24 VOLT TRANSFORMER SIZED
APPROPRIATELY TO FIXTURE LOAD

FINISH: GLOSS WHITE

INCANDESCENT UNDER CABINET TASK LIGHT

TYPE: PF1



FEATURES

LAMP TYPE: F13TT/RS
PROFILE: 4 LAMPS
SHIELDING: OPAL ACRYLIC
BALLAST: REMOTE, ELECTRONIC

OPTIONS

LAMP TYPE: F26DTT/RS OR F39TT/RS;
SHIELDING: OPAL GLASS, TOP LENS
BALLAST: HIGH POWER FACTOR
MAGNETIC, DIMMING,
EMERGENCY
BOWL SIZES: 762, 914, 1143 OR 1295 mm
(30", 36", 45" OR 51") DIA.

NOM. DIMENSIONS 610 mm X 305 mm
(24" DIA. X 12" D)

GENERAL DESCRIPTION

HOUSING: WHITE OPAL ACRYLIC BOWL, TRIM RINGS OF MINIMUM 20 GAUGE STEEL OR DIE-CAST ALUMINUM

MOUNTING: STEM MOUNTED WITH HANG STRAIGHT STEM

REFLECTORS: FABRICATED ALUMINUM SPECULAR REFLECTOR

ELECTRICAL: 120 OR 277 VOLT BALLAST

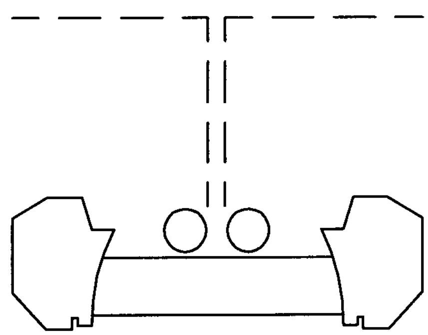
FINISH: CHROME-PLATED SOLID BRASS, POLISHED SOLID BRASS OR PAINTED; TRIM RING, STEM AND CANOPY FINISH TO MATCH

PENDANT MOUNTED DIRECT/INDIRECT COMPACT FLUORESCENT BOWL

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PF2



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
MOUNTING: AIRCRAFT CABLE
SHIELDING: LOW IRIDESCENT, SEMI-SPECULAR PARABOLIC LOUVER DOWN, OPEN UP
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 3 LAMP
MOUNTING: RIGID STEM
SHIELDING: STRAIGHT BLADE BAFFLE DOWN
BALLAST: DIMMING, EMERGENCY, REMOTE, HIGH POWER FACTOR MAGNETIC
OTHER: CONTINUOUS ROW MOUNTING

NOM. DIMENSIONS 86 mm X 283 mm X 1219 mm
(3 3/8 " H X 11 1/8 " W X 4' L)

GENERAL DESCRIPTION

HOUSING: DIE FORMED AND WELDED MINIMUM 20 GA. COLD ROLLED STEEL UP TO 2440 mm (8'-0") LENGTH. END CAPS TO BE MINIMUM 18 GAUGE COLD ROLLED STEEL WITH NO HOLES OR KNOCKOUTS.

REFLECTORS: SPECULAR ALUMINUM.

ELECTRICAL: 120 OR 277 VOLT BALLAST.

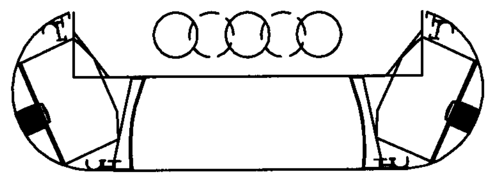
FINISH: PAINTED BAKED ENAMEL, WHITE STANDARD

PENDANT MOUNTED STEEL DIRECT/INDIRECT FLUORESCENT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PF3



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
MOUNTING: AIRCRAFT CABLE SUSPENSION
SHIELDING: LOW IRIDESCENT, SEMI-SPECULAR PARABOLIC LOUVER DOWN, OPEN UP
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 3 LAMP
MOUNTING: RIGID STEM
SHIELDING: STRAIGHT BLADE BAFFLE DOWN
BALLAST: DIMMING, EMERGENCY, HIGH POWER FACTOR MAGNETIC

NOM. DIMENSIONS 89 mm X 229 mm X 1219 mm (3 1/2 " H X 9" W X 4' L)

GENERAL DESCRIPTION

HOUSING: EXTRUDED ALUMINUM UP TO 7.3 m (24') FOR CONTINUOUS ROWS, MINIMUM

REFLECTORS: SPECULAR ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

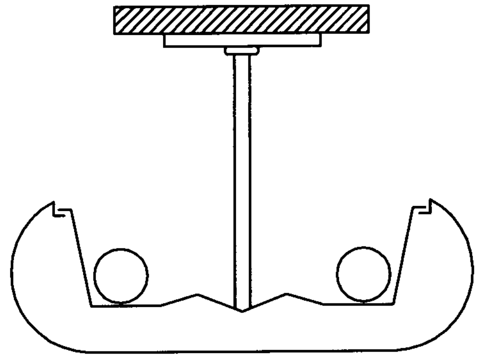
FINISH: PAINTED BAKED ENAMEL, WHITE STANDARD

PENDANT MOUNTED ALUMINUM DIRECT/INDIRECT FLUORESCENT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PF4



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
MOUNTING: AIRCRAFT CABLE
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F40TT/RS, F50TT/RS
PROFILE: 3 LAMP
MOUNTING: RIGID STEM
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 73 mm X 254 mm X 1219 mm (2 7/8 " H X 10" W X 4' L)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED 20 GA. COLD ROLLED STEEL UP TO 2440 mm (8'-0") LONG

REFLECTORS: DIE-FORMED SPECULAR ALUMINUM WITH 95% REFLECTANCE

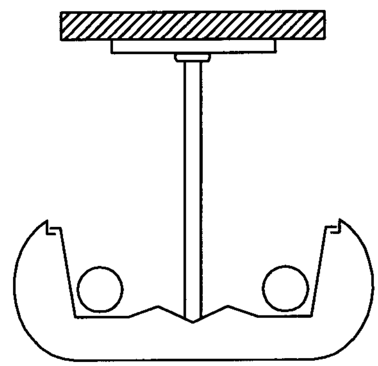
ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: BAKED ENAMEL OR POLYESTER POWDER COAT, WHITE STANDARD

PENDANT MOUNTED STEEL INDIRECT FLUORESCENT

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: PF5



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
MOUNTING: AIRCRAFT CABLE
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 3 LAMP
MOUNTING: STEM
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 89 mm X 254 mm X 1219 mm (3 1/2 " H X 10" W X 4' L)

GENERAL DESCRIPTION

HOUSING: TWO PIECE EXTRUDED ALUMINUM 1.8 mm (.07") THICK, STANDARD LENGTHS UP TO 3.7 M (12'-0")

REFLECTORS: DIE-FORMED SPECULAR ALUMINUM WITH 95% REFLECTANCE

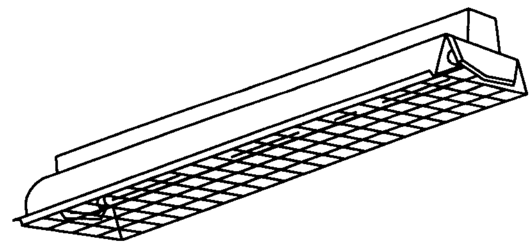
ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: BAKED ENAMEL OR POLYESTER POWDER COAT, WHITE STANDARD

PENDANT ALUMINUM INDIRECT FLUORESCENT

CORPS OF ENGINEERS | DEPARTMENT OF THE ARMY

TYPE: PF6



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
SHIELDING: WIRE GUARD
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 3 LAMP
MOUNTING: SURFACE
BALLAST: HIGH POWER FACTOR
MAGNETIC, EMERGENCY

NOM. DIMENSIONS 178 mm X 356 mm X 1219 mm
(7" H X 14" W X 4' L)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED CRS HOUSING WITH ROLLED SYMMETRIC REFLECTOR/BALLAST COVER

REFLECTORS: COLD ROLLED STEEL, PAINTED WHITE, 10% UPLIGHT APERTURES

ELECTRICAL: 120 OR 277 VOLT BALLAST

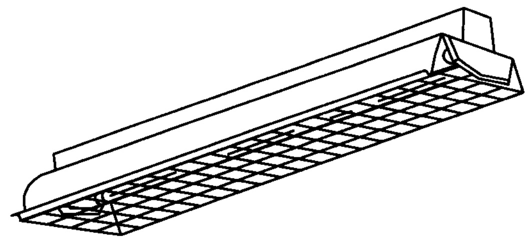
FINISH: WHITE ENAMEL POLYESTER POWDER COAT

CHAIN HUNG 4' TURRET INDUSTRIAL FLUORESCENT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PF7



FEATURES

LAMP TYPE: F96T8/HO
PROFILE: 2 LAMP
SHIELDING: WIRE GUARD
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 3 LAMP
MOUNTING: SURFACE
BALLAST: HIGH POWER FACTOR
MAGNETIC, EMERGENCY

NOM. DIMENSIONS 178 mm X 356 mm X 2438 mm
(7" H X 14" W X 8' L)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED COLD ROLLED STEEL HOUSING

REFLECTORS: SYMMETRIC STEEL REFLECTOR/BALLAST COVER PAINTED WHITE,
10% UPLIGHT APERTURES

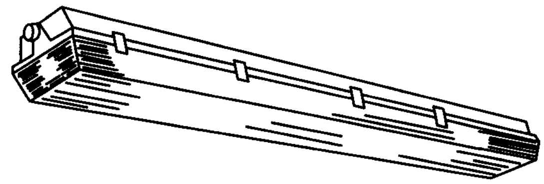
ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: WHITE ENAMEL OR POLYESTER POWDER COAT, WHITE STANDARD

CHAIN HUNG 8' TURRET INDUSTRIAL FLUORESCENT

CORPS OF ENGINEERS | DEPARTMENT OF THE ARMY

TYPE: PF8



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
SHIELDING: STIPPLED ACRYLIC
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 1 LAMP
MOUNTING: SURFACE
BALLAST: HIGH POWER FACTOR MAGNETIC

NOM. DIMENSIONS 152 mm X 203 mm X 1270 mm
(6" H X 8" W X 50" L)

SPECIFICATIONS

HOUSING: MOLDED HIGH-IMPACT POLYESTER OR FIBERGLASS REINFORCED PLASTIC WITH COLD ROLLED STEEL INTERIOR COMPONENTS

REFLECTORS: INTERNAL WHITE REFLECTOR

ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: WHITE PAINTED

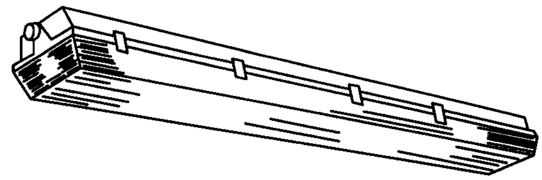
OTHER: UL LISTED FOR WET LOCATION

PENDANT MOUNTED 4' SEALED AND GASKETED INDUSTRIAL FLUORESCENT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PF9



FEATURES

LAMP TYPE: F96T8/HO
PROFILE: 2 LAMP
SHIELDING: STIPPLED ACRYLIC
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 3 LAMP
MOUNTING: SURFACE
BALLAST: HIGH POWER FACTOR MAGNETIC

NOM. DIMENSIONS 153 mm X 203 mm X 2438 mm (6" H X 8" W X 8' L)

GENERAL DESCRIPTION

HOUSING: MOLDED HIGH-IMPACT POLYESTER OR FIBERGLASS REINFORCED PLASTIC WITH COLD ROLLED STEEL INTERIOR COMPONENTS

REFLECTORS: INTERNAL WHITE REFLECTOR

ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: WHITE PAINTED

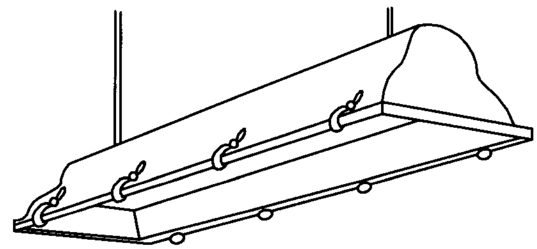
OTHER: UL LISTED FOR WET LOCATION

PENDANT MOUNTED 8' SEALED AND GASKETED INDUSTRIAL FLUORESCENT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PF10



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
MOUNTING: CHAIN HUNG
SHIELDING: CLEAR TEMPERED GLASS
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 3 OR 4 LAMP
MOUNTING: BRACKET
BALLAST: HIGH POWER FACTOR MAGNETIC

NOM. DIMENSIONS: 375 mm X 178 mm X 1346 mm
(14 3/4 " W X 7" H X 53" L)

GENERAL DESCRIPTION

HOUSING: ONE-PIECE 20 GA. SEAMLESS STEEL HOUSING WITH WELDED END CAPS; SILICONE RUBBER GASKET BETWEEN LENS/FRAME ASSEMBLY AND HOUSING

REFLECTORS: CORROSION-RESISTANT WHITE POLYESTER POWDER COAT

ELECTRICAL: 120 OR 277 VOLT BALLAST

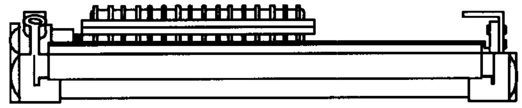
FINISH: POLYESTER POWDER COAT

OTHER: NEC CLASS II, GROUP G & CLASS III LOCATIONS

PENDANT MOUNTED VAPOR TIGHT INDUSTRIAL FLUORESCENT

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: PF11



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
SHIELDING: CLEAR TEMPERED GLASS
BALLAST: ELECTRONIC

OPTIONS

BALLAST: HIGH POWER FACTOR
MAGNETIC

NOM. DIMENSIONS: 292 mm X 216 mm X 1219 mm
(11 1/2 " W X 8 1/2 " H X 4' L)

GENERAL DESCRIPTION

HOUSING: COPPER FREE (LESS THAN .4% COPPER), HEAVY GAUGE ALUMINUM CAST END PLATES

MOUNTING: POSITIVE CLAMP MOUNTING BRACKETS, ANGLE MOUNTING BRACKET OR EXTENDED MOUNTING BRACKET

REFLECTORS: COPPER FREE HEAVY GAUGE EXTRUDED ALUMINUM PAINTED WHITE

ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: NATURAL ALUMINUM

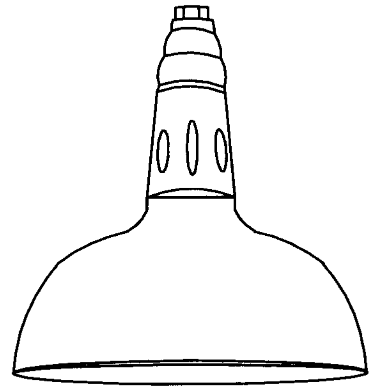
OTHER: NEC CLASS I, DIV. 1 & 2, GROUPS C & D, CLASS II, DIV. I & II, GROUPS E, F, & CLASS III

PENDANT MOUNTED EXPLOSION PROOF INDUSTRIAL FLUORESCENT, CLASS 1/ DIV I & II

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PF12



FEATURES

LAMP TYPE: F26DTT/RS
PROFILE: 1 LAMP
MOUNTING: RIGID STEM WITH SWIVEL BALL ALIGNER
SHIELDING: ALUMINUM
BALLAST: ELECTRONIC

OPTIONS

SHIELDING: VARIOUS SHAPES, WIRE GUARD

NOM. DIMENSIONS 406 mm X 305 mm (16" DIA X 12" H)

GENERAL DESCRIPTION

HOUSING: SPUN ALUMINUM SHADE

REFLECTORS: ALL WHITE PORCELAIN

ELECTRICAL: 120 OR 277 VOLT BALLAST

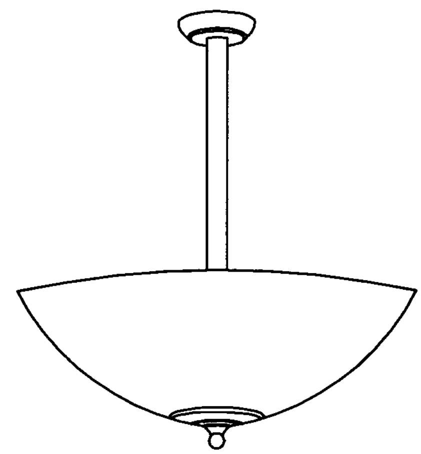
FINISH: BAKED ENAMEL OR NATURAL METAL

PENDANT MOUNTED COMPACT FLUORESCENT INDUSTRIAL DOME

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PH1



FEATURES

LAMP TYPE: 100W METAL HALIDE
PROFILE: 1 LAMP
MOUNTING: RIGID STEM
SHIELDING: OPAL ACRYLIC
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 175W, 250W
MOUNTING: THREE RIGID STEMS
SHIELDING: SANDBLASTED ACRYLIC DIFFUSER; BOWL SIZES OF 610–1295 mm (24"–51")
BALLAST: REMOTE

NOM. DIMENSIONS 914 mm X 356 mm (36" DIA. X 14" D)

GENERAL DESCRIPTION

HOUSING: OPAL ACRYLIC BOWL

REFLECTORS: SPECULAR ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

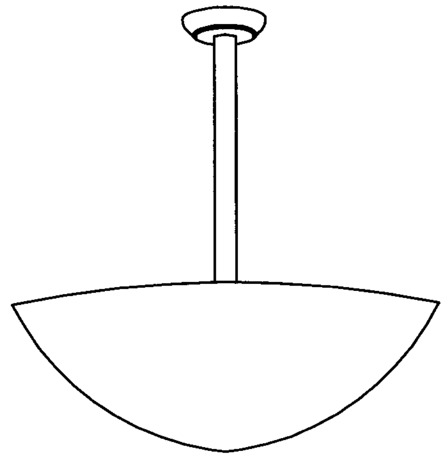
FINISH: POLISHED BRASS, CHROME OR PAINTED

PENDANT MOUNTED INDIRECT METAL HALIDE BOWL

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PH2



FEATURES

LAMP TYPE: 100W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: SPUN ALUMINUM
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 175W, 250W, 400W
BALLAST: SURFACE MOUNTED IN CANOPY

NOM. DIMENSIONS 914 mm X 305 mm (36" DIA. X 12" D)

GENERAL DESCRIPTION

HOUSING: SPUN ALUMINUM BOWL

MOUNTING: STEM MOUNTED WITH HANG STRAIGHT STEM

REFLECTORS: FABRICATED ALUMINUM SPECULAR REFLECTOR

ELECTRICAL: 120 OR 277 VOLT REMOTE BALLAST MOUNTED WITHIN 3 m (10')

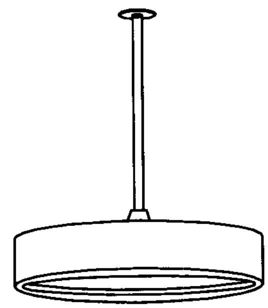
FINISH: POLISHED CHROME, POLISHED BRASS OR PAINTED

PENDANT MOUNTED INDIRECT METAL HALIDE BOWL

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PH3



FEATURES

LAMP TYPE: 175W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: OPAL ACRYLIC
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 250W, 400W
SHIELDING: CLEAR TEMPERED GLASS

NOM. DIMENSIONS 457 mm X 152 mm (18" DIA. X 6" D)

GENERAL DESCRIPTION

HOUSING: SPUN ALUMINUM

MOUNTING: SWIVEL BALL RIGID STEM TO ALLOW 45° SWIVEL AT CEILING

REFLECTORS: ALZAK® ALUMINUM, VERTICALLY FLUTED FOR SYMMETRICAL CANDLEPOWER DISTRIBUTION

ELECTRICAL: 120 OR 277 VOLT REMOTE BALLAST MOUNTED WITHIN 3 m (10')

