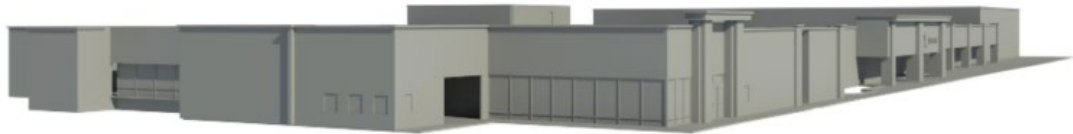




Client Project Number: XLWU21-1013D
Bldg 950



SPECIFICATIONS

Issued for Construction

BX and Mall HVAC and MCC Replacement Building 950 TYNDALL AIR FORCE BASE, FLORIDA

September 13, 2024

Contract No. FA890321D0012 | Delivery Order: FA481222F0105

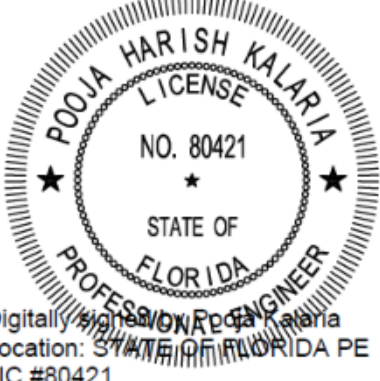
Project No. XLWU21-1013D

A/E PROJECT NO.: 1220654

FA481922F0105 BX HVAC and MCC Replacement
B950 Tyndall AFB, Florida

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<u>ARCHITECT</u>  Richard L. Elbert 09.13.2024 AR 0015372 REGISTERED ARCHITECT	<u>CIVIL</u>  Efraim Mangiwa LICENSE No 98386 09.13.2024 STATE OF FLORIDA PROFESSIONAL ENGINEER	<u>STRUCTURAL</u>  Pooja Harish Kalaria LICENSE NO. 80421 STATE OF FLORIDA PROFESSIONAL ENGINEER Digitally signed by Pooja Kalaria Location: STATE OF FLORIDA PE LIC #80421 Date: 2024.09.13 13:46:56-04'00'
<u>FIRE PROTECTION</u>  GEORGIA REGISTERED No. PE037581 PROFESSIONAL ENGINEER BRANDON T. HOFSTEAD Digitally signed by Brandon Hofstead Date: 2024.09.04 11:29:37-04'00'	<u>PLUMBING</u>	<u>MECHANICAL</u>  GEORGIA REGISTERED No. PE038014 PROFESSIONAL ENGINEER RYAN T. CARTER
<u>ELECTRICAL</u>  SPENCER J. PERRY JR. LICENSE NO. 62587 STATE OF FLORIDA PROFESSIONAL ENGINEER Spencer J Perry FL PE 62587 2024.09.13 13:58:47-04'00'	<u>TELECOMMUNICATIONS</u>  REGISTERED COMMUNICATIONS DISTRIBUTION DESIGNER Bicsi Michael Watkins BICSI ID # 292123 EXPIRES 12-31-25 RCDD Michael S. Watkins 9/10/2024	

FA481922F0105 BX HVAC and MCC Replacement
B950 Tyndall AFB, Florida

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SECTION 01 11 00

SUMMARY OF WORK

PART 1 GENERAL

1.1 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Welding Permits

Salvage Plan; G

1.2 WORK COVERED BY CONTRACT DOCUMENTS

1.2.1 Project Description

The work includes Demolition and replacement of existing HVAC system and Motor Control Center (MCC) with new equipment and associated systems serving the Base Exchange (BX, or Building 950) and its adjacent mall/shop areas and food court. The same building envelope contains the Base Commissary (grocery), but the Commissary is NOT included in this scope of work.

This project requires construction phasing to enable continuing operation of the upgraded facilities in support of base personnel and their families. Such operation includes public retail areas, all back offices, restaurants and shops, warehouse spaces, truck dock, delivery aprons, and safe ingress/egress for pedestrians and vehicles throughout the project area, including emergency vehicles and security forces at all times.

Total area of the building impacted by the work is in the range of 75,000 SF. Particular components to be considered include temporary cooling of spaces undergoing system upgrade, and limited adjacent exterior construction work area or laydown areas. A new mechanical room is added.

1.2.2 Location

The work is located at the Tyndall AFB, near Panama City Florida, approximately as indicated on the drawing cover sheet. The exact location will be shown by the Contracting Officer.