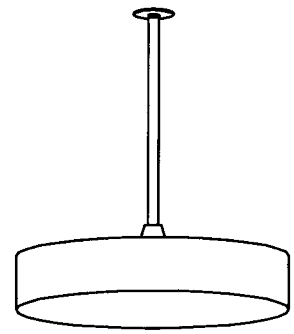
FINISH: EPOXY PRIMED WITH BAKED POLYESTER ENAMEL FINISH

PENDANT MOUNTED DIRECT/INDIRECT METAL HALIDE DRUM

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PH4



FEATURES

LAMP TYPE: 175W METAL HALIDE
PROFILE: 1 LAMP
MOUNTING: RIGID STEM
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 250W, 400W
BALLAST: SURFACE CANOPY MOUNTED

NOM. DIMENSIONS 457 mm X 152 mm (18" DIA. X 6" D)

GENERAL DESCRIPTION

HOUSING: SPUN ALUMINUM

REFLECTORS: ALZAK®, LAMP TO BE CENTERED IN REFLECTOR

ELECTRICAL: 120 OR 277 VOLT REMOTE BALLAST MOUNTED WITHIN 3 m (10')

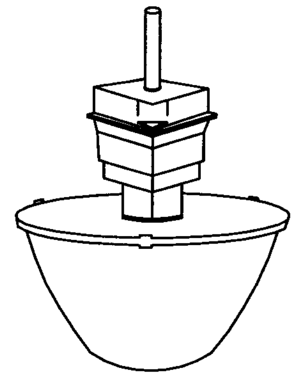
FINISH: BAKED ENAMEL OR POLYESTER POWDER COAT

PENDANT MOUNTED INDIRECT METAL HALIDE DRUM

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PH5



FEATURES

LAMP TYPE: 150W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: PRISMATIC BOROSILICATE GLASS
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 50W, 70W, 100W, 175W HPS: 70W, 100W, 150W
BALLAST: SURFACE CANOPY MOUNTED
OTHER: DECORATIVE BALLAST COVER

NOM. DIMENSIONS 330 mm X 254 mm (13" DIA. X 10" H)

GENERAL DESCRIPTION

HOUSING: COPPER FREE DIE-CAST ALUMINUM

MOUNTING: STEM MOUNTED ON QUICK DISCONNECT, POSITIVE LOCKING, VIBRATION RESISTANT CONNECTOR WITH SET SCREW

REFLECTORS: SPUN ALZAK® ALUMINUM

ELECTRICAL: 120 OR 277 VOLT REMOTE BALLAST MOUNTED WITHIN 3 M (10')

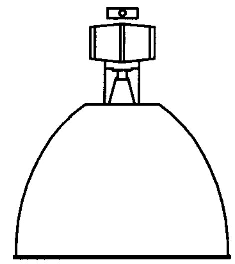
FINISH: CORROSION RESISTANT WHITE POLYESTER POWDER COAT PAINT

PENDANT MOUNTED DIRECT/INDIRECT METAL HALIDE

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: PH6



FEATURES

LAMP TYPE: 250W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: CLEAR GLASS LENS
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 175W, 400W
HPS: 150W, 200W, 400W
BALLAST: HI-LOW

NOM. DIMENSIONS 483 mm X 660 mm
(19" DIA X 26" D)

GENERAL DESCRIPTION

HOUSING: HEAVY GAUGE COLD ROLLED STELL

MOUNTING: RIGID STEM WITH SWIVEL BALL ALIGNER

REFLECTORS: HIGHLY SPECULAR EXTRUDED-CONTOUR OPTICAL REFLECTOR AND FORMED SPECULAR REFLECTOR

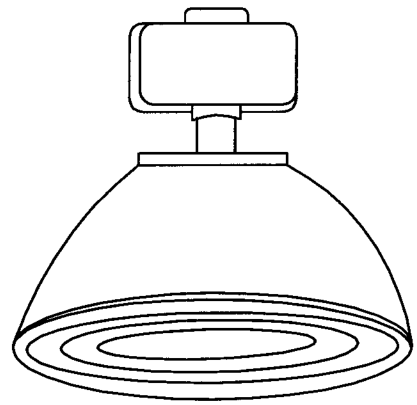
ELECTRICAL: 120, 277, 208, 240, 347 OR 480 VOLT MULTI TAP BALLAST

FINISH: NATURAL METAL

PENDANT MOUNTED METAL HALIDE HIGH BAY WAREHOUSE AISLE LIGHT

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: PH7



FEATURES

LAMP TYPE: 400W METAL HALIDE
PROFILE: 1 LAMP
MOUNTING: RIGID STEM
REFLECTOR: ALUMINUM WITH OPEN TOP
SHIELDING: DROP PRISMATIC
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 250W, 1000W
MOUNTING: SURFACE
BALLAST: HI-LOW, REMOTE

NOM. DIMENSIONS 660 mm X 457 mm (26" H X 18" DIA)

GENERAL DESCRIPTION

HOUSING: DIE-CAST ALUMINUM BALLAST HOUSING WITH HEAT SINK

REFLECTORS: SPUN OR HYDRO-FORMED ALUMINUM REFLECTOR WITH 10% OPEN TOP AND ANODIZED FINISH

ELECTRICAL: 120, 277 OR 480 VOLT MULTI TAP BALLAST

FINISH: NATURAL ALUMINUM, ANODIZED OR CLEAR LACQUERED

PENDANT MOUNTED METAL HALIDE HIGH BAY INDUSTRIAL

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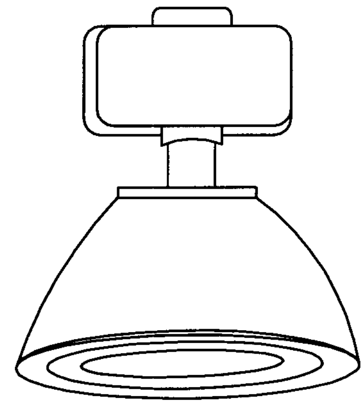
CORPS OF ENGINEERS | DEPARTMENT OF THE ARMY

TYPE: PH8



FEATURES

LAMP TYPE: 250W METAL HALIDE
PROFILE: 1 LAMP
SHIELDING: DROP-DISH PRISMATIC REFRACTOR
MOUNTING: RIGID STEM WITH SWIVEL BALL ALIGNER
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 175W
MOUNTING: SURFACE
BALLAST: HI-LOW, REMOTE

NOM. DIMENSIONS 635 mm X 711 mm (25" H X 28" DIA)

GENERAL DESCRIPTION

HOUSING: DIE-CAST ALUMINUM BALLAST HOUSING WITH HEAT SINK

REFLECTORS: SPUN OR HYDRO-FORMED ALUMINUM FOR LOW GLARE SHIELDING; ANODIZED FINISH

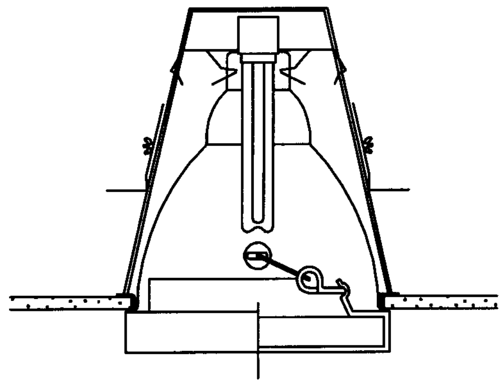
ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: NATURAL ALUMINUM, ANODIZED OR CLEAR LACQUERED

PENDANT MOUNTED METAL HALIDE LOW BAY INDUSTRIAL

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



TYPE: RF1

FEATURES

LAMP TYPE: F13DTT/RS
PROFILE: 1 LAMP
SHIELDING: PRISMATIC ACRYLIC
BALLAST: ELECTRONIC

OPTIONS

BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 178 mm X 229 mm (7" DIA. X 9" D)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED 20 GA. GALVANIZED STEEL MOUNTING FAN, UNIVERSAL MOUNTING BRACKETS

REFLECTORS: HYDRO FORMED 1 mm (.04") THICK ALUMINUM, SEMI-SPECULAR

ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: CLEAR, SEMI-SPECULAR LOW IRIDESCENT CONE

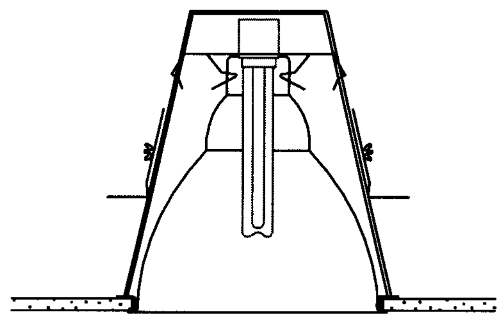
EFFICIENCY: 35%

7" DIA. RECESSED COMPACT FLUORESCENT LENSED DOWNLIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF2



FEATURES

LAMP TYPE: F32DTT/RS
PROFILE: 1 LAMP
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F26DTT/RS
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY
OTHER: CHAMPAGNE GOLD OR PEWTER REFLECTOR, WHITE PAINTED FLANGE, SLOPED CEILING ADAPTER

NOM. DIMENSIONS 152 mm X 311 mm (6" DIA. X 12 1/4 " D)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED 20 GA. GALVANIZED STEEL MOUNTING PAN, UNIVERSAL MOUNTING BRACKETS

REFLECTORS: CLEAR SEMI-SPECULAR ALZAK ® ALUMINUM, LOW IRIDESCENT WITH SELF FLANGE

ELECTRICAL: 120 OR 277 VOLT BALLAST

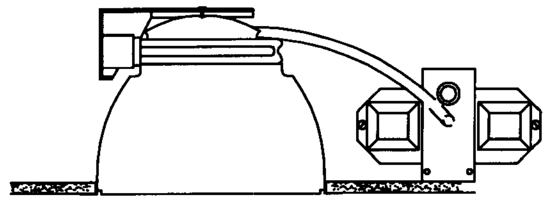
EFFICIENCY: 55%

6" DIA. RECESSED COMPACT FLUORESCENT DOWNLIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF3



FEATURES

LAMP TYPE: F18DTT/RS
PROFILE: 2 LAMP
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F13TT/RS, F26DTT/RS
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY, DUAL SWITCHING
OTHER: WHITE PAINTED FLANGE; CHAMPAGNE GOLD, PEWTER, BRONZE OR WHITE REFLECTOR & TRIM RING; DAMP LOCATION LISTING

NOM. DIMENSIONS 203 mm X 173 mm (8" DIA. X 6 13/16 " D)

GENERAL DESCRIPTION

HOUSING: DIE CAST ALUMINUM WITH UNIVERSAL MOUNTING BRACKETS

REFLECTORS: SEMI-SPECULAR, LOW IRIDESCENT, 1.3 mm (.05") THICK ALUMINUM REFLECTOR, SELF-FLANGED

ELECTRICAL: 120 OR 277 VOLT BALLAST

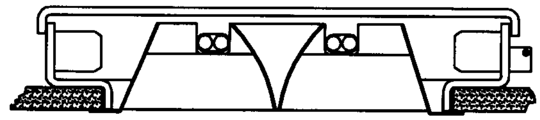
EFFICIENCY: 70%

8" DIA. RECESSED COMPACT FLUORESCENT DOWNLIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF4



FEATURES

LAMP TYPE: F18DTT/RS
PROFILE: 2 LAMP
BALLAST: ELECTRONIC
SHIELDING: 4 CELL SEMI-SPECULAR, LOW IRIDESCENT PARABOLIC CROSS BLADE LOUVER WITH SELF FLANGE

OPTIONS

LAMP TYPE: F26DTT/RS
BALLAST: DIMMING, HIGH POWER FACTOR MAGNETIC, DUAL SWITCHING, EMERGENCY
OTHER: WHITE PAINTED FLANGE; CHAMPAGNE GOLD, PEWTER, BRONZE OR WHITE REFLECTOR & TRIM RING; DAMP LOCATION LISTING

NOM. DIMENSIONS 203 mm X 124 mm (8" DIA. X 4 7/8 " D)

GENERAL DESCRIPTION

HOUSING: DIE-CAST ALUMINUM WITH UNIVERSAL MOUNTING BRACKETS

REFLECTORS: SEMI-SPECULAR 1.3 mm (.05") THICK ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

EFFICIENCY: 40%

8" DIA. RECESSED COMPACT FLUORESCENT LOUVERED DOWNLIGHT

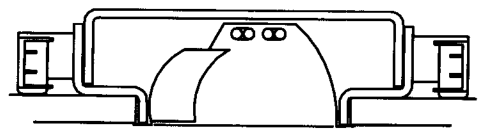
CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF5

FEATURES

LAMP TYPE: F18DTT/RS
PROFILE: 2 LAMP
BALLAST: ELECTRONIC



OPTIONS

LAMP TYPE: F13TT/RS, F26DTT/RS
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY, DUAL SWITCHING
OTHER: WHITE PAINTED FLANGE; CHAMPAGNE GOLD, PEWTER, BRONZE OR WHITE REFLECTOR & TRIM RING; DAMP LOCATION LISTING

NOM. DIMENSIONS 203 mm X 173 mm (8" DIA. X 6 13/16 " D)

GENERAL DESCRIPTION

HOUSING: DIE CAST ALUMINUM WITH UNIVERSAL MOUNTING BRACKETS

REFLECTORS: SEMI-SPECULAR, LOW IRIDESCENT WITH SEMI-SPECULAR WALLWASH KICKER AND SELF FLANGE TRIM

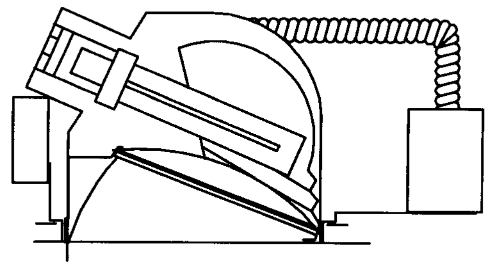
ELECTRICAL: 120 OR 277 VOLT BALLAST

8" DIA. RECESSED COMPACT FLUORESCENT DOWNLIGHT/WALLWASHER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF6



FEATURES

LAMP TYPE: F18DTT/RS
PROFILE: 2 LAMP
SHIELDING: CLEAR PRISMATIC GLASS SPREAD LENS
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F26DTT/RS
BALLAST: DIMMING, HIGH POWER FACTOR MAGNETIC, EMERGENCY
OTHER: WHITE PAINTED FLANGE; SPECULAR BLACK OR CHAMPAGNE GOLD REFLECTOR AND TRIM RING

NOM. DIMENSIONS 178 mm X 172 mm (7" DIA. X 6 3/4 " D)

GENERAL DESCRIPTION

HOUSING: ROLLED STEEL OR DIE CAST ALUMINUM WITH COLLAR TO ACCOMMODATE VARYING CEILING THICKNESSES

REFLECTORS: CLEAR, SEMI-SPECULAR, LOW IRIDESCENT ALZAK® WITH SELF FLANGE

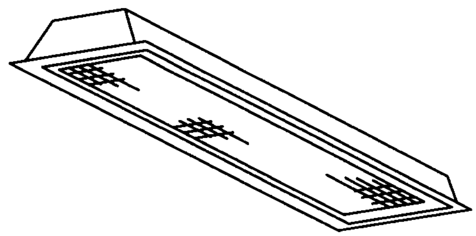
ELECTRICAL: 120 OR 277 VOLT BALLAST

7"DIA. RECESSED COMPACT FLUORESCENT LENSED WALLWASHER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF7



FEATURES

LAMP TYPE: F32T8/ 75 CRI
PROFILE: 2 LAMP
SHIELDING: ACRYLIC PRISMATIC LENS
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 3 LAMP
SHIELDING: 3.2 mm (0.125") PATTERN 12, PATTERN 19, RFI SUPPRESSION
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY
OTHER: GASKETED; AIR HANDLING AND/OR HEAT REMOVAL

NOM. DIMENSIONS 305 mm X 1219 mm X 127 mm (12" W X 4' L X 5" D)

GENERAL DESCRIPTION

HOUSING: COLD ROLLED STEEL WITH VARIOUS TRIM OPTIONS TO COORDINATE WITH CEILING; EXTRUDED ALUMINUM LENS FRAME WITH HINGED REMOVAL AND SPRING-LOADED CATCHES

MOUNTING: RECESSED INTO STANDARD NON METRIC GRID

REFLECTORS: GLOSS WHITE

ELECTRICAL: 120 OR 277 VOLT BALLAST

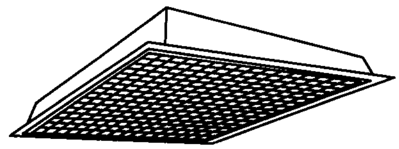
EFFICIENCY: 60%

RECESSED LENSED 1'x4' FLUORESCENT TROFFER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF8



FEATURES

LAMP TYPE: F32/T8/U/6/75 CRI
PROFILE: 2 LAMP
SHIELDING: ACRYLIC PRISMATIC LENS
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F39/BX/RS
PROFILE: 3 LAMP
SHIELDING: 3.2 mm (0.125")
PATTERN 12, PATTERN
19, RFI SUPPRESSION
BALLAST: HIGH POWER FACTOR
MAGNETIC, DIMMING,
EMERGENCY
OTHER: GASKETED; AIR HANDLING
AND/OR HEAT REMOVAL

NOM. DIMENSIONS 610 mm X 610 mm X 152 mm
(24" W X 24" L x 6" D)

GENERAL DESCRIPTION

HOUSING: COLD ROLLED STEEL, FLANGE TO COORDINATE WITH CEILING;
EXTRUDED ALUMINUM LENS FRAME, HINGED REMOVAL AND SPRING-LOADED CATCHES

MOUNTING: RECESSED INTO STANDARD NON METRIC GRID

REFLECTORS: HIGH REFLECTANCE GLOSS WHITE

ELECTRICAL: 120 OR 277 VOLT BALLAST

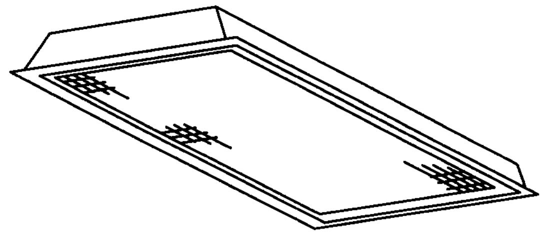
EFFICIENCY: 65%

RECESSED LENSED 2'x2' FLUORESCENT TROFFER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF9



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 3 LAMP
SHIELDING: ACRYLIC PRISMATIC LENS
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 4 LAMP
SHIELDING: 3.2 mm (0.125") PATTERN 12, PATTERN 19, RFI SUPPRESSION
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY
OTHER: GASKETED; AIR HANDLING AND/OR HEAT REMOVAL

NOM. DIMENSIONS 610 mm X 1219 mm X 152 mm (24" W X 4' L X 6" D)

GENERAL DESCRIPTION

HOUSING: COLD ROLLED STEEL, FLANGE TO COORDINATE WITH CEILING; EXTRUDED ALUMINUM LENS FRAME, HINGED REMOVAL AND SPRING-LOADED CATCHES

MOUNTING: RECESSED INTO STANDARD NON METRIC GRID

REFLECTORS: HIGH REFLECTANCE GLOSS WHITE

ELECTRICAL: 120 OR 277 VOLT BALLAST

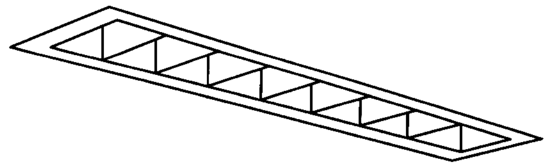
EFFICIENCY: 80%

RECESSED LENSED 2'x4' FLUORESCENT TROFFER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF10



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
SHIELDING: 76 mm (3") DEEP, 8 CELL SEMI-SPECULAR, LOW IRIDESCENT PARABOLIC LOUVER
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 1 LAMP
SHIELDING: SPECULAR LOUVER, CELL CONFIGURATION
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY
OTHER: GASKETED; AIR HANDLING AND/OR HEAT REMOVAL

NOM. DIMENSIONS 305 mm X 1219 mm X 152 mm
(12" W X 4' L X 6" D)

GENERAL DESCRIPTION

HOUSING: COLD ROLLED STEEL, FLANGE TO COORDINATE WITH CEILING

MOUNTING: RECESSED INTO STANDARD NON METRIC GRID

REFLECTORS: HIGH REFLECTANCE GLOSS WHITE

ELECTRICAL: 120 OR 277 VOLT BALLAST

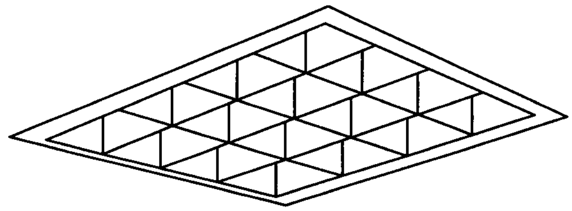
EFFICIENCY: 65%

RECESSED PARABOLIC 1'x4' FLUORESCENT TROFFER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF11



FEATURES

LAMP TYPE: F32T8/U/6/ 75 CRI
PROFILE: 2 LAMP
SHIELDING: 76 mm (3") DEEP, 16 CELL SEMI-SPECULAR, LOW IRIDESCENT PARABOLIC LOUVER
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F39TT/RS
PROFILE: 3 LAMP
SHIELDING: SPECULAR LOUVER, CELL CONFIGURATION
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY
OTHER: GASKETED; AIR HANDLING AND/OR HEAT REMOVAL

NOM. DIMENSIONS 610 mm X 610 mm X 152 mm
(2' W X 2' L X 6" D)

GENERAL DESCRIPTION

HOUSING: COLD ROLLED STEEL, FLANGE TO COORDINATE WITH CEILING

MOUNTING: RECESSED INTO STANDARD NON METRIC GRID

REFLECTORS: HIGH REFLECTANCE GLOSS WHITE

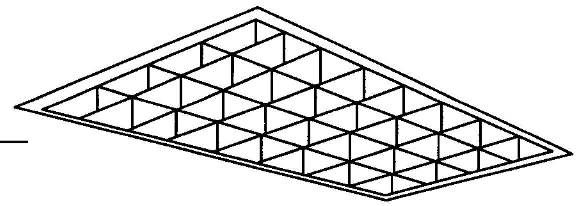
ELECTRICAL: 120 OR 277 VOLT BALLAST

EFFICIENCY: 60%

RECESSED PARABOLIC 2'x2' FLUORESCENT TROFFER

CORPS OF ENGINEERS　　　　　　　　　　DEPARTMENT OF THE ARMY

TYPE:　　　RF12



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 3 LAMP
MOUNTING: RECESSED GRID
SHIELDING: 76 mm (3") DEEP, 24 CELL SEMI-SPECULAR, LOW IRIDESCENT PARABOLIC LOUVER
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 4 LAMP
SHIELDING: SPECULAR LOUVER, CELL CONFIGURATION
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY
OTHER: GASKETED; AIR HANDLING AND/OR HEAT REMOVAL

NOM. DIMENSIONS 610 mm X 1219 mm X 152 mm
(24" W X 4' L X 6" D)

GENERAL DESCRIPTION

HOUSING: COLD ROLLED STEEL, FLANGE TO COORDINATE WITH CEILING

MOUNTING: RECESSED INTO STANDARD NON METRIC GRID

REFLECTORS: HIGH REFLECTANCE GLOSS WHITE

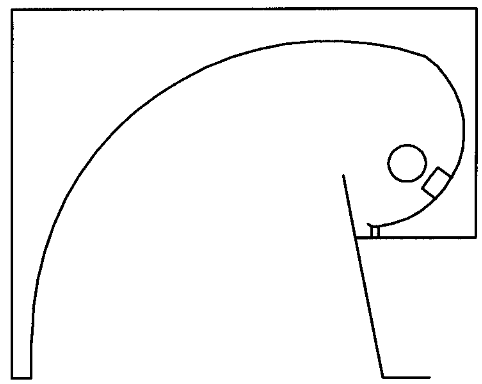
ELECTRICAL: 120 OR 277 VOLT BALLAST

EFFICIENCY: 70%

RECESSED PARABOLIC 2'X4' FLUORESCENT TROFFER

CORPS OF ENGINEERS | DEPARTMENT OF THE ARMY

TYPE: RF13



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 1 LAMP
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F25T8/RS
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY.

NOM. DIMENSIONS 229 mm X 1219 mm X 203 mm
(9" W X 4' L X 8" D)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED, 20 GA. STEEL WITH 19 mm (3/4") EXTRUDED ALUMINUM CEILING FLANGE; TELESCOPING END MODULES FOR CONTINUOUS LIGHT

MOUNTING: RECESSED GRID OR FLANGE

REFLECTORS: SEMI-SPECULAR ROLLED ALUMINUM, CONTINUOUS AND UNBROKEN, NO VISIBLE JOINTS, CONTOURED TO SHIELD LAMP, SELF FLANGE

ELECTRICAL: 120 OR 277 VOLT BALLAST

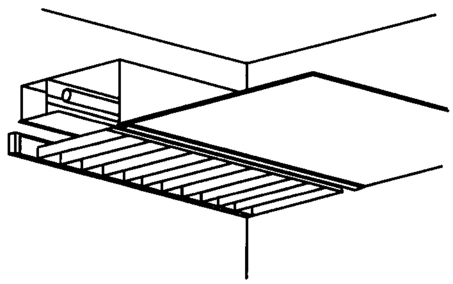
FINISH: CLEAR, SEMI-SPECULAR, LOW IRIDESCENT ALUMINUM

RECESSED OPEN LINEAR FLUORESCENT WALL SLOT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF14



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 1 LAMP
SHIELDING: 32 mm (1.25") HIGH X 61 mm (2.4") OC, SEMI-SPECULAR, LOW IRIDESCENT PARABOLIC LOUVER
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F25T8/RS
PROFILE: 2 LAMP
SHIELDING: STRAIGHT BLADE BAFFLE
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 229 mm X 1219 mm X 203 mm
(9" W X 4' L X 8" D)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED, 20 GA. COLD ROLLED STEEL, WITH TELESCOPING END MODULES FOR CONTINUOUS LIGHT

REFLECTORS: SEMI-SPECULAR ALUMINUM, CONTINUOUS AND UNBROKEN, NO VISIBLE JOINTS, SELF FLANGE

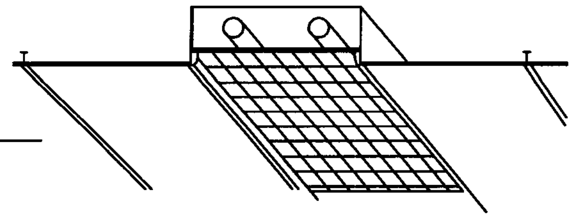
ELECTRICAL: 120 OR 277 VOLT BALLAST

RECESSED LOUVERED FLUORESCENT WALL SLOT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RF15



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
SHIELDING: PRISMATIC LENS
BALLAST: ELECTRONIC

OPTIONS

BALLAST: HIGH POWER FACTOR
MAGNETIC, DIMMING,
EMERGENCY

NOM. DIMENSIONS 305 mm X 1219 mm X 152 mm
(12" W X 4' L X 6" D)

GENERAL DESCRIPTION

HOUSING: 20 GAUGE COLD ROLLED STEEL

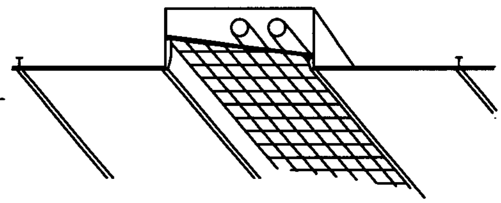
REFLECTORS: SEMI-SPECULAR

ELECTRICAL: 120 OR 277 VOLT BALLAST

RECESSED TELECONFERENCING FLUORESCENT TROFFER

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: RF16



FEATURES

LAMP TYPE: F32T8/RS
PROFILE: 2 LAMP
SHIELDING: PRISMATIC LENS
BALLAST: ELECTRONIC

OPTIONS

BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 305 mm X 1219 mm X 187 mm (12" W X 4' L X 7 3/8 " D)

GENERAL DESCRIPTION

HOUSING: 20 GAUGE COLD ROLLED STEEL

REFLECTORS: SPECULAR ALZAK®

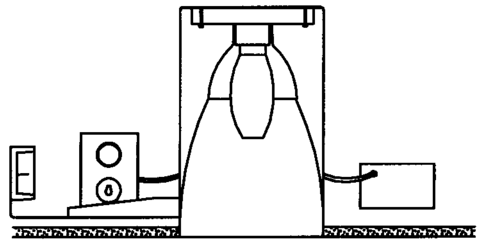
ELECTRICAL: 120 OR 277 VOLT BALLAST

RECESSED TELECONFERENCING FLUORESCENT TROFFER WITH ANGLED LENS

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RH1



FEATURES

LAMP TYPE:	100W MH (OPEN FIXTURE)
PROFILE:	1 LAMP
BALLAST:	HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE:	MH: 50W, 70W
REFLECTOR:	BRONZE REFLECTOR AND FLANGE
OTHER:	EMERGENCY RESTRIKE

NOM. DIMENSIONS 178 mm X 279 mm (7" DIA. X 11" D)

GENERAL DESCRIPTION

HOUSING: ASSEMBLED CAST ALUMINUM HEAT SINK/SOCKET HOUSING; SPUN ALUMINUM REFLECTOR/CONE AND MOUNTING PAN

MOUNTING: SELF-LOCKING ADJUSTABLE BARS

REFLECTORS: SEMI-SPECULAR CLEAR ALUMINUM WITH SELF FLANGE

ELECTRICAL: 120 OR 277 VOLT BALLAST

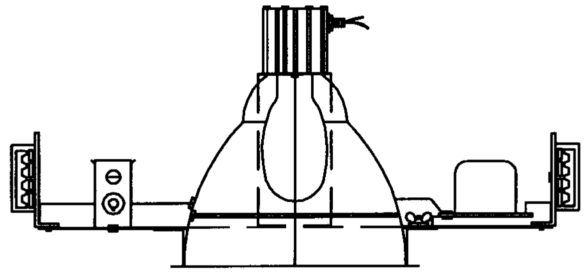
EFFICIENCY: 65%

7" DIA. RECESSED LOW WATTAGE OPEN METAL HALIDE DOWNLIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RH2



FEATURES

LAMP TYPE: 175W MH
PROFILE: 1 LAMP
SHIELDING: CLEAR TEMPERED GLASS
BALLAST: HIGH POWER FACTOR,
CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 250W
HPS: 150W, 250W
REFLECTOR: BRONZE REFLECTOR WITH
SELF FLANGE
OTHER: EMERGENCY RESTRIKE

NOM. DIMENSIONS 229 mm X 432 mm
(9" DIA. X 17" H)

GENERAL DESCRIPTION

HOUSING: CAST ALUMINUM HEAT SINK/SOCKET HOUSING; SPUN ALUMINUM REFLECTOR/CONE AND MOUNTING PAN

MOUNTING: RECESSED ACOUSTICAL TILE

REFLECTORS: CLEAR, SEMI-SPECULAR, HYDROFORMED ANODIZED ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

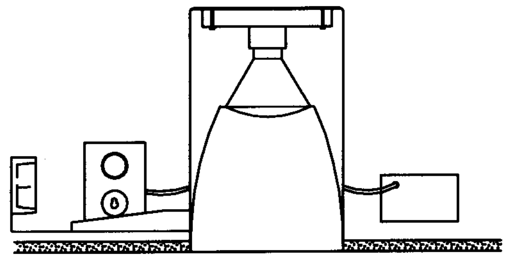
EFFICIENCY: 50%

9" DIA. RECESSED METAL HALIDE DOWNLIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RH3



FEATURES

LAMP TYPE: 70W PAR38/MH
PROFILE: 1 LAMP
SHIELDING: CLEAR TEMPERED GLASS
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: MH: 50W, 100W, 150W
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA
REFLECTOR: BRONZE OR CHAMPAGNE GOLD REFLECTOR AND FLANGE
OTHER: EMERGENCY RESTRIKE

NOM. DIMENSIONS 178 mm X 356 mm (7" DIA. X 14" D)

GENERAL DESCRIPTION

HOUSING: CAST ALUMINUM HEAT SINK/SOCKET HOUSING; SPUN ALUMINUM REFLECTOR/CONE AND MOUNTING PAN

REFLECTORS: SEMI-SPECULAR, CLEAR ALUMINUM WITH SELF FLANGE

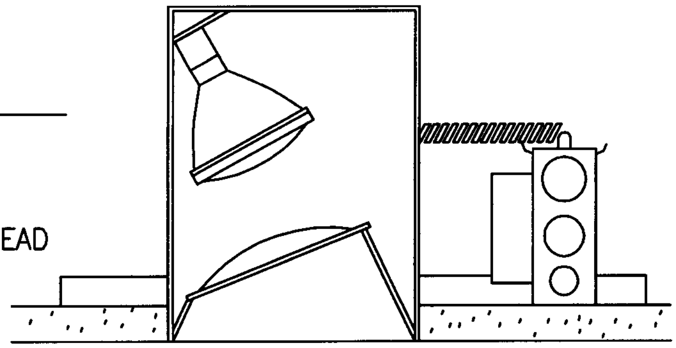
ELECTRICAL: 120 OR 277 VOLT BALLAST

EFFICIENCY: 90%

7" DIA. RECESSED METAL HALIDE PAR DOWNLIGHT

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: RH4



FEATURES

LAMP TYPE: 70W PAR38/MH
PROFILE: 1 LAMP
SHIELDING PRISMATIC TEMPERED GLASS CONCAVE SPREAD LENS
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: MH: 50W, 100W, 150W
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA
REFLECTOR: BRONZE, PEWTER OR CHAMPAGNE GOLD REFLECTOR AND FLANGE
OTHER: EMERGENCY RESTRIKE

NOM. DIMENSIONS 178 mm X 356 mm
(7" DIA. X 14" D)

GENERAL DESCRIPTION

HOUSING: FORMED COLD ROLLED STEEL WITH INTEGRAL BALLAST AND LAMP HOLDER

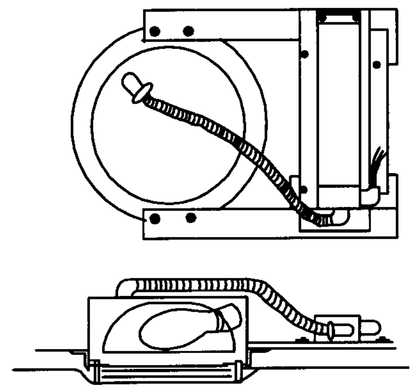
REFLECTORS: SEMI-SPECULAR ALUMINUM WITH SELF FLANGE

ELECTRICAL: 120 OR 277 VOLT BALLAST

7" DIA. RECESSED METAL HALIDE LENSED WALLWASHER

CORPS OF ENGINEERS | DEPARTMENT OF THE ARMY

TYPE: RH5



FEATURES

LAMP TYPE: 100W MH
PROFILE: 1 LAMP
SHIELDING: REGRESSED FRESNEL
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 70W, 175W
HPS: 50W, 70W, 100W
SHIELDING: HOLOPHANE LENS
OTHER: EMERGENCY RESTRIKE

NOM. DIMENSIONS 254 mm X 178 mm (10" DIA. X 7" D)

GENERAL DESCRIPTION

HOUSING: HEAVY GAUGE ALUMINUM, RUSTPROOF WITH BUILT-IN PLASTER FRAME

MOUNTING: RECESSED INTO PLASTER

REFLECTORS: SPECULAR ALZAK® ALUMINUM WITH SELF FLANGE

ELECTRICAL: 120 OR 277 VOLT BALLAST

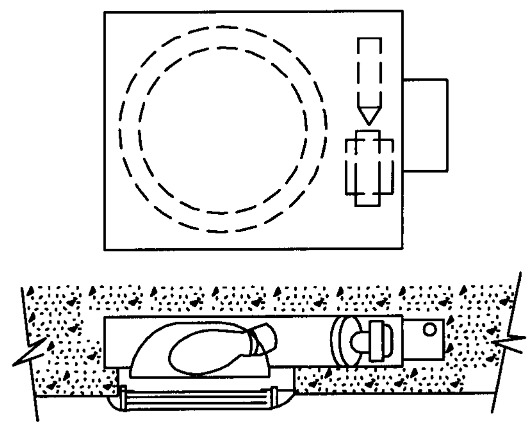
EFFICIENCY: 55%

10" DIA. RECESSED, ENCLOSED & GASKETED METAL HALIDE DOWNLIGHT, PLASTER CEILING

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RH6



FEATURES

LAMP TYPE: 100W MH
PROFILE: 1 LAMP
SHIELDING: PRISMATIC TEMPERED GLASS
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 50W, 70W
HPS: 50W, 70W, 100W
OTHER: EMERGENCY RESTRIKE

NOM. DIMENSIONS 216 mm X 159 mm
(8 1/2 " DIA X 6 1/4 " D)

GENERAL DESCRIPTION

HOUSING: 18 GAUGE GALVANIZED STEEL, RED OXIDE RUSTPROOF PRIMER COAT, WHITE ENAMEL FINISH

MOUNTING: RECESSED INTO CONCRETE

REFLECTORS: SEMI-SPECULAR ALZAK® WITH SELF FLANGE

ELECTRICAL: 120 OR 277 VOLT BALLAST

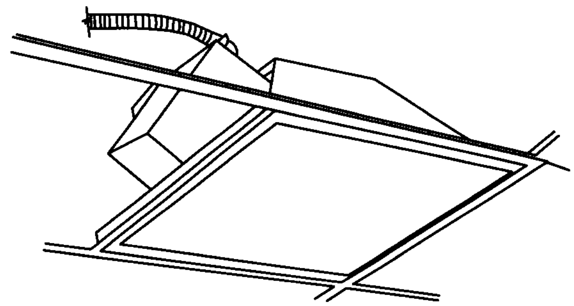
EFFICIENCY: 55%

9" DIA. RECESSED, ENCLOSED & GASKETED METAL HALIDE DOWNLIGHT, CONCRETE CEILING

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RH7



FEATURES

LAMP TYPE: 250W METAL HALIDE
PROFILE: 1 LAMP
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 175W, 400W
BALLAST: HI–LOW
OTHER: EMERGENCY RESTRIKE

NOM. DIMENSIONS 610 mm X 610 mm X 406 mm (24" W X 24" L X 16" D)

GENERAL DESCRIPTION

HOUSING: COLD ROLLED STEEL, FORMED AND WELDED; EXTRUDED ALUMINUM LENS FRAME, MITERED WITH CONTINUOUS GASKET, HINGED FOR EASY REMOVAL WITH CAPTIVE SCREW FASTENERS

MOUNTING: RECESSED INTO STANDARD NON METRIC GRID

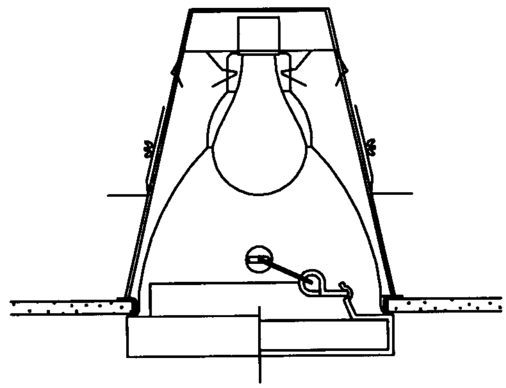
REFLECTORS: SEMI–SPECULAR SEGMENTED ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

RECESSED LENSED 2'X2' METAL HALIDE TROFFER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



TYPE: RI1

FEATURES

LAMP TYPE: 90W TB/IF
PROFILE: 1 LAMP
SHIELDING: OPAL POLYCARBONATE DROP DIFFUSER
BALLAST: NONE

OPTIONS

LAMP TYPE: 75W A19/IF

NOM. DIMENSIONS 152 mm X 203 mm (6" DIA. X 8" D)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED 20 GA. GALVANIZED STEEL MOUNTING PAN; UNIVERSAL MOUNTING BRACKETS, CONTINUOUS NEOPRENE GASKET ON FLANGE OF REFLECTOR