1.3 OCCUPANCY OF PREMISES

Building(s) will be occupied during performance of work under this Contract. Occupancy notifications will be posted in a prominent location in the work area.

Before work is started, arrange with the Contracting Officer a sequence of

procedure, means of access, space for storage of materials and equipment, and use of approaches, corridors, and stairways. Also refer to submittal requirement Section 02 41 00, paragraph 1.5 describing initial area planning and scheduling of safe barricade areas in coordination with facility management to provide safe demarcation of work areas throughout construction.

1.4 EXISTING WORK

In addition to FAR 52.236-9 Protection of Existing Vegetation, Structures, Equipment, Utilities, and Improvements:

- a. Remove or alter existing work in such a manner as to prevent injury or damage to any portions of the existing work which remain.
- b. Repair or replace portions of existing work which have been altered during construction operations to match existing or adjoining work, as approved by the Contracting Officer. At the completion of operations, existing work must be in a condition equal to or better than that which existed before new work started.

1.5 ON-SITE PERMITS

1.5.1 Utility Outage Requests and Utility Connection Requests

Schedule work to minimize outages. For utility outages and connections required during the execution of work that affect existing systems, schedule outside the regular working hours or on weekends, as approved by the Contracting Officer. Schedule utility outages and connections to minimize disruptions to the Government. No additional payment will be provided for utility outages and connections required to be performed outside the regular work hours.

Submit requests for utility outages and connections in writing to the Contracting Officer for approval at least 5 calendar days in advance of the time required. In each request, state the system involved, area involved, approximate duration of outage, and the nature of work involved.

1.5.2 Borrow, Excavation, Welding, and Burning Permits

ACTIVITY	SUBMISSION DATE	SUBMISSION FORM
Welding Permits	5 calendar days prior to work	

Post permits at a conspicuous location in the construction area.

Burning of trash or rubbish is not permitted at on project site.

1.6 LOCATION OF UNDERGROUND UTILITIES

Obtain digging permits prior to start of any required excavation, and comply with Installation requirements for locating and marking underground utilities. Contact local utility locating service a minimum of 48 hours prior to excavating, to mark utilities, and within sufficient time required if work occurs on a Monday or after a Holiday. Verify existing utility locations indicated on contract drawings, within area of work.

Identify and mark all other utilities not managed and located by the local utility companies. Scan the construction site with Ground Penetrating

Radar (GPR), electromagnetic, or sonic equipment, and mark the surface of the ground or paved surface where existing underground utilities are discovered. Verify the elevations of existing piping, utilities, and any type of underground obstruction not indicated, or specified to be removed, that is indicated or discovered during scanning, in locations to be traversed by piping, ducts, and other work to be conducted or installed. Verify elevations before installing new work closer than nearest manhole or other structure at which an adjustment in grade can be made.

1.6.1 Notification Prior to Excavation

Notify the Contracting Officer at least 15 days prior to starting excavation work.

1.7 SALVAGE MATERIAL AND EQUIPMENT

Items designated by the Contracting Officer to be salvaged remain the property of the Government. Segregate, itemize, deliver and off-load the salvaged property at the Government designated storage area located within 2miles of the construction site.

Provide a salvage plan, listing material and equipment to be salvaged, and their storage location. Maintain property control records for material or equipment designated as salvage. Provide a system for property control in the salvage plan. Store and protect salvaged materials and equipment until disposition by the Contracting Officer.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

-- End of Section --

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SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 GENERAL

1.1 SUMMARY

1.1.1 Submittal Information

The Contracting Officer may request submittals in addition to those specified when deemed necessary to adequately describe the work covered in the respective sections. Each submittal is to be complete and in sufficient detail to allow ready determination of compliance with contract requirements.

Units of weights and measures used on all submittals are to be the same as those used in the contract drawings.

1.1.2 Project Type

The Contractor's Quality Control (CQC) System Manager are to check and approve all items before submittal and stamp, sign, and date indicating action taken. Proposed deviations from the contract requirements are to be clearly identified. Include within submittals 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.

The Contractor and the Designer of Record (DOR), if applicable, are to check and approve all items before submittal and stamp, sign, and date indicating action taken. Proposed deviations from the contract requirements are to be clearly identified. Include within submittals 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.

1.1.3 Submission of Submittals

Schedule and provide submittals requiring Government approval before acquiring the material or equipment covered thereby. Pick up and dispose of samples not incorporated into the work in accordance with manufacturer's Safety Data Sheets (SDS) and in compliance with existing laws and regulations.