REFLECTORS: SEMI-SPECULAR HYDRO-FORMED 1 mm (0.04") THICK ALUMINUM; WHITE TRIM RING

ELECTRICAL: 120 VOLT

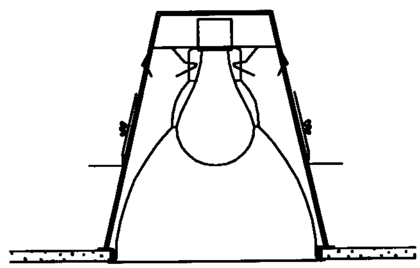
EFFICIENCY: 30%

6" DIA. RECESSED INCANDESCENT DROPPED OPAL GLASS DOWNLIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RI2



FEATURES

LAMP TYPE: 90W TB/IF
PROFILE: 1 LAMP
REFLECTORS: CLEAR ALZAK® SEMI-SPECULAR WITH SELF-FLANGE

OPTIONS

LAMP TYPE: 100W A21/IF, 150W A21/IF
REFLECTOR: CHAMPAGNE GOLD REFLECTOR WITH SELF FLANGE, WHITE PAINTED FLANGE, SLOPED CEILING ADAPTER

NOM. DIMENSIONS 178 mm X 305 mm (7" DIA. X 12" D)

GENERAL DESCRIPTION

HOUSING: ONE PIECE PRECISION DIE-CAST ALUMINUM COLLAR, DIE-FORMED 20 GA. MOUNTING PLATE

ELECTRICAL: 120 VOLT

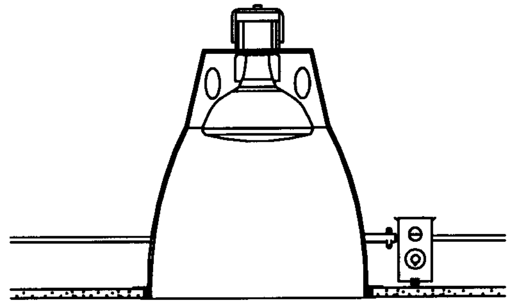
EFFICIENCY: 71%

7" DIA. RECESSED INCANDESCENT DOWNLIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RI3



FEATURES

LAMP TYPE: 90W PAR38
PROFILE: 1 LAMP
REFLECTORS: CLEAR ALZAK® SEMI-SPECULAR, SELF-FLANGED

OPTIONS

LAMP TYPE: 60W, Q150W, Q250W PAR38
OTHER: CHAMPAGNE GOLD REFLECTOR WITH SELF FLANGE, WHITE PAINTED FLANGE, SLOPED CEILING ADAPTER

NOM. DIMENSIONS 178 mm X 330 mm (7" DIA. X 13" D)

GENERAL DESCRIPTION

HOUSING: ONE PIECE PRECISION DIE-CAST ALUMINUM COLLAR; DIE-FORMED 20 GA. MOUNTING PLATE

ELECTRICAL: 120 VOLT

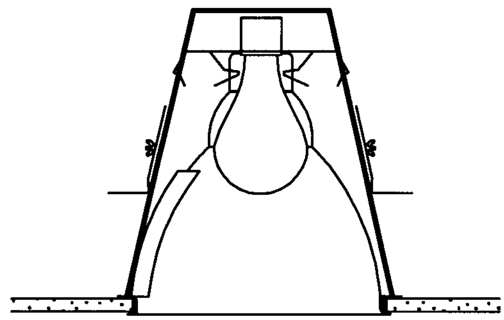
EFFICIENCY: 95%

7" DIA. RECESSED PAR LAMP DOWNLIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RI4



FEATURES

LAMP TYPE: 90W TB/IF
PROFILE: 1 LAMP
REFLECTORS: CLEAR, SEMI-SPECULAR, SELF FLANGED ALUMINUM CONE; SINGLE 120 DEGREE SPUN PARABOLIC CONTOUR KICKER REFLECTOR

OPTIONS

LAMP TYPE: 100W A21/IF, 150W A21/IF
REFLECTOR: CORNER OR DOUBLE WALL WASH
OTHER: CHAMPAGNE GOLD REFLECTOR WITH SELF-FLANGE, WHITE PAINTED FLANGE, SLOPED CEILING ADAPTER

NOM. DIMENSIONS 178 mm X 356 mm (7" DIA. X 14" D)

GENERAL DESCRIPTION

HOUSING: ONE PIECE PRECISION DIE-CAST ALUMINUM COLLAR; DIE-FORMED 20 GA. MOUNTING PLATE

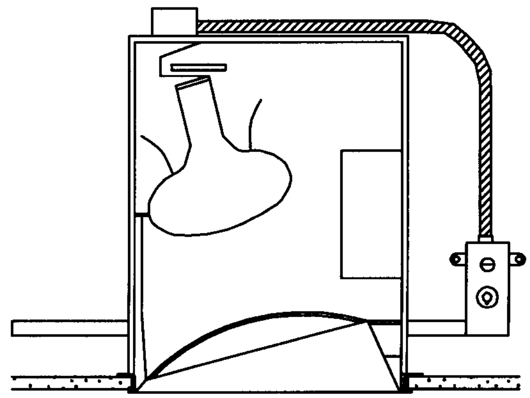
ELECTRICAL: 120 VOLT

7" DIA. RECESSED INCANDESCENT DOWNLIGHT/WALL WASHER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RI5



FEATURES

LAMP TYPE: 90W PAR38
PROFILE: 1 LAMP
SHIELDING: CLEAR TEMPERED SPREAD LENS
REFLECTORS: CLEAR ALZAK® SEMI-SPECULAR, SELF-FLANGED

OPTIONS

LAMP TYPE: 60W, Q150W, Q250W PAR38
OTHER: CHAMPAGNE GOLD REFLECTOR WITH SELF FLANGE, WHITE PAINTED FLANGE, SLOPED CEILING ADAPTER

NOM. DIMENSIONS 203 mm X 305 mm (8" DIA. X 12" D)

GENERAL DESCRIPTION

HOUSING: ONE PIECE PRECISION DIE-CAST ALUMINUM COLLAR; DIE-FORMED 20 GA. MOUNTING PLATE

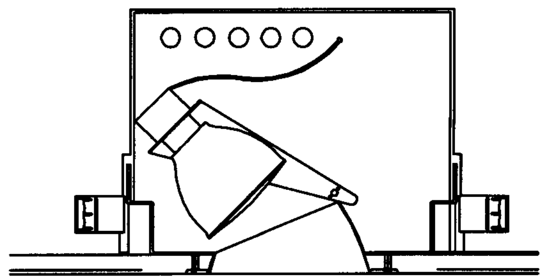
ELECTRICAL: 120 VOLT

7" DIA. RECESSED INCANDESCENT LENSED WALLWASHER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RI6



FEATURES

LAMP TYPE: 90W PAR38
PROFILE: 1 LAMP
REFLECTORS: CLEAR SEMI-SPECULAR, TAPERED 0-30 DEG CUT CONE, SELF FLANGED

OPTIONS

LAMP TYPE: 60W, Q150W, Q250W PAR38
REFLECTOR: CHAMPAGNE GOLD OR BLACK REFLECTOR WITH SELF FLANGE, WHITE PAINTED FLANGE

NOM. DIMENSIONS 178 mm X 289 mm (7" DIA. X 11 3/8 " D)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED 20 GA. COLD ROLLED STEEL, LAMP ASSEMBLY ROTATES 360 DEGREES AND TILTS 40 DEGREES

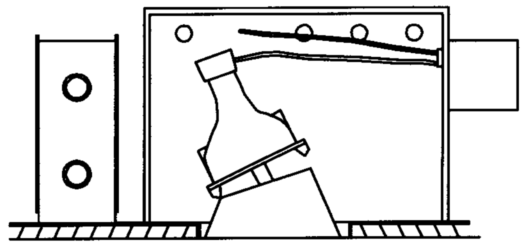
ELECTRICAL: 120 VOLT

7" DIA. RECESSED INCANDESCENT ADJUSTABLE ACCENT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: RI7



FEATURES

LAMP TYPE: 50W MR16
PROFILE: 1 LAMP
SHIELDING: CLEAR GLASS
REFLECTORS: SELF-FLANGE, SEMI-SPECULAR 0-30 DEG. TAPERED CONE

OPTIONS

LAMP TYPE: 20W, 35W, 75W MR16
SHIELDING: SPREAD LENS
OTHER: CHAMPAGNE GOLD REFLECTOR AND FLANGE; WHITE FLANGE

NOM. DIMENSIONS 102 mm X 229 mm (4" DIA. X 9" D)

GENERAL DESCRIPTION

HOUSING: DRAWN STEEL HOUSING MOUNTED TO DIE-FORMED MOUNTING PAN

ELECTRICAL: 120/12 VOLT OR 277/12 VOLT MAGNETIC TRANSFORMER

4" DIA. RECESSED LOW VOLTAGE INCANDESCENT ADJUSTABLE ACCENT

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: SF1

FEATURES

LAMP TYPE: F13TT/RS
PROFILE: 2 LAMP
SHIELDING: ACRYLIC WITH SAND ETCHED SURFACE
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F18DTT/RS, F26DTT/RS
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY
OTHER: 660 OR 965 mm (26" OR 38") DIA. BOWL

NOM. DIMENSIONS 406 mm X 152 mm (16" DIA. X 6" D)

GENERAL DESCRIPTION

HOUSING: DIE–FORMED 20 GAUGE COLD ROLLED STEEL BACK PAN WITH HIGHLY REFLECTIVE WHITE PAINTED FINISH

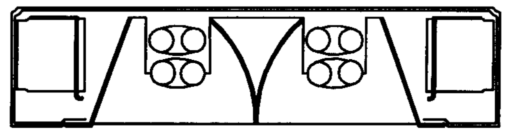
ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: WHITE, CUSTOM OR METALLIC PAINTED TRIM

SURFACE MOUNTED COMPACT FLUORESCENT DECORATIVE BOWL

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: SF2



FEATURES

LAMP TYPE: F18DTT/RS
PROFILE: 2 LAMP
SHIELDING: 4 CELL CLEAR SEMI-SPECULAR LOW IRIDESCENT PARABOLIC LOUVER WITH SELF FLANGE
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F13TT/RS, F26DTT/RS
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY
OTHER: PEWTER OR BRONZE REFLECTOR WITH SELF FLANGE; WHITE PAINTED FLANGE

NOM. DIMENSIONS 330 mm X 178 mm (13" DIA. X 7" D)

GENERAL DESCRIPTION

HOUSING: CYLINDRICAL 20 GAUGE COLD ROLLED STEEL

REFLECTORS: CLEAR SEMI-SPECULAR

ELECTRICAL: 120 OR 277 VOLT BALLAST

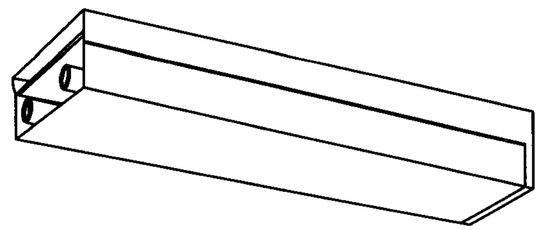
EFFICIENCY: 38%

13" DIA. SURFACE MOUNTED BAFFLED COMPACT FLUORESCENT DOWNLIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SF3



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
SHIELDING: 4.8 mm (0.187") PRISMATIC POLYCARBONATE
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 1 LAMP
SHIELDING: CLEAR POLYCARBONATE
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY, COLD WEATHER

NOM. DIMENSIONS 229 mm X 1219 mm X 152 mm (9" W X 4' L X 6" H)

GENERAL DESCRIPTION

HOUSING: WELDED ONE-PIECE CONSTRUCTION, DIE-FORMED 16 GA. COLD ROLLED STEEL WITH CONTINUOUSLY WELDED EXPOSED SEAMS GROUND SMOOTH

MOUNTING: FIXTURE IS LONGER THAN STANDARD METRIC GRID

REFLECTORS: WHITE URETHANE POWDER COAT FINISH WITH 88 PERCENT MINIMUM REFLECTANCE

ELECTRICAL: 120 OR 277 VOLT BALLAST

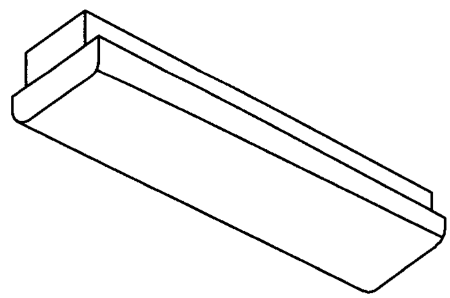
FINISH: WHITE POLYESTER ENAMEL

SURFACE MOUNTED FLUORESCENT HIGH ABUSE LUMINAIRE

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SF4



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
SHIELDING: 4.8 mm (0.187") THICK OPAL ACRYLIC INJECTION MOLDED LENS
BALLAST: ELECTRONIC

OPTIONS

MOUNTING: PENDANT
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 356 mm X 1295 mm X 102 mm (14" W X 51" L X 4" D)

GENERAL DESCRIPTION

HOUSING: FORMED COLD ROLLED STEEL

MOUNTING: FIXTURE IS LONGER THAN METRIC GRID

REFLECTORS: GLOSS WHITE REFLECTOR AND INTERNAL HOUSING

ELECTRICAL: 120 OR 277 VOLT BALLAST

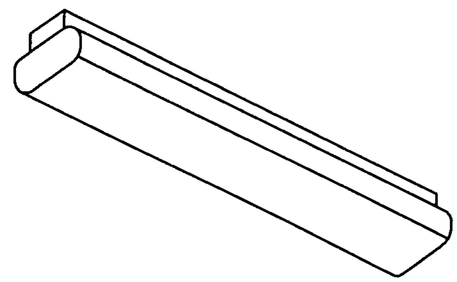
FINISH: WHITE ENAMEL OR POLYESTER POWDER COAT

SURFACE MOUNTED 1' X 4' DROP OPAL LENS

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SF5



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 1 LAMP
SHIELDING: PRISMATIC ACRYLIC WRAP LENS
BALLAST: ELECTRONIC

OPTIONS

BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 178 mm X 1219 mm X 114 mm
(7" W X 4' L X 4 1/2 " D)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED COLD ROLLED STEEL

MOUNTING: FIXTURE IS LONGER THAN METRIC GRID

REFLECTORS: GLOSS WHITE INTERIOR FINISH

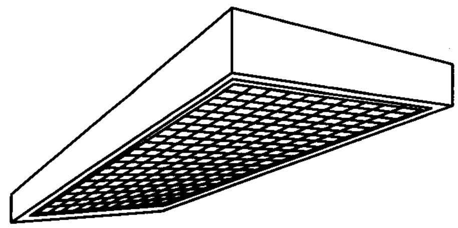
ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: WHITE ENAMEL OR POLYESTER POWDER COAT

SURFACE MOUNTED WRAPAROUND

CORPS OF ENGINEERS   DEPARTMENT OF THE ARMY

TYPE: SF6



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
SHIELDING: PRISMATIC LENS
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 3 LAMP
SHIELDING: OPAL WHITE, 3.2 mm (0.125") PATTERN 12, PATTERN 19, RFI SUPPRESSION
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 305 mm X 1219 mm X 102 mm (12" W X 4' L X 4" D)

GENERAL DESCRIPTION

HOUSING: COLD ROLLED STEEL WITH NO VISIBLE HOLES OR KNOCKOUTS; EXTRUDED ALUMINUM HINGED FRAME AND SPRING-LOADED CATCHES

MOUNTING: FIXTURE IS LONGER THAN METRIC GRID

REFLECTORS: GLOSS WHITE

ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: BAKED WHITE ENAMEL OR POLYESTER POWDER COAT

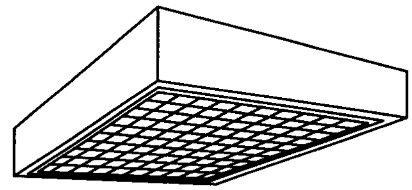
EFFICIENCY: 60%

SURFACE MOUNTED LENSED 1'X4' TROFFER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SF7



FEATURES

LAMP TYPE: F32T8/U/6/75 CRI
PROFILE: 2 LAMP
SHIELDING: PRISMATIC LENS
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F39TT/RS
PROFILE: 3 LAMP
SHIELDING: OPAL WHITE, 3.2 mm (0.125") PATTERN 12, PATTERN 19, RFI SUPPRESSION
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 610 mm X 610 mm X 102 mm (24" W X 24" L X 4" D)

GENERAL DESCRIPTION

HOUSING: COLD ROLLED STEEL WITH NO VISIBLE HOLES OR KNOCKOUTS; EXTRUDED ALUMINUM HINGED LENS FRAME WITH SPRING-LOADED CATCHES

MOUNTING: FIXTURE IS LONGER THAN METRIC GRID

REFLECTORS: GLOSS WHITE

ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: BAKED WHITE ENAMEL OR POLYESTER POWDER COAT

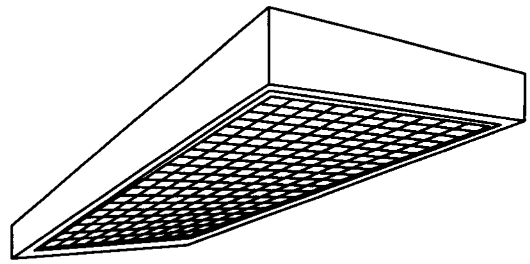
EFFICIENCY: 65%

SURFACE MOUNTED LENSED 2'X2' FLUORESCENT TROFFER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SF8



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 3 LAMP
SHIELDING: PRISMATIC LENS
BALLAST: ELECTRONIC

OPTIONS

PROFILE: 4 LAMP
SHIELDING: OPAL WHITE, 3.2 mm (0.125") PATTERN 12, PATTERN 19, RFI SUPPRESSION
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 610 mm X 1219 mm X 102 mm (24" W X 4' L X 4" D)

GENERAL DESCRIPTION

HOUSING: COLD ROLLED STEEL WITH NO VISIBLE HOLES OR KNOCKOUTS; EXTRUDED ALUMINUM HINGED LENS FRAME WITH SPRING-LOADED CATCHES

MOUNTING: FIXTURE IS LONGER THAN METRIC GRID

REFLECTORS: GLOSS WHITE

ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: BAKED WHITE ENAMEL OR POLYESTER POWDER COAT

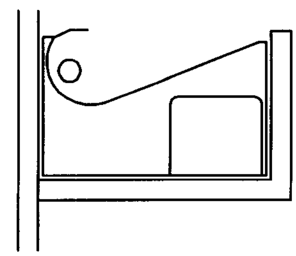
EFFICIENCY: 80%

SURFACE MOUNTED LENSED 2'X4' FLUORESCENT TROFFER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SF9



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 1 LAMP
REFLECTORS: SPECULAR ALUMINUM ASYMMETRIC REFLECTOR WITH BAKED WHITE ENAMEL KICK REFLECTOR
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F40TT/RS, F50TT/RS
PROFILE: 2 LAMP
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 229 mm X 1219 mm X 114 mm
(9" W X 4' L X 4 1/2 " H)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED AND WELDED 20 GA. COLD ROLLED STEEL

MOUNTING: CONCEALED IN ARCHITECTURAL COVE

ELECTRICAL: 120 OR 277 VOLT BALLAST

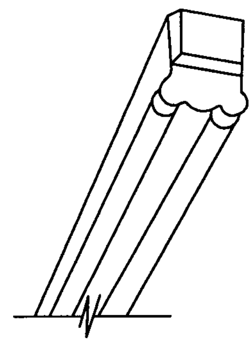
FINISH: WHITE BAKED ENAMEL

ASYMMETRIC INDIRECT FLUORESCENT MOUNTED IN ARCHITECTURAL COVE

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SF10



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F25T8/RS
PROFILE: 1 LAMP
REFLECTOR: SYMMETRIC OR ASYMMETRIC
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY
SHIELDING: WIRE GUARD

NOM. DIMENSIONS 125 mm X 102 mm X 1219 mm
(5" W X 4" H X 4' L)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED COLD ROLLED STEEL, DESIGNED FOR INDIVIDUAL OR CONTINUOUS ROW MOUNTING

REFLECTORS: GLOSS WHITE

ELECTRICAL: 120 OR 277 VOLT BALLAST

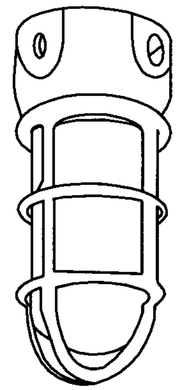
FINISH: WHITE ENAMEL OR POLYESTER POWDER COAT

FLUORESCENT STRIP LIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SF11



FEATURES

LAMP TYPE: F18DTT/RS
PROFILE: 1 LAMP
SHIELDING: CLEAR GLASS GLOBE
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: 90W TB/IF
MOUNTING: PENDANT, ARM MOUNT ADAPTER
SHIELDING: HEAT RESISTANT
BALLAST: HIGH POWER FACTOR MAGNETIC

NOM. DIMENSIONS 111 mm X 251 mm (4 3/8 " DIA. X 9 7/8 " H)

GENERAL DESCRIPTION

HOUSING: 30 PERCENT GLASS-FILLED THERMOPLASTIC POLYESTER

ELECTRICAL: 120 OR 277 VOLT BALLAST

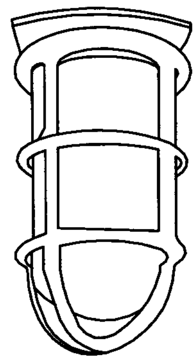
FINISH: MOLDED IN NON-GRAYING FINISH

SURFACE MOUNTED COMPACT FLUORESCENT VAPOR TIGHT JELLY JAR WITH WIRE GUARD

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SF12



FEATURES

LAMP TYPE: F18DTT/RS
PROFILE: 1 LAMP
SHIELDING: CLEAR GLASS GLOBE
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: 90W TB/IF
MOUNTING: PENDANT, ARM MOUNT ADAPTER
SHIELDING: HEAT RESISTANT GLASS
BALLAST: HIGH POWER FACTOR MAGNETIC

NOM. DIMENSIONS 111 mm X 251 mm (4 3/8 " W X 9 7/8 " H)

GENERAL DESCRIPTION

HOUSING: 30% GLASS FILLED THERMOPLASTIC POLYESTER

MOUNTING: SURFACE MOUNT ON CONCEALED OUTLET BOX

ELECTRICAL: 120 OR 277 VOLT BALLAST

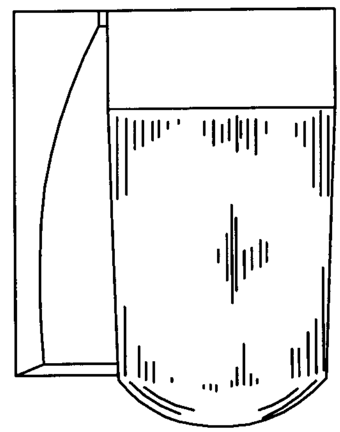
FINISH: MOLDED IN NON-FADING GRAY OR WHITE FINISH

SURFACE MOUNTED COMPACT FLUORESCENT VAPOR TIGHT JELLY JAR WITH WIRE GUARD AND CONCEALED OUTLET BOX

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SF13



FEATURES

LAMP TYPE: F18DTT/RS
PROFILE: 1 LAMP
SHIELDING: GASKETED OPAL POLYCARBONATE
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: 90W TB/IF
MOUNTING: WALL, DUAL BRACKET
BALLAST: HIGH POWER FACTOR MAGNETIC

NOM. DIMENSIONS 121 mm X 200 mm (4 3/4 " DIA. X 7 7/8 " H)

GENERAL DESCRIPTION

HOUSING: DIE CAST ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

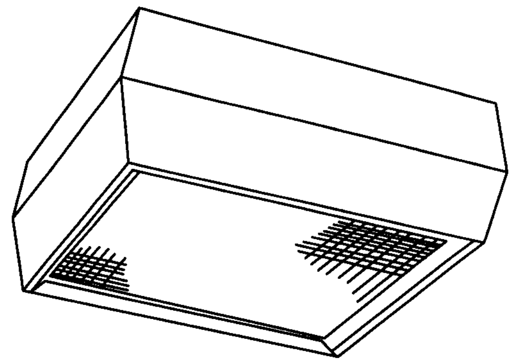
FINISH: NATURAL ALUMINUM

WALL MOUNTED COMPACT FLUORESCENT AREA LIGHT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SH1



FEATURES

LAMP TYPE: 175W MH
PROFILE: 1 LAMP
SHIELDING: PRISMATIC TEMPERED GLASS
BALLAST: HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

NOM. DIMENSIONS 610 mm X 610 mm X 356 mm (24" W X 24" L X 14" D)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED ALUMINUM WITH HINGED LOWER SECTION FOR EASY RELAMPING AND BALLAST ACCESS; HOUSING SHALL LOCK TOGETHER SECURELY USING CAPTIVE CLAMPS AND SHALL BE CONTINUOUSLY GASKETED AGAINST MOISTURE AND INSECTS

MOUNTING: FIXTURE IS LONGER THAN METRIC GRID

REFLECTORS: SEMI-SPECULAR ALUMINUM

ELECTRICAL: 120, 277, 208, 240, 347 & 480 VOLT MULTI TAP BALLAST

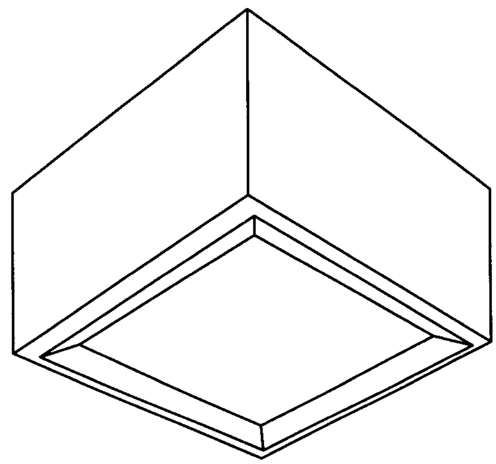
FINISH: WHITE ENAMEL OR POLYESTER POWDER COAT

ENCLOSED, INTEGRALLY BALLASTED 2'X2' METAL HALIDE LUMINAIRE

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SH2



FEATURES

LAMP TYPE: 175W MH
PROFILE: 1 LAMP
SHIELDING: CLEAR FLAT TEMPERED GLASS
REFLECTORS: HYDROFORMED, ANODIZED ALUMINUM
BALLAST: HIGH POWER FACTOR MAGNETIC, CORE & COIL, CWA

OPTIONS

LAMP TYPE: 150W HPS
MOUNTING: YOKE
SHIELD: POLYCARBONATE
REFLECTOR: TYPE II, III, IV, & V DISTRIBUTION

NOM. DIMENSIONS 425 mm X 425 mm X 267 mm
(16 3/4 " SQ. X 10 1/2 " H)

GENERAL DESCRIPTION

HOUSING: HEAVY GAUGE ALUMINUM, CONTINUOUSLY SEAM WELDED, GROUND SMOOTH. CONTINUOUS GASKETING AROUND EXTRUDED ALUMINUM HINGED DOOR FRAME

ELECTRICAL: 120, 277, 208, 240, 347 & 480 VOLT MULTI TAP BALLAST

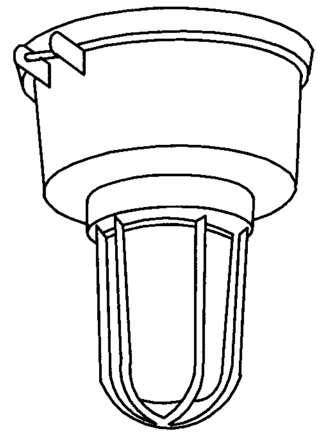
FINISH: POLYESTER POWDER COAT

SURFACE MOUNTED METAL HALIDE GARAGE LUMINAIRE

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SH3



FEATURES

LAMP TYPE: 175W MH
PROFILE: 1 LAMP
SHIELDING: HEAT/IMPACT RESISTANT RIBBED GLASS
BALLAST: HIGH POWER FACTOR MAGNETIC, CORE & COIL, CWA

OPTIONS

LAMP TYPE: HPS: 150W, 250W, 400W
MH: 250W, 400W
MOUNTING: PENDANT, BRACKET, STANCHION
SHIELDING: STANDARD DOME, 30 DEGREE DOME

NOM. DIMENSIONS 286 mm X 559 mm
(11 1/4 " DIA. X 22" H)

GENERAL DESCRIPTION

HOUSING: CAST ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: POWDER COAT PAINT

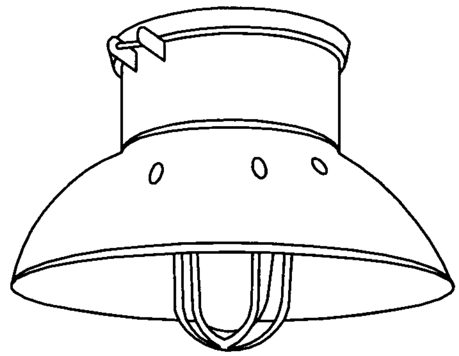
OTHER: NEC CLASS I, DIV. II, GROUPS C & D; CLASS II, DIV. I & II GROUPS E, F, G; CLASS III LOCATIONS

SURFACE MOUNTED EXPLOSION PROOF METAL HALIDE MOGUL BASE JELLY JAR, CLASS I / DIV II

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SH4



FEATURES

LAMP TYPE: 175W MH
PROFILE: 1 LAMP
SHIELDING: HEAT/IMPACT RESISTANT RIBBED GLASS
BALLAST: HIGH POWER FACTOR MAGNETIC, CORE & COIL, CWA

OPTIONS

LAMP TYPE: HPS: 150W, 250W, 400W
MH: 250W, 400W
MOUNTING: PENDANT, BRACKET, STANCHION
SHIELDING: STANDARD DOME, 30 DEGREE DOME

NOM. DIMENSIONS 286 mm X 559 mm (11 1/4 " DIA. X 22" H)

GENERAL DESCRIPTION

HOUSING: CAST ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: POWDER COAT PAINT

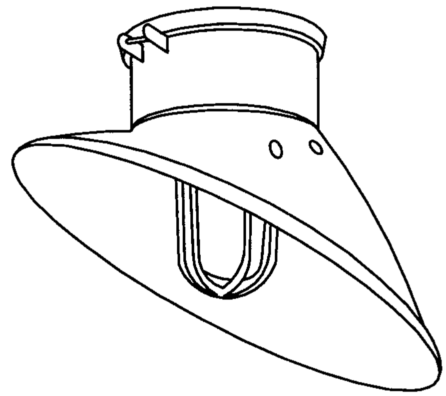
OTHER: NEC CLASS I, DIV. I, GROUPS C & D; CLASS II, DIV. I & II GROUPS E, F, G; CLASS III LOCATIONS

SURFACE MOUNTED EXPLOSION PROOF METAL HALIDE MOGUL BASE JELLY JAR, CLASS I/DIV 1

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SH5



FEATURES

LAMP TYPE: 175W MH
PROFILE: 1 LAMP
SHIELDING: HEAT/IMPACT RESISTANT RIBBED GLASS
BALLAST: HIGH POWER FACTOR MAGNETIC, CORE & COIL, CWA

OPTIONS

LAMP TYPE: HPS: 70W, 150W
MH: 100W, 150W
MOUNTING: PENDANT, BRACKET, STANCHION
SHIELDING: STANDARD DOME, 30 DEGREE DOME

NOM. DIMENSIONS 429 mm X 559 mm (16 7/8 " DIA. X 22" H)

GENERAL DESCRIPTION

HOUSING: CAST ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

FINISH: POWDER COAT PAINT

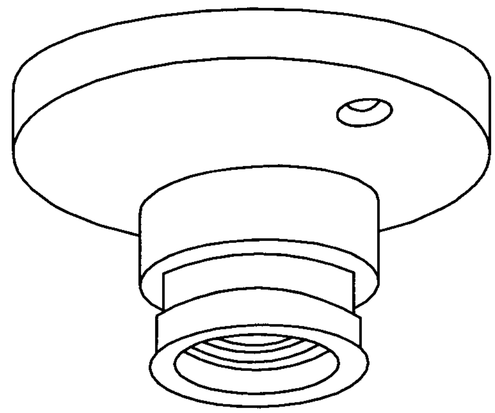
OTHER: NEC CLASS I, DIV. II, GROUPS A, B, & C; CLASS II, DIV I & II GROUPS E, F, G & CLASS III LOCATIONS

SURFACE MOUNTED EXPLOSION PROOF METAL HALIDE, MEDIUM BASE, JELLY JAR, CLASS I/DIV 2

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: SI1



FEATURES

LAMP TYPE: 90W TB/IF
PROFILE: 1 LAMP

OPTIONS

LAMP TYPE: 100W A21/IF
OTHER: GROUNDED DUPLEX RECEPTACLE, PULL CHAIN.

NOM. DIMENSIONS 102 mm X 60 mm
(4" DIA. X 2 3/8 " D)

GENERAL DESCRIPTION

HOUSING: PORCELAIN SOCKET LAMP HOLDER WITH MEDIUM BASE SOCKET

ELECTRICAL: 120 VOLT

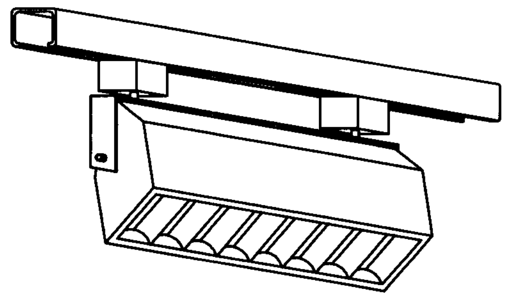
FINISH: WHITE

SURFACE MOUNTED INCANDESCENT PORCELAIN LAMP HOLDER

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: TF1



FEATURES

LAMP TYPE: F39TT/RS
PROFILE: 1 LAMP
SHIELDING: SEMI-SPECULAR LOW IRIDESCENT PARABOLIC LOUVER
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F40TT/RS, F50TT/RS
MOUNTING: RECESSED, PENDANT, 2 CIRCUIT TRACK
BALLAST: HIGH POWER FACTOR MAGNETIC

NOM. DIMENSIONS 127 mm X 178 mm X 508 mm
(5" H X 7" W X 20" L)

GENERAL DESCRIPTION

HOUSING: EXTRUDED OR DIE-CAST ALUMINUM

REFLECTORS: ANODIZED SPECULAR ALUMINUM

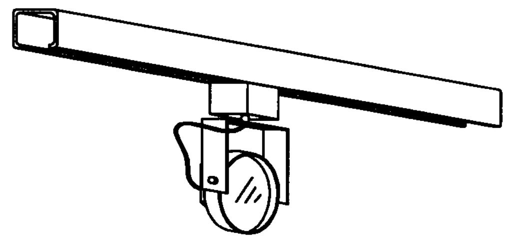
ELECTRICAL: 120 VOLT BALLAST

FINISH: WHITE OR BLACK BAKED ENAMEL PAINT

COMPACT FLUORESCENT WALLWASH TRACK HEAD AND TRACK

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY

TYPE: TI1



FEATURES

LAMP TYPE: 90W PAR38
PROFILE: 1 LAMP

OPTIONS

LAMP TYPE: 60W, Q150W PAR38
MOUNTING: RECESSED, PENDANT, 2 CIRCUIT TRACK
SHIELDING: SPREAD LENS, UV FILTER, COLOR FILTERS
OTHER: LOCKING YOKE, ACCESSORY HOLDER

NOM. DIMENSIONS 183 mm X 133 mm
(7 3/16 " H X 5 1/4 " DIA.)

GENERAL DESCRIPTION

HOUSING: EXTRUDED ALUMINUM STRUCTURAL CHANNEL WITH NOMINAL 1.5 mm (0.06") WALL THICKNESS; DIE-CAST ALUMINUM TRACK RING, ADJUSTABLE BOTH HORIZONTALLY AND VERTICALLY; PAINTED STEEL YOKE.

ELECTRICAL: 120 VOLT

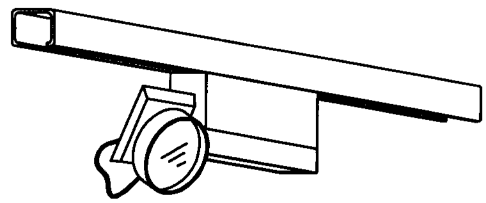
FINISH: WHITE BAKED ENAMEL PAINT

INCANDESCENT GIMBEL RING TRACK HEAD AND TRACK

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: TI2



FEATURES

LAMP TYPE: 50W MR16
PROFILE: 1 LAMP
OTHER: ELECTRONIC TRANSFORMER

OPTIONS

LAMP TYPE: 75W MR16
MOUNTING: RECESSED, PENDANT, 2 CIRCUIT TRACK
SHIELDING: SPREAD LENS, UV FILTER, COLOR FILTERS
OTHER: LOCKING YOKE, ACCESSORY HOLDER, MAGNETIC TRANSFORMER

NOM. DIMENSIONS 127 mm X 114 mm (5" H X 4 1/2" W)

GENERAL DESCRIPTION

HOUSING: EXTRUDED ALUMINUM STRUCTURAL CHANNEL WITH NOMINAL 1.5 mm (0.06") WALL THICKNESS; DIE-CAST ALUMINUM TRACK RING, ADJUSTABLE BOTH HORIZONTALLY AND VERTICALLY; PAINTED STEEL YOKE

ELECTRICAL: 120/12 VOLT INTEGRAL TRANSFORMER

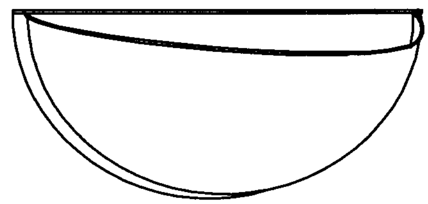
FINISH: WHITE BAKED ENAMEL PAINT

LOW VOLTAGE INCANDESCENT GIMBEL RING TRACK HEAD AND TRACK

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: WF1



FEATURES

LAMP TYPE: F13TT/RS
PROFILE: 2 LAMP
SHIELDING: OPAL ACRYLIC
BALLAST: ELECTRONIC

OPTIONS

BALLAST: HIGH POWER FACTOR
MAGNETIC, DIMMING

NOM. DIMENSIONS 457 mm X 229 mm X 102 mm
(18" W X 9" H X 4" D)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED 20 GAUGE COLD ROLLED STEEL BACK PAN WITH BALLAST COVER, PAINTED HIGHLY REFLECTIVE WHITE

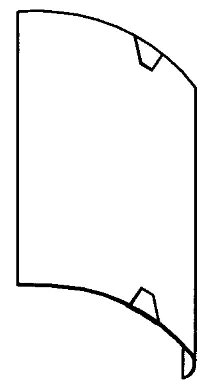
ELECTRICAL: 120 OR 277 VOLT BALLAST

WALL MOUNTED COMPACT FLUORESCENT SCONCE, ADA COMPLIANT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: WF2



FEATURES

LAMP TYPE: F13TT/RS
PROFILE: 2 LAMP
SHIELDING: OPAL ACRYLIC
BALLAST: ELECTRONIC

OPTIONS

BALLAST: HIGH POWER FACTOR
MAGNETIC, DIMMING

NOM. DIMENSIONS 305 mm X 305 mm X 102 mm
(12" W X 12" H X 4" D)