1.2 DEFINITIONS

1.2.1 Submittal Descriptions (SD)

Submittal requirements are specified in the technical sections. Examples and descriptions of submittals identified by the Submittal Description (SD) numbers and titles follow:

SD-01 Preconstruction Submittals

Submittals that are required prior to or commencing with the start of work on site. Submittals that are required prior to or at the start of construction (work) or the next major phase of the construction on a multiphase contract.

For Government approved division 01 preconstruction submittals that are required prior to or commencing with the start of work must be submitted within 30 calendar days of contract award unless specified elsewhere in the specifications. For contractor approved division 01 submittals that are required prior to or commencing with the start of work must be submitted within 45 calendar days of contract award unless specified elsewhere in the specifications.

Preconstruction Submittals include schedules and a tabular list of locations, features, and other pertinent information regarding products, materials, equipment, or components to be used in the work.

Certificates Of Insurance

Surety Bonds

List Of Proposed Subcontractors

List Of Proposed Products

Baseline Network Analysis Schedule (NAS)

Submittal Register

Schedule Of Prices Or Earned Value Report

Accident Prevention Plan Health And Safety Plan

Work Plan

Quality Control (QC) plan

Environmental Protection Plan

SD-02 Shop Drawings

Drawings, diagrams and schedules specifically prepared to illustrate some portion of the work.

Diagrams and instructions from a manufacturer or fabricator for use in producing the product and as aids to the Contractor for integrating the product or system into the project.

Drawings prepared by or for the Contractor to show how multiple systems and interdisciplinary work will be coordinated.

SD-03 Product Data

Catalog cuts, illustrations, schedules, diagrams, performance charts, instructions and brochures illustrating size, physical appearance and other characteristics of materials, systems or equipment for some portion of the work.

Samples of warranty language when the contract requires extended product warranties.

SD-04 Samples

Fabricated or unfabricated physical examples of materials, equipment or workmanship that illustrate functional and aesthetic characteristics of a material or product and establish standards by which the work can be judged.

Color samples from the manufacturer's standard line (or custom color samples if specified) to be used in selecting or approving colors for the project.

Field samples and mock-ups constructed on the project site establish standards ensuring work can be judged. Includes assemblies or portions of assemblies that are to be incorporated into the project and those that will be removed at conclusion of the work.

SD-05 Design Data

Design calculations, mix designs, analyses or other data pertaining to a part of work.

Design submittals, design substantiation submittals and extensions of design submittals.

SD-06 Test Reports

Report signed by authorized official of testing laboratory that a material, product or system identical to the material, product or system to be provided has been tested in accord with specified requirements. Unless specified in another section, testing must have been within three years of date of contract award for the project.

Report that includes findings of a test required to be performed on an actual portion of the work or prototype prepared for the project before shipment to job site.

Report that includes finding of a test made at the job site or on sample taken from the job site, on portion of work during or after installation.

Investigation reports

Daily logs and checklists

Final acceptance test and operational test procedure

SD-07 Certificates

Statements printed on the manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that the product, system, or material meets specification requirements. Must be dated after award of project contract and clearly name the project.

Document required of Contractor, or of a manufacturer, supplier,

installer or Subcontractor through Contractor. The document purpose is to further promote the orderly progression of a portion of the work by documenting procedures, acceptability of methods, or personnel qualifications.

Confined space entry permits

Text of posted operating instructions

SD-08 Manufacturer's Instructions

Preprinted material describing installation of a product, system or material, including special notices and (SDS) concerning impedances, hazards and safety precautions.

SD-09 Manufacturer's Field Reports

Documentation of the testing and verification actions taken by manufacturer's representative at the job site, in the vicinity of the job site, or on a sample taken from the job site, on a portion of the work, during or after installation, to confirm compliance with manufacturer's standards or instructions. The documentation must be signed by an authorized official of a testing laboratory or agency and state the test results; and indicate whether the material, product, or system has passed or failed the test.

Factory test reports.

SD-10 Operation and Maintenance Data

Data provided by the manufacturer, or the system provider, including manufacturer's help and product line documentation, necessary to maintain and install equipment, for operating and maintenance use by facility personnel.

Data required by operating and maintenance personnel for the safe and efficient operation, maintenance and repair of the item.

Data incorporated in an operations and maintenance manual or control system.

SD-11 Closeout Submittals

Documentation to record compliance with technical or administrative requirements or to establish an administrative mechanism.

Submittals required for Guiding Principle Validation (GPV) or Third Party Certification (TPC).