GENERAL DESCRIPTION

HOUSING: 20 GAUGE COLD ROLLED STEEL BACK PAN, PAINTED HIGHLY REFLECTIVE WHITE

ELECTRICAL: 120 OR 277 VOLT BALLAST

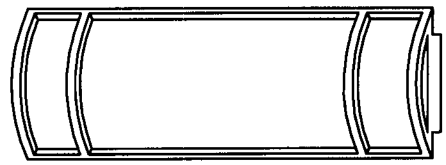
FINISH: SATIN BRASS, SATIN ALUMINUM, OR PAINTED

WALL MOUNTED COMPACT FLUORESCENT SCONCE, ADA COMPLIANT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: WF3



FEATURES

LAMP TYPE: F27TT/RS
PROFILE: 1 LAMP
SHIELDING: WHITE ACRYLIC
BALLAST: ELECTRONIC

OPTIONS

BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 203 mm X 102 mm X 457 mm (8" W X 4" D X 18" H)

GENERAL DESCRIPTION

HOUSING: HEAVY GAUGE COLD ROLLED STEEL BACK PLATE

ELECTRICAL: 120 OR 277 VOLT BALLAST

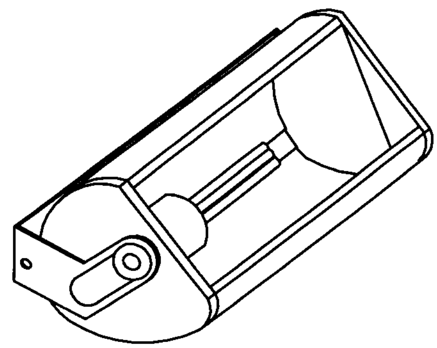
FINISH: POLISHED CHROME OR BRASS, OR PAINTED

COMPACT FLUORESCENT VANITY LIGHT, ADA COMPLIANT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: WF4



FEATURES

LAMP TYPE: F26DTT/RS
PROFILE: 1 LAMP
SHIELDING: CLEAR ACRYLIC LENS
BALLAST: ELECTRONIC

OPTIONS

BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 121 mm X 121 mm X 305 mm (4 3/4 " D X 4 3/4 " W X 12" L)

GENERAL DESCRIPTION

HOUSING: EXTRUDED ALUMINUM OR FORMED 20 GA. COLD ROLLED STEEL

REFLECTORS: SPECULAR ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

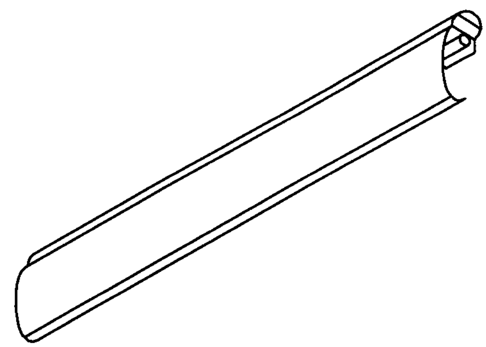
FINISH: POLYESTER POWDER COAT OR BAKED ENAMEL PAINT

WALL MOUNTED COMPACT FLUORESCENT INDIRECT ASYMMETRIC LUMINAIRE

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: WF5



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 1 LAMP
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F25T8/RS
BALLAST: HIGH POWER FACTOR MAGNETIC, DIMMING, EMERGENCY

NOM. DIMENSIONS 229 mm X 1219 mm X 108 mm (9" W X 4' L X 4 1/4 " H)

GENERAL DESCRIPTION

HOUSING: ONE PIECE 20 GAUGE COLD ROLLED STEEL WITH DIE-FORMED END PLATES. STANDARD LENGTHS UP TO 2440 mm (8'-0")

REFLECTORS: SPECULAR ALUMINUM

ELECTRICAL: 120 OR 277 VOLT BALLAST

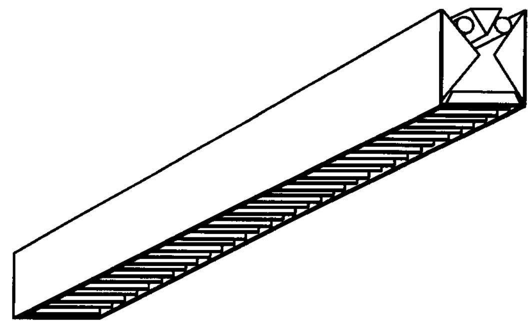
FINISH: WHITE BAKED ENAMEL PAINT

SURFACE MOUNTED ASYMMETRIC FLUORESCENT WALL WASH

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: WF6



FEATURES

LAMP TYPE: F32T8/75 CRI
PROFILE: 2 LAMP
SHIELDING: CLEAR, SEMI-SPECULAR, LOW IRIDESCENT PARABOLIC LOUVER
BALLAST: ELECTRONIC

OPTIONS

LAMP TYPE: F25T8/RS

NOM. DIMENSIONS 159 mm X 1219 mm X 186 mm
(6 1/4 " H X 4' L X 7 5/16 " W)

GENERAL DESCRIPTION

HOUSING: DIE-FORMED, 20 GA. COLD ROLLED STEEL, INSIDE PAINTED WITH HIGH REFLECTANCE WHITE FINISH

REFLECTORS: DIE-FORMED STEEL WITH HIGH REFLECTANCE WHITE FINISH

ELECTRICAL: 120 OR 277 VOLT BALLAST

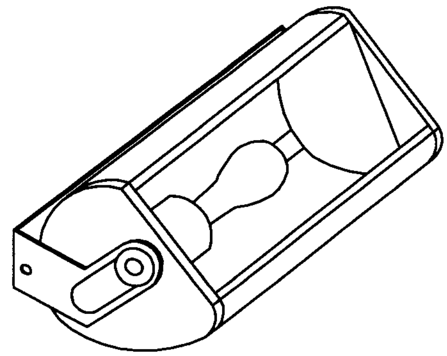
FINISH: WHITE BAKED ENAMEL PAINT

WALL MOUNTED DIRECT/INDIRECT FLUORESCENT LUMINAIRE, STEEL CONSTRUCTION

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: WH1



FEATURES

LAMP TYPE: 175W MH
PROFILE: 1 LAMP
SHIELDING: IMPACT AND HEAT RESISTANT GLASS
BALLAST: REMOTE HIGH POWER FACTOR, CORE & COIL, CWA

OPTIONS

LAMP TYPE: MH: 250W, 400W
HPS: 250W, 400W

NOM. DIMENSIONS 406 mm X 254 mm X 165 mm
(16" L X 10" D X 6 1/2 " H)

GENERAL DESCRIPTION

HOUSING: ROLL FORMED 18 GA. CRS WITH DIE CAST END CAPS

REFLECTORS: DIE CUT SEGMENTED PANELS, POLISHED ANODIZED ALUMINUM WITH MINIMUM 83% REFLECTANCE

ELECTRICAL: 120 OR 277 VOLT REMOTE BALLAST MOUNTED WITHIN 3 M (10')

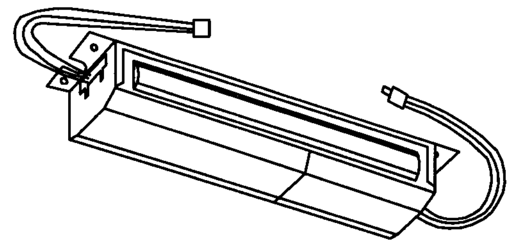
FINISH: POLYESTER POWDER COAT PAINT

SURFACE MOUNTED METAL HALIDE INDIRECT ADJUSTABLE LUMINAIRE

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: XF1



FEATURES

LAMP TYPE: F32T8/RS, F25T8/RS
PROFILE: 1 LAMP
MOUNTING: CONCEALED IN FIXTURE
OTHER: CHARGING INDICATOR LIGHT; TEST SWITCH
BATTERY: 90 MINUTE OPERATION

OPTIONS

PROFILE: 2 LAMPS
LAMP TYPE: F40TT, F40/U/

NOM. DIMENSIONS 38 mm X 64 mm X 241 mm
(1 1/2 " W x 2 1/2 " H x 9 1/2 ")

GENERAL DESCRIPTION

HOUSING: 22 GAUGE RED PAINTED STEEL ENCLOSURE

ELECTRICAL: 120 OR 277 VOLT

BATTERY: HIGH TEMPERATURE NICKEL CADMIUM

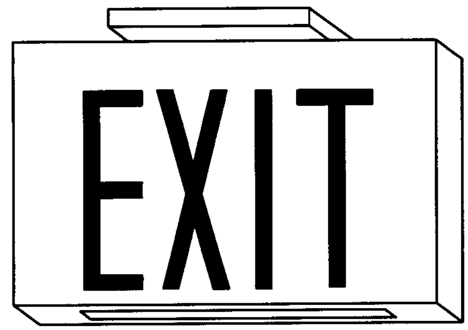
OTHER: NOT SUITABLE FOR INSTALLATION IN HEATED AIR OUTLET FIXTURES, WET, DAMP OR HAZARDOUS LOCATION FIXTURES

EMERGENCY BATTERY PACK UNIT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: XF2



FEATURES

LAMP TYPE: F7TT/RS
PROFILE: 1 LAMP
MOUNTING: UNIVERSAL
SHIELDING: FLAT SHEET ACRYLIC
BALLAST: MAGNETIC
LETTERS: GREEN
FINISH: BLACK

OPTIONS

PROFILE: 2 LAMP
LAMP TYPE: F5TT
LETTERS: RED
FINISH: WHITE, BRONZE, BRASS, CHROME

NOM. DIMENSIONS 298 mm W X 222 mm H X 95 mm D (11 3/4 " W x 8 3/4 " H x 3 3/4 " D)

GENERAL DESCRIPTION

HOUSING: DIE-CAST ALUMINUM OR 20 GA. CRS, HARDWARE FINISH TO MATCH HOUSING FINISH. LETTERS ARE 152 mm (6") HIGH WITH 19 mm (3/4") STROKE OR AS SPECIFIED. DIRECTIONAL ARROWS AS REQUIRED.

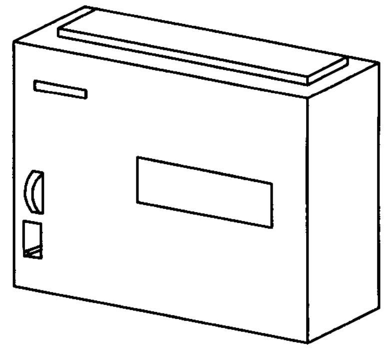
ELECTRICAL: 6 OR 12 VOLT DC; 120 OR 277 VOLT AC

OTHER: MINIMUM BRIGHTNESS 50 CD/SQ METER ON FACE OF SIGN.

FLUORESCENT STENCIL FACE EXIT SIGN

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



TYPE: XI1

FEATURES

BATTERY: SEALED LEAD CALCIUM, 3 YEAR

OPTIONS

BATTERY: SEALED LONG LIFE, 5 YEAR
SEALED NICKEL CADMIUM

NOM. DIMENSIONS 267 mm X 140 mm X 73 mm
(10 1/2 " L X 5 1/2 " H X 2 7/8 " W)

GENERAL DESCRIPTION

HOUSING: COMPACT FIRE-RETARDANT THERMOPLASTIC

MOUNTING: LIGHTING HEADS MOUNTED TOP OR SIDE, WALL-MOUNTED UNIT.

ELECTRICAL: 120 OR 277 VOLT PRIMARY, 6 OR 12 VOLT SECONDARY

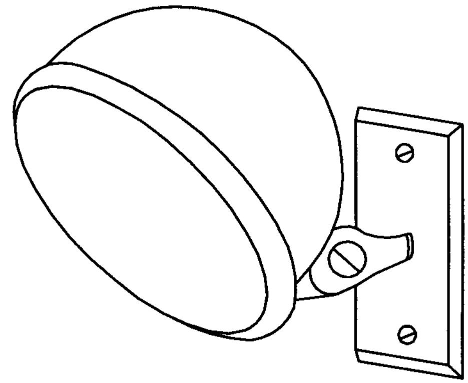
FINISH: OFF WHITE

EMERGENCY LIGHTING BATTERY UNIT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

TYPE: XI2



FEATURES

LAMP TYPE: 18W PAR36
PROFILE: 1 LAMP

OPTIONS

LAMP TYPE: 8W, 12W PAR36
PROFILE: 2 LAMP

NOM. DIMENSIONS 76 mm X 197 mm X 168 mm
(3" D X 7 3/4 " H X 6 5/8 " W)

SPECIFICATIONS

HOUSING: IMPACT RESISTANT, FLAME RETARDANT THERMOPLASTIC

MOUNTING: TOP MOUNTING OR SIDE MOUNTING TO XI1 EMERGENCY UNIT

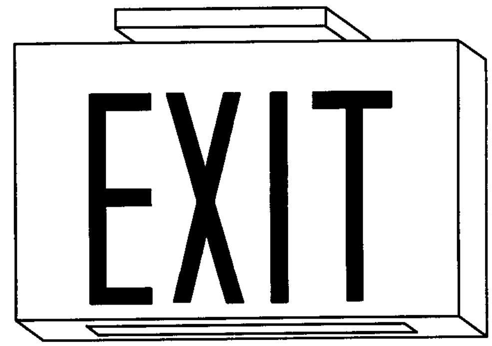
ELECTRICAL: 6 OR 12 VOLT SUPPLY FROM EMERGENCY UNIT

FINISH: OFF WHITE

EMERGENCY REMOTE-MOUNTED FLOODLIGHT FOR USE WITH TYPE XI1 EMERGENCY UNIT

CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY



TYPE: XL1

FEATURES

LAMP TYPE: LED
MOUNTING: UNIVERSAL
SHIELDING: FLAT SHEET ACRYLIC
LETTERS: GREEN

OPTIONS

LETTERS: RED
OTHER: BRUSHED ALUMINUM, WHITE AND BRONZE

NOM. DIMENSIONS 289 mm X 200 mm X 44 mm (11 3/8 " W X 7 7/8 " H X 1 3/4 " D)

GENERAL DESCRIPTION

HOUSING: DIE-CAST ALUMINUM OR 20 GA. COLD ROLLED STEEL, HARDWARE FINISH TO MATCH HOUSING FINISH. 152 mm (6") H LETTERS WITH 19 mm (3/4") STROKE. DIRECTIONAL ARROWS AS REQUIRED

ELECTRICAL: 120 OR 277 VOLT

FINISH: BLACK

OTHER: MINIMUM BRIGHTNESS 20 CD/SQ METER ON FACE OF SIGN.

LED STENCIL FACE EXIT SIGN

SECTION 16711

TELEPHONE SYSTEM, OUTSIDE PLANT

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C62.61 (1993) Gas Tube Surge Arrestors on Wire Line Telephone Circuits

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 2239 (1999) Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA ANSI/EIA 455-81A-91
(1992) FOTP-81 Compound Flow (Drip) Test for Filled Fiber Optic Cable

EIA ANSI/EIA/TIA-455-30B
(1991) FOTP-30 Frequency Domain Measurement of Multimode Optical Fiber Information Transmission Capacity

EIA ANSI/EIA/TIA-455-53A
(1990) FOTP-53 Attenuation by Substitution Measurement for Multimode Graded-Index Optical Fibers or Fiber Assemblies Used in Long Length Communications Systems

EIA ANSI/EIA/TIA-455-78A-98
(1990; R 1998) FOTP-78 Spectual Attenuation Cutback Measurement for Single Mode Optical Fibers

EIA ANSI/TIA/EIA-568-A
(1995; Addendum 3 1998) Commercial Building Telecommunications Cabling Standard

EIA ANSI/TIA/EIA-607
(1994) Commercial Building Grounding and Bonding Requirements for Telecommunications

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2002) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-85-625 (1996) Airecore, Polyolefin Insulated, Copper Conductor Telecommunications Cable

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2002) National Electrical Code

U.S. DEPARTMENT OF AGRICULTURE (USDA)

REA Bulletin 345-39
(1985) Telephone Station Protectors

REA Bulletin 345-50
(1979) Trunk Carrier Systems (PE-60)

REA Bulletin 345-65
(1985) Shield Bonding Connectors (PE-33)

REA Bulletin 345-72
(1995) Filled Splice Closures (PE-74)

REA Bulletin 345-151
(1989) Conduit and Manhole Construction, REA Form 515c

REA Bulletin 1753F-205 (PE-39)
(1993) Filled Telephone Cables

REA Bulletin 1753F-207 (PE-87)
(1994) Terminating Cables

REA Bulletin 1753F-208
(1993) Filled Telephone Cables with Expanded Insulation (PE-89)

RUS Bulletin 1751F-635
(1996) Aerial Plant Construction

RUS Bulletin 1751F-643
(1998) Underground Plant Design

RUS Bulletin 1753F-302 (PE-91)
(1994) Outside Plant Housings and Serving Area Interface Systems

RUS Bulletin 1753F-401(PC-2)
(1995) Splicing Copper and Fiber Optic Cables

RUS REA Bulletin 1751F-641
(1995) Construction of Buried Plant

RUS REA Bull 1753F-201 (PC-4)
(1997) Acceptance Tests and Measurements of Outside Plant

RUS REA Bull 1753F-601 (PE-90)
(1994) Filled Fiber Optic Cables

RUS REA Bulletin 1755I-100
(1999) List of Materials Acceptable for Use on Telecommunications Systems of RUS Borrowers

UNDERWRITERS LABORATORIES (UL)

UL 50 (1995; Rev thru Nov 1999) Enclosures for Electrical Equipment

UL 497 (1995; Rev Oct 1999) Protectors for Paired Conductor Communication Circuits

KOREAN INDUSTRIAL STANDARDS (KS)

KS C 3103 (1986) Copper Wire, Electrical, Stranded, Softdrawn

KS C 8401 (1997) Rigid Steel Conduit

KS C 8422 (2002) Steel Flexible Conduit

KS C 8431 (2001) Unplasticized Polyvinyl Chloride (UPVC) Conduit

KS C 8458 (2001) Outlet Boxes, Switch Boxes, Special Outlet Boxes, Box Covers for Rigid Metal Conduit

KS C 8459 (1997) Coupling, Connector for Flexible Conduit

KS C 8460 (2001) Bushing, Saddles, Locknuts, Couplings, Insulated Bushings for Rigid Metal Conduit

KS C 8461	(1997) Universal Fittings, Terminal Caps, Surface Switch Boxes, Circular Surface Boxes For Rigid Metal Conduit
KS D 3501	(1994) Hot Rolled Milled Steel Plate Sheet And Strip
KS D 8308	(2001) Zinc Coating (Hot Dipped) on Iron and Steel

1.2 SYSTEM DESCRIPTION

The outside plant system shall consist of all cable, conduit, manholes, poles, etc. required to provide signal paths from the closest point of presence to the new facility, including free standing frames or backboards, terminating cables, lightning and surge protection modules at the entry facility. The work consists of furnishing, installing, testing and making operational a complete outside plant system for continuous use.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telephone System; G

Installation;

Detail drawings, consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, and catalog cuts. Detail drawings shall also contain complete configuration information, wiring diagrams and any other details required to demonstrate that the cable system has been coordinated to support the transmission systems identified in the specifications and drawings. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operations.

Record Drawings; G

Record drawings for the installed wiring system showing the actual location of all cable terminations, splices, routing, and size and type of all cables. The identifier for each termination and cable shall appear on the drawings. The drawings shall include gauge and pair or fiber count for each cable, duct and innerduct arrangement, or conductor assignment of outside plant, and protector and connector block layout at the termination points after installation.

SD-03 Product Data

Spare Parts;
Equipment; G

A data list of recommended spare parts, tools, and test equipment for each different item of material and equipment specified prior to beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

Installation; G

Printed copies of the manufacturer's recommendations for the material being installed, prior to installation. Installation of the item will not be allowed to proceed where installation procedures, or any part thereof, are required to be in accordance with those recommendations until the recommendations are received and approved.

Acceptance Tests; G

Test plans defining all tests required to ensure that the system meets specified requirements. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested.

Cutover and Records; G

The cutover plan shall provide procedures and schedules for relocation of facility station numbers without interrupting service to any active location.