Special requirements necessary to properly close out a construction contract. For example, Record Drawings and as-built drawings. Also, submittal requirements necessary to properly close out a major phase of construction on a multi-phase contract.

1.2.2 Approving Authority

Office or designated person authorized to approve the submittal.

1.2.3 Work

As used in this section, on-site and off-site construction required by contract documents, including labor necessary to produce submittals, construction, materials, products, equipment, and systems incorporated or to be incorporated in such construction. In exception, excludes work to produce SD-01 submittals.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Submittal Register; G

1.4 SUBMITTAL CLASSIFICATION

1.4.1 Government Approved (G)

Government approval is required for extensions of design, critical materials, variations, equipment whose compatibility with the entire system must be checked, and other items as designated by the Government.

Government approval is required for any variations from the Solicitation or the Accepted Proposal and for other items as designated by the Government.

Within the terms of the Contract Clause SPECIFICATIONS AND DRAWINGS FOR CONSTRUCTION, submittals are considered to be "shop drawings."

1.4.2 Design-Build Submittal Classifications

1.4.2.1 Designer of Record Approved (DA)

Designer of Record (DOR) approval is required for extensions of design; critical materials; any variations from the Solicitation, the Accepted Proposal, or the completed design; equipment whose compatibility with the entire system must be checked; and other items as designated by the Contracting Officer. Provide the Government with the number of copies designated hereinafter of all DOR approved submittals. The Government may review any or all Designer of Record approved submittals for conformance with the Solicitation, the Accepted Proposal, and the completed design. The Government will review all submittals designated as varying from the Solicitation or Accepted Proposal, as described below. Generally, list design submittals under SD-05 Design Data.

1.4.2.2 Government Conformance Review of Design (CR)

The Government will review all intermediate and final design submittals for conformance with the technical requirements of the Solicitation. Review will be only for conformance with the applicable codes, standards, and contract requirements.

1.4.2.3 Designer of Record Approved/Government Conformance Review (DA/CR)

1.4.2.3.1 Variations from the Accepted Design

DOR approval and the Government's concurrence are required for any proposed variation from the accepted design that still complies with the contract before the Contractor is authorized to proceed with material acquisition or installation. If necessary to facilitate the project schedule, before official submission to the Government, the Contractor and the DOR may discuss with the Contracting Officer's Representative a submittal proposing a variation. However, the Government reserves the right to review the submittal before providing an opinion. In any case, the Government will not formally agree to or provide a preliminary opinion on any variation without the DOR's approval or recommended approval. The Government reserves the right to reject any design, variation that may affect furniture, furnishings, equipment selections, or operational decisions that were made, based on the reviewed and concurred design.

1.4.2.3.2 Substitutions

Unless prohibited or otherwise provided for elsewhere in the contract, where the Accepted Proposal named products, systems, materials or equipment by manufacturer, brand name, model number, or other specific identification, and the Contractor desires to substitute a manufacturer or model after award, submit a requested substitution for Government concurrence. Include substantiation, through identifying information and the DOR's approval, that the substitute meets the contract requirements and that it is equal in function, performance, quality, and salient features to that in the accepted contract proposal. If the contract otherwise prohibits substitutions of equal named products, systems, materials or equipment by manufacturer, brand name, model number or other specific identification, the request is considered a "variation" to the contract. Variations are discussed below in paragraphs: "DESIGNER OF RECORD APPROVED/GOVERNMENT APPROVED" and VARIATIONS.

1.4.2.4 Designer of Record Approved/Government Approved (DA/GA)

In addition to the above-stated requirements for proposed variations to the accepted design, both DOR and Government Approval and, where applicable, a contract modification are required before the Contractor is authorized to proceed with material acquisition or installation for any proposed variation to the contract (the Solicitation or the Accepted Proposal), that constitutes a change to the contract terms. The Government reserves the right to accept or reject any such proposed variation.

1.4.3 For Information Only

Submittals not requiring Government approval will be for information only. For Design-build construction all submittals not requiring DOR or Government approval will be for information only. Within the terms of the Contract Clause SPECIFICATIONS AND DRAWINGS FOR CONSTRUCTION, they are not considered to be "shop drawings."

1.5 FORWARDING SUBMITTALS REQUIRING GOVERNMENT APPROVAL

As soon as practicable after award of contract, and before procurement or fabrication, forward to the KO, 325th CON submittals required in the technical sections of this specification, including shop drawings, product

data and samples. In addition, forward a copy of the submittals to the Contracting Officer.