SD-06 Test Reports

Acceptance Tests; G

Test reports in booklet form showing all field tests performed, upon completion and testing of the installed system. Measurements shall be tabulated on a pair by pair or strand by strand basis.

SD-07 Certificates

Telephone System; G

Proof that the items furnished under this section conform to the specified requirements in FCC, ICEA, REA, RUS, ANSI, ASTM, NFPA, EIA, or UL, where materials and equipment are so specified.

Qualifications; G

The qualifications of the manufacturer, splicer, and installation supervisor as specified.

1.4 QUALIFICATIONS

1.4.1 Cable Installers

Installation shall be under the direct supervision of an individual with a minimum of 2 years experience in the installation of the specified copper and fiber optic cable and components.

1.4.2 Cable Splicing and Termination

All cable splicers shall have training in the proper techniques and have a minimum of 2 years experience in splicing and terminating the specified cables. Modular splices shall be performed by factory certified personnel or under direct supervision of factory trained personnel for products used.

1.4.3 Manufacturers

The cable, equipment, and hardware provided shall be from manufacturers that have a minimum of 2 years experience in producing the types of cable, equipment, and hardware specified.

1.5 DELIVERY AND STORAGE

1.5.1 Cable Requirements

All cable shall be shipped on reels. The diameter of the drum shall be large enough to prevent damage to the cable during reeling and unreeling. The reels shall be constructed to prevent damage during shipment and handling. The outer end of the cable shall be securely fastened to the reel head to prevent the cable from becoming loose in transit. The inner end of the cable shall project into a slot in the side of the reel, or into a housing on the inner slot of the drum, with sufficient length to make it available for testing. The inner end shall be fastened to prevent the cable from becoming loose during installation. End seals shall be applied to each of the cables to prevent moisture from entering the cable. The reels with cable shall be suitable for outside storage conditions when the temperature ranges from minus 40 to plus 65 degrees C (minus 40 to plus 148 degrees F) with relative humidity from 0 to 100 percent.

1.5.2 Equipment

All equipment shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants, in accordance with the manufacturer's requirements.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least 2 years prior to bid opening. Each major component of equipment shall have the manufacturer's name and type identified on the equipment. All products supplied shall be specifically designed and manufactured for use with outside plant communications systems. All items of the same class of equipment shall be the products of a single manufacturer.

2.2 CABLE

2.2.1 Copper Conductor Cable

Copper conductor cable shall conform to the following:

2.2.1.1 Aerial

a. Lashed: REA Bulletin 1753F-208.

b. Self Supporting: ICEA S-85-625.

2.2.1.2 Direct Buried

Cable shall be manufactured per REA Bulletin 1753F-208 or REA Bulletin 345-39. A metallic shield shall be provided.

2.2.1.3 Underground

Cable shall be manufactured per REA Bulletin 1753F-205 (PE-39) or REA Bulletin 1753F-208. A metallic shield shall be provided.

2.2.1.4 Screened

Screened cable shall comply with REA Bulletin 1753F-205 (PE-39) or REA Bulletin 1753F-208.

2.2.2 Fiber Optic Cable

Fiber optic cable shall be specifically designed for outside use with tight or loose buffer construction. The tight buffer optical fiber cable shall consist of a central glass optical fiber surrounded by a soft intermediate buffer to allow for thermal expansions and proper fitting of the secondary buffer. The loose buffer optical fiber cable shall have the glass optical fiber within a filled loose tube. All fiber optic cables used shall conform to the requirements of RUS REA Bull 1753F-601 (PE-90)including any special requirements made necessary by a specialized design..

2.2.2.1 Cable Cores

A central, nonmetallic core member shall be included to serve as a cable core foundation to reduce strain on the fibers, but not to serve as a pulling strength member.

2.2.2.2 Optical Fiber

Single-mode optical fibers shall be Class IV. Multi-mode optical fibers shall be Class Ia.

2.2.2.3 Shielding or Other Metallic Covering

A metallic covering or shield shall be provided per RUS REA Bull 1753F-601 (PE-90).

2.2.2.4 Performance Requirements

The fiber optic cable shall comply with the specified mechanical performance requirements while used in buried and underground duct applications where the temperature varies from minus 20 to plus 60 degrees C (minus 5 to plus 140 degrees F). Optical performance degradation shall be less than 5 percent of the optical performance requirements in the temperature range of minus 20 to plus 60 degrees C (minus 5 to plus 140 degrees F). The fiber optic cable shall not be damaged in storage where the temperature may vary from minus 40 to plus 65 degrees C (minus 40 to plus 148 degrees F).

2.3 CLOSURES

2.3.1 Copper Conductor Closures

2.3.1.1 Aerial Closure

The aerial closure shall be free breathing and suitable for housing straight and butt splices of non-pressurized communications cables. The closure shall be constructed with ultraviolet resistant PVC.

2.3.1.2 Buried Closure

Buried closure shall conform to REA Bulletin 345-72.

2.3.1.3 Underground Closure

Underground closures shall conform to REA Bulletin 345-72. The closure shall be of thermoplastic, thermoset, or stainless steel material and be suitable for use in a vault or manhole.

2.3.2 Fiber Optic Closures

2.3.2.1 Fiber Optic Aerial

The aerial closure shall be free breathing and suitable for housing a splice organizer of non-pressurized communications cables. The closure shall be constructed with ultraviolet resistant PVC.

2.3.2.2 Fiber Optic Buried

The buried closure shall be suitable for enclosing a splice organizer in a container into which can be poured an encapsulating compound and shall meet the requirement of the local telephone system provider. The closure shall protect the splice and be suitable for use in the buried environment.

2.3.2.3 Fiber Optic Underground

The underground closure shall be suitable to house a splice organizer in a protective housing. An encapsulating compound shall be poured into this enclosure. The closure shall be of thermo-plastic, thermoset-plastic, or stainless steel material and suitable for use in a vault or manhole and meet the requirement of the local telephone provider.

2.4 CABLE SPLICES AND ORGANIZERS

2.4.1 Copper Cable Splices

All cables greater than 25 pairs shall be spliced using modular splicing connectors, which accommodate 25 pairs of conductors at a time. The correct connector size shall be used to accommodate the wire gauge of the cable to be spliced. The connectors used shall be listed in RUS REA Bulletin 1755I-100.

2.4.2 Fiber Optic Cable Splices

Each fiber optic splice shall be physically protected by a splice kit. The kit shall be specially designed for the splice.

2.4.3 Fiber Optic Splice Organizer

The splice organizer shall be suitable for housing fiber optic splices in a neat and orderly fashion. The splice organizer shall allow for a minimum of 1 m (3 feet) of fiber for each fiber within the cable to be neatly stored without kinks or twists. The splice organizer shall accommodate individual strain relief for each splice. The splice organizer shall allow for future maintenance or modification, without damage to the cable or splices. All required splice organizer hardware, such as splice trays, protective glass shelves, and shield bond connectors shall be provided in the organizer kit.

2.5 CABLE TERMINALS

2.5.1 Pedestal-Type Cable Terminals

Pedestal-type cable terminals shall conform to RUS Bulletin 1753F-302 or PE-91.

2.5.2 Cross-connect Cable Terminals

Cross-connect cable terminals shall be weatherproofed for outdoor use and suitable for pole, pad, or stake mounting. The terminal shall be equipped with mounting columns and distribution rings for jumper-wire routing. The terminal shall be of aluminum or steel construction and ribbed for strength.

2.6 MANHOLE AND DUCT

All manhole and duct products shall conform to RUS Bulletin 1751F-643.

2.6.1 New Manholes

New manholes shall be equipped with pulling-in irons, cable racks, and ground rod, and conform to the requirements of REA Bulletin 345-151. Manholes shall be a minimum of 3.7 m long by 1.8 m wide by 2.0 m high (12 feet long by 6 feet wide by 6.5 feet high). Manholes shall be designed so that the main trunk conduits enter and exit near the center of the ends, and lateral conduits exit on the sides near the corners. Manholes may be pre-cast or cast in place.

2.6.2 Manhole Overbuilds

Existing manholes which are enlarged as part of this project shall be equipped with new pulling-in irons, cable racks, and ground rod.

2.6.3 Duct/Conduit

Conduit shall be furnished as specified in Sections 16415 ELECTRICAL WORK, INTERIOR and 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND and as shown on project drawings.

2.6.4 Innerduct

Innerduct shall be SIDR 11.5 polyethylene plastic pipe conforming to ASTM D 2239.

2.7 EQUIPMENT RACKS

Distribution frames, cabinets, and back-boards shall be provided as shown and designed to mount connector blocks, protector blocks, cross connects, and other hardware required to terminate and protect the outside telephone plant cable; to provide a demarcation point between inside and outside plant cable; and to allow inside and outside plant cable to be cross connected.

2.7.1 Floor Mounted Open Frame

Floor mounted equipment racks shall be single sided or double sided or welded steel relay racks with uprights to mount equipment minimum 480 mm (19 inches) wide. Uprights shall be 75 mm (3 inch) deep channel, 32 mm (1-1/4 inch) wide, drilled and tapped 12-24 in a 13 mm (1/2 inch) pattern. Racks shall be provided with a standard top cross-member, and predrilled base plate to allow floor fastening. Open frame equipment racks shall be 2.1 m (7 feet) in height. AC outlets shall be provided as shown.

2.7.2 Wall Mounted Open Frame

Wall mounted open frame equipment racks shall be steel relay racks to mount equipment 480 mm (19 inches) wide with standoff brackets for wall mounting. Uprights shall be drilled and tapped 12-24 in a 13 mm (1/2 inch) pattern. Standoff brackets shall be of sufficient length for a 150 mm (6 inch) clearance between rack and wall. Wall mounted open frame racks shall be hinged. AC outlets shall be provided as shown.

2.7.3 Cable Guides

Cable guides shall be specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 480 mm (19 inch) equipment racks. Cable guides shall consist of ring or bracket-like devices mounted on rack panels for horizontal use or individually mounted for vertical use. Cable guides shall mount to racks by screws and/or nuts and lock-washers.

2.7.4 Floor Mounted Cabinets

Equipment cabinets shall be floor mounted enclosures with side panels, acrylic plastic front doors, rear louvered metal doors, depth-adjustable front and rear mounting rails, and louvered top. Vertical cable management devices shall be integral to the cabinet. Power strips or a receptacle with a minimum of 2 outlets shall be mounted within the cabinet. Equipment racks shall mount equipment a minimum of 480 mm (19 inches) wide and shall be 1828 mm (72 inches) high and 760 mm (30 inches) deep. Cabinet exteriors shall be painted ivory/off-white or as specified.

2.7.5 Wall Mounted Cabinets

Wall mounted cabinets shall conform to UL 50 and have boxes constructed of zinc-coated sheet steel with dimensions not less than shown on drawings. Trim shall be fitted with hinged door and flush catch. Doors shall provide maximum openings to the box interiors. Boxes shall be provided with 19 mm (3/4 inch) plywood backboard painted white or a light color. A duplex AC outlet shall be installed within the cabinet.

2.7.6 Equipment Mounting Backboard

Backboards shall be 19 mm (3/4 inch) AC plywood, sized as shown, painted with white or light colored paint.

2.8 CONNECTOR BLOCKS

Connector blocks consisting of flame-retardant molded plastic fastened to a metal mounting bar shall be provided to terminate the outside plant cable as shown. The connector blocks shall be of 100-pair block size and equipped with protection modules. The connector blocks shall be 24 gauge stub type. The cable stubs shall be 100 pair and conform to REA Bulletin 1753F-207 (PE-87).

2.9 PROTECTOR MODULES

The protector modules shall be of the two-element gas tube type. Protection modules shall be heavy duty, A>10 kA, B>400, C>65A where A is the maximum single impulse discharge current, B is the impulse life and C is the AC discharge current per ANSI C62.61. The gas modules shall shunt high voltage to ground, fail short, be equipped with an external spark gap and heat coils, and shall comply with UL 497.

2.10 FIBER-OPTIC TERMINATIONS

2.10.1 Fiber Optic Connectors

All outside plant fiber strands shall be terminated in a SC or ST type fiber optic connector, with ceramic ferrule material and a maximum insertion loss of 0.5 dB. Connectors shall meet performance standards of EIA ANSI/TIA/EIA-568-A. If pre-connectorized cable assemblies or pigtails are used, the connectors shall be terminated on a 3 m (10 foot) length of single-fiber cable. The single-fiber cable shall contain a buffered optical fiber of the same type and specification as that used in the multi-fiber cable.

2.10.2 Fiber Optic Patch Panels

Patch panels shall be a complete system of components by a single manufacturer, and shall provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Patch panels shall be a minimum of 480 mm (19 inch) rack mounted or wall mounted panels. Patch panels shall provide strain relief for cables. Panels shall be provided with labeling space. Patch panel connectors and couplers shall be the same type and configuration as used elsewhere in the system.

2.11 MISCELLANEOUS ITEMS

2.11.1 Shield Connectors

Shield connectors shall make a stable, low-impedance electrical connection between the shield of the communications cable and a conductor such as a strap, bar, or wire. The connector shall be made of tin-plated tempered brass. Shield bond connectors shall comply with REA Bulletin 345-65.

2.11.2 Grounding Braid

Grounding braid shall provide low electrical impedance connections for dependable shield bonding. The braid shall be made from flat tin-plated copper.

2.11.3 Warning Tape

Marking and locating tape shall be acid and alkali resistant polyethylene film, 150 mm (6 inches) wide with a minimum strength of 12.1 MPa (1750 psi) lengthwise and 10.3 MPa (1500 psi) crosswise. The tape shall be manufactured with integral wires, foil backing, or other means to enable detection by a metal detector when the tape is buried up to 1 m (3 feet) deep. The metallic core shall be encased in a protective jacket or provided with other means to protect it from corrosion and shall be specifically manufactured for marking and locating underground utilities. The warning tape shall be orange in color and continuously imprinted with the words "WARNING - COMMUNICATIONS CABLE BELOW" at not more than 1.2 m (48 inch) intervals.

2.11.4 Cable Warning Signs

Cable warning signs, which identify the route of buried cable, shall be stake mounted. The stake shall be driven into undisturbed soil and the sign shall be mounted to the stake in accordance with the manufacturer's instructions. Warning signs shall be placed at intervals of no more than 152.5 m (500 feet) and at each change of direction in the cable route. Warning signs shall also be placed on each side of every crossing of surface obstacles such as roads, railroads, stream crossings, or any similar crossing where excavation is likely to occur.

PART 3 EXECUTION

3.1 INSTALLATION

All system components and appurtenances shall be installed in accordance with the manufacturer's instructions and as shown. All installation work shall be done in accordance with the safety requirements set forth in the general requirements of IEEE C2 and NFPA 70.

3.1.1 Cable Inspection and Repair

All cable and wire used in the construction of the project shall be handled with care. Each reel shall be inspected for cuts, nicks or other damage. All damage shall be repaired to the satisfaction of the Contracting Officer. The reel wrap shall remain intact on the reel until the cable or wire is ready to be placed.

3.1.2 Buried Cable

Buried cable installation shall be accomplished in accordance with RUS REA Bulletin 1751F-641.

3.1.2.1 Cable Depth

Cables placed in soil shall be at a minimum depth of local frost depth or as specified. Cables placed at ditch crossings shall be at a minimum depth of 915 mm (36 inches). A warning tape shall be placed above the cable and approximately 450 mm (18 inches) below ground level. Cables placed in rock shall be at a minimum depth of 150 mm (6 inches).

3.1.2.2 Above Ground Cable Protection

Cable installed on the outside of buildings, less than 2.5 m (8 feet) above finished grade, shall be protected against physical damage.

3.1.2.3 Telephone Cable Bends

Telephone cable bends shall have a radius of not less than 10 times the cable diameter.

3.1.2.4 Penetrations

Penetrations in walls, ceilings or other parts of the building, made to provide for cable access, shall be caulked and sealed. Where conduits and ducts pass through fire walls, fire partitions, above grade floors, and fire rated chase walls, the penetration shall be sealed with fire stopping materials as specified in Section 07840 FIRESTOPPING. Fire stopped penetrations shall not compromise the fire rating of the walls or floors. All underground building entries shall be through waterproof facilities.

3.1.2.5 Cable Protection

Unless otherwise shown or specified, direct buried cable shall be protected in accordance with NFPA 70. Where additional protection is required, cable may be placed in galvanized iron pipe (GIP) sized on a maximum fill of 40% of cross-sectional area, or in concrete encased 100 mm (4 inch) PVC pipe. Conduits shall extend at least 150 mm per 305 mm (6 inches per 12 inches) burial depth beyond the edge of the surface where cable protection is required; all conduits shall be sealed on each end. Conduit may be installed by jacking or trenching. Trenches shall be backfilled with earth and mechanically tamped at 150 mm (6 inch) lifts so that the earth is restored to the same density, grade and vegetation as adjacent undisturbed material.

3.1.2.6 Backfill for Rocky Soil

When placing cable in a trench in rocky soil, the cable shall be cushioned by a fill of sand or selected soil at least 50 mm (2 inches) thick on the floor of the trench before placing the cable or wire. The backfill for at least 100 mm (4 inches) above the wire or cable shall be free from stones, rocks, or other hard or sharp materials which might damage the cable or wire. If the buried cable is placed less than 600 mm (24 inches) in depth, a protective cover shall be used.

3.1.3 Underground Cable

Underground cable installation shall be accomplished in accordance with the requirements set forth in RUS REA Bulletin 1751F-641.

3.1.3.1 Cable Pulling

For cable installed in ducts and conduit, a cable feeder guide shall be used, between the cable reel and the face of the duct and conduit, to protect the cable and guide it into the duct and conduit as it is paid off the reel. As the cable is paid off the reel, it shall be inspected for jacket defects. Precautions shall be taken during installation to prevent the cable from being kinked or crushed. A pulling eye shall be attached to the cable and used to pull the cable through the duct and conduit system. Cable shall be hand fed and guided through each manhole. As the cable is paid off the reel into the cable feeder guide, it shall be sufficiently lubricated with a type of lubricant recommended by the cable manufacturer. Where the cable is pulled through a manhole, additional lubricant shall be applied at all intermediate manholes. Dynamometers or load-tension instruments shall be used to ensure that the pulling line tension does not exceed the installation tension value specified by the cable manufacturer. The mechanical stress placed upon a cable during installation shall not cause the cable to be twisted or stretched.

3.1.3.2 Penetrations for Cable Access

Penetrations in walls, ceilings or other parts of the building, made to provide for cable access, shall be caulked and sealed. Where conduits and ducts pass through fire walls, fire partitions, above grade floors, and fire rated chase walls, the penetration shall be sealed with fire stopping materials as specified in section 07840 FIRE STOPPING. Fire stopped penetrations shall not compromise the fire rating of the walls or floors. All underground building entries shall be through waterproof facilities.

3.1.3.3 Cable Bends

Telephone cable bends shall have a radius of not less than 10 times the cable diameter. Only large radius sweeps shall be used in conduit runs and shall not exceed a cumulative 90 degrees between manholes.

3.1.4 Aerial Cable

Aerial cable installation shall be accomplished in accordance with the requirements set forth in RUS Bulletin 1751F-635.

3.1.5 Manhole and Ducts

Manhole and duct systems shall be installed in accordance with Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Manholes shall be placed in line with the main duct. Splice cases shall be mounted in the center on the long sides. Lateral conduits shall exit the long sides near the corners.

3.1.5.1 Innerduct Installation

Innerduct shall be pulled through existing duct-manhole system in continuous sections. Splices, joints, couplings, or connections of any type will not be allowed between manholes. Innerduct shall be plugged at both ends with polyurethane foam duct seal; this material shall also be inserted between the innerduct and the duct if cables are placed in the innerducts. Only one cable shall be installed in a given innerduct. Existing and new unoccupied innerducts shall be trimmed leaving 50 mm (2 inches) exposed.

3.1.5.2 Pull Cord

Pull cords of 10 mm (3/8 inch) polypropylene shall be installed in all unused ducts and inner-ducts with a minimum of 610 mm (2 feet) spare cord protruding from each end.

3.1.6 Surge Protection

Except for fiber optic cable, all cables and conductors, which serve as communication lines, shall have surge protection meeting the requirements of REA Bulletin 345-50 installed at the entry facility.

3.2 SPLICING

3.2.1 Copper Conductor Splices

Copper conductor cable splicing shall be accomplished in accordance with RUS Bulletin 1753F-401(PC-2). Modular splicing shall be used on all cables larger than 25 pairs.

3.2.2 Fiber Optic Splices

Fiber optic splicing shall be in accordance with the manufacturer's recommendation; each splice shall have a loss of less than 0.1 dB.

3.3 GROUNDING

Except where specifically indicated otherwise, all exposed non-current carrying metallic parts of telephone equipment, cable sheaths, cable splices, and terminals shall be grounded. Grounding shall be in accordance with requirements of NFPA 70.

3.3.1 Ground Bars

3.3.1.1 Telecommunications Master Ground Bar (TMGB)

A copper TMGB shall be provided, in accordance with EIA ANSI/TIA/EIA-607, to be the hub of the basic grounding system by providing a common point of connection for ground from outside cable, MDF, and equipment. The TMGB shall have a ground resistance, including ground, of 10 ohms or less.

3.3.1.2 Telecommunications Ground Bar (TGB)

Copper TGB shall be provided in accordance with EIA ANSI/TIA/EIA-607 in each communications closet and room and each frame. The TGB shall be connected to the TMGB in accordance with EIA ANSI/TIA/EIA-607. Each TGB shall be connected to the TMGB by the most direct route utilizing a copper wire conductor with a total resistance of less than 0.01 ohms.

3.3.2 Incoming Outside Plant Cables

All incoming outside plant cable shields shall be bonded directly to the TMGB or the closest TGB.

3.3.3 Cable Stubs

All shields of cable stubs shall be bonded to a TGB located on the frame.

3.3.4 Shields

The shields of all incoming cables shall not be bonded across the splice to the cable stubs.

3.3.5 Protection Assemblies

The protector assemblies shall be mounted directly on the vertical frame ironwork. The assemblies mounted on each vertical frame shall be connected with a No. 6 AWG copper conductor to provide a low resistance path to the TGB.

3.3.6 Manholes

The shields of all cables in each manhole shall be bonded together by a bonding wire or ribbon. At intermediate manholes, where the cable is pulled through without a sheath opening, bonds are not required. If the manhole has a lacerating bonding ribbon, the shields of spliced cables shall be attached to it.

3.4 CUTOVER AND RECORDS

All necessary transfers and cutovers, shall be accomplished by the Contractor.

3.5 ACCEPTANCE TESTS

The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform all required testing. Notification of any planned testing shall be given to the Contracting Officer at least 14 days prior to any test; testing shall not proceed until after the Contractor has received written Contracting Officer's approval of the test plans as specified. The test plans shall define all the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested.

3.5.1 Copper Conductor Cable

The following acceptance tests shall be performed in accordance with RUS REA Bull 1753F-201 (PC-4):

a. Shield continuity.

b. Conductor continuity.

c. Conductor insulation resistance.

d. Structural return loss.

e. Cable insertion loss and loss margin at carrier frequencies.

f. Shield ground for single jacketed cables.

g. DC loop resistance.

3.5.2 Fiber Optic Cable

Two optical tests shall be performed on all optical fibers: Optical Time Domain Reflectometry (OTDR) Test, and Attenuation Test. In addition, a Bandwidth Test shall be performed on all multi-mode optical fibers. These tests shall be performed on the completed end-to-end spans which include the near-end pre-connectorized single fiber cable assembly, outside plant as specified, and the far-end pre-connectorized single fiber cable assembly.

3.5.2.1 OTDR Test

The OTDR test shall be used to determine the adequacy of the cable installations by showing any irregularities, such as discontinuities, microbendings, improper splices, for the cable span under test. Hard copy fiber signature records shall be obtained from the OTDR for each fiber in each span and shall be included in the test results. The OTDR test shall be measured in both directions. A reference length of fiber, 1 km (3280 feet) minimum, used as the delay line shall be placed before the new end connector and after the far end patch panel connectors for inspection of connector signature. The OTDR test shall be conducted in accordance with EIA ANSI/EIA 455-81A-91 for single-mode fiber and EIA ANSI/EIA/TIA-455-78A-98 for multi-mode fiber. Splice losses shall not exceed 0.1db. Attenuation losses shall not exceed 0.5 db/km at 1310 nm and 1550 nm for single-mode fiber. Attenuation losses shall not exceed 5.0 db/km at 850 nm and 1.5 db/km at 1300 nm for multi-mode fiber.

3.5.2.2 Attenuation Test

End-to-end attenuation measurements shall be made on all fibers, in both directions, using a 850 or 1300 nanometer light source at one end and the optical power meter on the other end to verify that the cable system attenuation requirements are met. The measurement method shall be in accordance with EIA ANSI/EIA/TIA-455-53A.

3.5.2.3 Bandwidth Test

The end-to-end bandwidth of all multi-mode fiber span links shall be measured by the frequency domain method. The bandwidth shall be measured in both directions on all fibers. The bandwidth measurements shall be in accordance with EIA ANSI/EIA/TIA-455-30B.

SECTION 16783

COMMUNITY ANTENNA TELEVISION (CATV) SYSTEMS

TABLE OF CONTENTS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 76.605 (1999) Federal Communications Commission; Multichannel Video and Cable Television Service; Technical Standards

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2002) National Electrical Safety Code (ANSI/IEEE)

IEEE C62.31 (1991) Surge Voltages in Low-Voltage AC Power Circuits (ANSI/IEEE)

NATIONAL CABLE TELEVISION ASSOCIATION (NCTA)

NCTA RP (1989; R 1993) Measurements on Cable Television Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2002) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 969 (1995; R 1999) Marking and Labeling Systems

UL 1581	(1997; R 2000, Bul. 1999 and 2000) Electrical Wires, Cables, and Flexible Cords
UL 1666	(2000) Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts

1.2 RELATED REQUIREMENTS

Section 16050, "Basic Electrical Materials and Methods," applies to this section with the additions and modifications specified herein.

1.3 DEFINITIONS

1.3.1 CATV

Community antenna television (CATV) system, commonly referred to as cable television, is a network of cables, headend, electronic and passive components that process and amplify television (TV) signals for distribution from the headend equipment to the individual television outlets.

1.3.2 Headend

The connection point between CATV system equipment and equipment provided by the local CATV company.

1.3.3 Distribution System

Distribution system transports and delivers adequate signals to each receiver. Provides distortion-free signal to TV sets by isolating each receiver from the system and by providing proper amount of signal to each set.

1.3.4 Cable

Trunk and feeder cables are low-loss cables used to transport the desired signal from the headend equipment to the communications closet in the area to be served. These cables are used to transport signal from the communications closet or headend equipment into close proximity to a number of user locations in excess of 60 meters (200 feet) from the communications closet or headend equipment. Drop cables are used to transport the desired signal used from the communications closet or headend equipment to the wall outlet.

1.4 SYSTEM DESCRIPTION

1.4.1 Headend

Contractor shall provide interior equipment up to headend and including the main amplifier located at the interior CATV cabinet.

1.4.2 Cable

Provide trunk cables to transport the desired signal from the headend equipment to the communications closet in the area to be served. Provide feeder cables to transport signal from the communications closet to user locations in excess of 60 meters (200 feet) from the communications closet. Provide drop cables to transport the desired signal from the communications closet to the outlet.

1.4.3 System Components

System shall provide high quality TV signals to all outlets with a return path for interactive television and cable modem access. Provide any combination of items specified herein to achieve required performance, subject to approvals, limitations, acceptance test, and other requirements specified herein. System shall include amplifiers, splitters, combiners, line taps, cables, outlets, tilt compensators and all other parts, components, and equipment necessary to provide a complete and usable system.

1.4.3.1 System Bandwidth

As specified by the area cable network system proponent, Installation Management Agency, Korea Region Office, MWR Division, Cable TV Section, Unit # 15742, APO AP 96205-5742 DSN: 738-4212.

1.4.4 System Performance

System shall be in compliance with 47 CFR 76.605 or as specified by the area cable network system proponent, Installation Management Agency, Korea Region Office, MWR Division, Cable TV Section, Unit # 15742, APO AP 96205-5742.

1.4.4.1 Receiver Termination Signal Level

Each termination for a TV receiver must have a minimum signal level of 0 decibel millivolts (dBmV) (1000 microvolts) at 55 MHz and of 0 dBmV (1000 microvolts) at 860 MHz and a maximum signal of 15 dBmV or a level not to overload the receiver for the entire system bandwidth.

1.4.4.2 Distribution System

a. Modulation distortion at power frequencies: 4 percent or less hum distortion;

b. Composite third order distortion for:

(1) CW carriers: 53 dB.

(2) Modulated carriers: 59 dB.

c. Subscriber terminal isolation: 18 dB or greater.

d. Carrier to second order beat ratio: 60 dB.

e. Amplitude characteristic shall be within a range of plus or minus 2 decibels from 0.75 MHz to 5.0 MHz above the lower boundary frequency of the cable television channel, referenced to the average of the highest and lowest amplitudes within these frequency boundaries.

f. Visual, aural carrier level - 24-hour variation: 47 CFR 76.605, subpart (a), rules (4), (5), and (6).

g. Frequency determination: 47 CFR 76.605, subpart (a), rules (1),(2), and (3).

1.4.4.3 All New System Tolerance

The system shall not show a serious loss of carrier to noise when the system levels are lowered 3 dB below normal or a significant distortion when the levels are increased 3 dB above normal, as observed on a TV set located at the far end extremities of the system.

1.5 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

CATV system wiring diagrams and installation details; G

CATV system components; G

SD-03 Product Data

Attenuators; G

Amplifiers, including headend, trunk, bridging, and distribution; G

Cables, including trunk, feeder, and drop; G

Terminators; G

Splitters/combiners; G

Line Taps; G

Outlets; G

Connectors; G

Tilt compensator; G

Grounding block; G

Submittals for each manufactured item shall be the current manufacturer's descriptive literature of catalog products, equipment drawings, diagrams, performance and characteristics curves, and catalog cuts.

SD-05 Design Data

CATV System Loss Calculations; G

SD-06 Test Reports

Operational test plan; G

Operational test procedures; G

System pretest; G

Acceptance tests; G

SD-08 Manufacturer's Instructions

Connector Installation; G

1.6 QUALITY ASSURANCE

1.6.1 Wiring Diagrams and Installation Details

Illustrate how each item of equipment functions in the system and include an overall system schematic indicating the relationship of CATV units on one diagram. Drawings shall include wiring diagrams and installation details of equipment indicating proposed locations, layout and arrangements, and other items that must be shown to ensure coordinated installation.

1.6.2 CATV System Loss Calculations

Calculations shall verify that the system does not exceed the loss values specified in dBmV at the receiver terminations. Provide a drawing displaying all distribution network calculations. The drawing should accurately show taps, splitters, outlets, and the type and length of all trunk, feeder, and drop cables. The drawing shall show how many taps, splitters, or outlets are served by each tap or splitter.

1.6.3 Operational Test Plan

Test plan shall define tests required to ensure that the system meets technical, operational, and performance specifications. Test plan shall be based on NCTA RP and be in accordance with FCC proof of performance requirements. Test plan shall include plan for testing for signal leakage. Provide test requirements and guidelines.

1.6.4 Operational Test Procedures

Use test plan and design documents to develop test procedures. Procedures shall consist of detailed instructions for a test setup, execution, and evaluation of test results.

1.6.5 Connector Installation

Provide manufacturer's instructions for installing connectors.

PART 2 PRODUCTS

2.1 ELECTRONIC EQUIPMENT

Electronic components of similar type shall be produced and designed by the same manufacturer as major components of the equipment and shall have the manufacturer's name and model permanently attached. Equipment shall function properly as a complete integrated system. Equipment shall be shielded. The system shall be designed to operate within 5 to 1000 MHz bandwidth using 1000 MHz passive devices and a minimum of 860 MHz active devices.

2.2 HEADEND EQUIPMENT

2.2.1 Headend Amplifiers

Provide broadband distribution amplifiers. Amplifiers shall amplify broadband signals from 40 to 860 MHz and provide an amplified return path for signals from 5 to 40 MHz for 75 ohms impedance. Amplifiers shall be bidirectional with variable slope and gain control.

2.2.2 Attenuators

Provide attenuators to equalize signal levels, when required. Variable attenuators are not permitted.

2.2.3 Power Supplies

Power supplies shall contain a current limiter circuit to protect against short circuits on the radio frequency (RF) line. Provide overvoltage protection to protect solid state equipment from line surges and induced voltages, in accordance with IEEE C62.31.

2.3 DISTRIBUTION EQUIPMENT

2.3.1 Distribution Amplifiers

Distribution amplifiers shall be equipped for 75 ohms input and output impedance. Electronic equipment exposed to weather shall be equipped with weatherproof housings. Amplifiers shall be bidirectional with variable slope and gain control and shall amplify broadband signals from 50 to 860 MHz and provide an amplified return path for signals from 5 to 40 MHz for 75 ohms impedance.

2.3.1.1 Trunk Amplifiers

Trunk amplifiers are equipped with trunk input output ports, and can be configurable for two, three, or four bridger-port. Trunk amplifiers shall have built-in Automatic Level Control (ALC) and status monitoring capability

2.3.1.2 Bridging Amplifiers

Trunk / Bridging amplifiers are equipped with trunk input output ports, and can be configurable for two, three, or four bridger-port. Trunk / Bridger amplifiers shall have built-in Automatic Level Control (ALC) and status monitoring capability.

2.3.1.3 Line Extender Amplifiers

Line extenders are used in the distribution system to amplify RF signals on the feeder or branches feeding users. Line Extenders are equipped with trunk input output ports, and have the capability for Automatic Level Control (ALC).

2.3.2 Cables and Associated Hardware

Cabling shall be UL listed for the application and shall comply with NFPA 70. Provide a labeling system for cabling as required by UL 969. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.3.2.1 Trunk Cable

UL 1666. Provide trunk cable with an NFPA 70 rating of CATVP.

a. Provide RG-11 (7C HFBT) coaxial cable with the following characteristics:

(1) #14 AWG copper-clad steel center conductor.

(2) Gas injected foam polyethylene dielectric with nominal 7.11 mm (0.28 inches) outer diameter.

(3) Bonded foil inner-shield and 60 percent aluminum braid or quad shield.

(4) 75 ohms impedance.

(5) 82 to 85 percent nominal velocity of propagation.

(6) Black PVC jacket

2.3.2.2 Feeder Cable

UL 1581, provide RG-11 coaxial trunk cable with an NFPA 70 rating of CATVP and the following characteristics:

a. #14 AWG copper-clad steel center conductor.

b. Gas injected foam polyethylene or Foam FEP dielectric with 7.11 mm (0.28 inches) nominal outer diameter.

c. Bonded foil inner-shield and a minimum of 60 percent aluminum braid or quad shield.

d. 75 ohms impedance.

e. 81 to 84 percent nominal velocity of propagation.

f. Black PVC or PVC low smoke polymer or FEP jacket.

2.3.2.3 Drop Cable

UL 1581. Provide RG 6 (5C HFBT) coaxial cable with an NFPA 70 rating of CATVP and with the following characteristics:

a. No. 18 AWG copper-clad steel center conductor.

b. Bonded foil inner-shield and 90 percent aluminum braid.

c. Characteristic impedance of 75 ohms.

d. Gas injected foam polyethylene or Foam FEP dielectric

e. Nominal capacitance, conductor to shield, of 53 pf per 100 m (16.2 pf per 100 ft).

f. Maximum operating voltage of 350 V RMS.

g. Black polyvinyl chloride (PVC) or PVC low smoke polymer or FEP jacket.

h. 100 percent sweep testing from 5 MHz to a minimum of 1000 MHz.

2.3.3 Terminators

Terminators shall be rated for 75 ohms and 1/4 watt.

2.3.4 Splitters/Combiners

Use splitters/combiners with characteristics equal to or exceeding the characteristics listed in this paragraph over the entire operating band. All unused outlets must be terminated with 75-ohm terminators.

a. Peak to Valley: Not to exceed 1.5 dB across bandwidth of device.

b. Return loss: 15 dB minimum.

c. Bandwidth: 5 - 860 Mhz

2.3.5 Line Taps

Line taps shall have 15 dB minimum isolation from each tap to the thru-line. Pressure tapoffs are not permitted. Taps shall be rated from 5 to 860 MHz and shall have a peak to valley not to exceed 1.5 dB to 1 GHz.

2.3.6 Outlets

Provide flush mounted, 75-ohm, F-type connector outlets rated from 0 to 860 MHz in standard electrical outlet boxes. The outlet unit shall be without the tab and to be 0 dB

2.3.7 Connectors

The coaxial cable connectors shall be 75 ohm solderless connectors designed for each specific type of coaxial cable. All hard line coaxial cable entry connectors are 2 piece pin type, and constructed of brass alloy materials, and suitable for both outdoor and indoor use. This type of connector seizes both the outer shield and center conductor of the cable. The connector must consist of a solid brass pin seizes and retains the center conductor within the body of the connector, sealing it in an airtight environment. All drop cable connectors are “F” type. The RG-6/u connectors shall be feed thru type and RG-11/u connectors are pin type.

2.3.8 Tilt Compensator

Provide tilt compensators as required.

2.4 BACKBOARDS

Provide void-free, fire rated interior grade plywood as required. Backboards shall be painted with a gray, nonconductive fire-resistant overcoat. Do not cover the fire stamp on the backboard.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Distribution System

Distribution system shall conform to requirements specified herein. Installation shall be in accordance with IEEE C2 and NFPA 70.

3.1.1.1 Raceway

Provide cable installed in raceways in conduit in compliance with NFPA 70. If entry is under ground, a 4inch conduit with 4 – 1 inch conduit will be run to nearest pole or hook-up.

3.1.1.2 Grounding System

Provide the grounding block at the main CATV backboard. Ground this device according to the requirements of IEEE C2 and NFPA 70.

3.1.1.3 Trunk, Feeder, and Drop Cable

Provide cable to grounding blocks, to line taps, and to outlets.

3.2 FIELD QUALITY CONTROL

3.2.1 System Pretest

Upon completing installation of the CATV system, the Contractor shall align and balance the system and shall perform complete pretesting and provide result to the area cable network system proponent. During the system pretest, Contractor, utilizing the approved spectrum analyzer or signal level meter, shall verify that the system is fully operational and meets all the system performance requirements of the specification. Contractor shall test the signal loss in dBmV at 55, 151, 547, and 860 MHz. The signal levels shall be 0 dBmV (1000 microvolts), minimum. The signal shall not exceed 15 dBmV over the entire system bandwidth. Any deficiencies found shall be corrected and revalidated by follow up testing. Contractor shall measure and record the video and audio carrier levels at each of the frequency levels specified at each of the following points in the system:

a. Furthest outlet from each communication closet and service entrance point of connection.

b. A random sampling of 25 percent of the outlets.

c. As specified by the area cable network system proponent.

3.2.2 Acceptance Tests

Contractor shall notify the Contracting Officer of system readiness 10 days prior to the date of acceptance testing. Contractor shall also coordinate with the local CATV provider and allow them to attend witness tests. CATV system shall be tested in accordance with the approved test plan in the presence of the Contracting Officer's representative to certify acceptable performance. System test shall verify that the total system meets all the requirements of the specification and complies with the specified standards. Contractor shall verify that no signal leakage exists in conformance with NCTA RP and 47 CFR 76.605. System leakage shall also be tested at the headend location with signal applied to system. Deficiencies revealed by the testing shall be corrected and revalidated by follow-up testing. Contractor shall conduct testing at each of the following points in the system:

a. Furthest outlet from each communication closet.

b. A random sampling of 25 percent of the outlets as designated by the Contracting Officer.

c. As specified by the area cable network system proponent.