1.5.1 O&M Data

Submit data specified for a given item within 30 calendar days after the item is delivered to the contract site.

In the event the Contractor fails to deliver O&M data within the time limits specified, the Contracting Officer may withhold from progress payments 50 percent of the price of the items to which such O&M data apply.

1.6 PREPARATION

1.6.1 Transmittal Form

Transmit each submittal, except sample installations and sample panels to the office of the approving authority using the transmittal form prescribed by the Contracting Officer. Include all information prescribed by the transmittal form and required in paragraph IDENTIFYING SUBMITTALS. Use the submittal transmittal forms to record actions regarding samples.

Use the ENG Form 4025-R transmittal form for submitting both Government-approved and information-only submittals. Submit in accordance with the instructions on the reverse side of the form. These forms or similar forms are included in the RMS CM software that the Contractor is required to use for this contract. Properly complete this form by filling out all the heading blank spaces and identifying each item submitted. Exercise special care to ensure proper listing of the specification paragraph and sheet number of the contract drawings pertinent to the data submitted for each item.

1.6.2 Identifying Submittals

The Contractor's Quality Control Manager must prepare, review and stamp submittals, including those provided by a subcontractor, before submittal to the Government.

Identify submittals, except sample installations and sample panels, with the following information permanently adhered to or noted on each separate component of each submittal and noted on transmittal form. Mark each copy of each submittal identically, with the following:

- a. Project title and location
- b. Construction contract number
- c. Dates of the drawings and revisions
- d. Name, address, and telephone number of Subcontractor, supplier, manufacturer, and any other Subcontractor associated with the submittal.
- e. Section number of the specification by which submittal is required
- f. Submittal description (SD) number of each component of submittal
- g. For a resubmission, add alphabetic suffix on submittal description, for example, submittal 18 would become 18A, to indicate resubmission

h. Product identification and location in project.

1.6.3 Submittal Format

1.6.3.1 Format of SD-01 Preconstruction Submittals

When the submittal includes a document that is to be used in the project, or is to become part of the project record, other than as a submittal, do not apply the Contractor's approval stamp to the document itself, but to a separate sheet accompanying the document.

Provide data in the unit of measure used in the contract documents.

1.6.3.2 Format for SD-02 Shop Drawings

Provide shop drawings not less than 8 1/2 by 11 inches nor more than 30 by 42 inches, except for full-size patterns or templates. Prepare drawings to accurate size, with scale indicated, unless another form is required. Ensure drawings are suitable for reproduction and of a quality to produce clear, distinct lines and letters, with dark lines on a white background.

- a. Include the nameplate data, size, and capacity on drawings. Also include applicable federal, military, industry, and technical society publication references.
- b. Dimension drawings, except diagrams and schematic drawings. Prepare drawings demonstrating interface with other trades to scale. Use the same unit of measure for shop drawings as indicated on the contract drawings. Identify materials and products for work shown.

Present shop drawings sized 8 1/2 by 11 inches as part of the bound volume for submittals. Present larger drawings in sets. Submit an electronic copy of drawings in PDF format.

1.6.3.2.1 Drawing Identification

Include on each drawing the drawing title, number, date, and revision numbers and dates, in addition to information required in paragraph IDENTIFYING SUBMITTALS.

Number drawings in a logical sequence. Each drawing is to bear the number of the submittal in a uniform location next to the title block. Place the Government contract number in the margin, immediately below the title block, for each drawing.

Reserve a blank space, no smaller than 1 inches on the right-hand side of each sheet for the Government disposition stamp.

1.6.3.3 Format of SD-03 Product Data

Present product data submittals for each section as a complete, bound volume. Include a table of contents, listing the page and catalog item numbers for product data.

Indicate, by prominent notation, each product that is being submitted; indicate the specification section number and paragraph number to which it pertains.

1.6.3.3.1 Product Information

Supplement product data with material prepared for the project to satisfy the submittal requirements where product data does not exist. Identify this material as developed specifically for the project, with information and format as required for submission of SD-07 Certificates.

Provide product data in units used in the Contract documents. Where product data are included in preprinted catalogs with another unit, submit the dimensions in contract document units, on a separate sheet.

1.6.3.3.2 Standards

Where equipment or materials are specified to conform to industry or technical-society reference standards of such organizations as the American National Standards Institute (ANSI), ASTM International (ASTM), National Electrical Manufacturer's Association (NEMA), Underwriters Laboratories (UL), or 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. 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. State on the certificate 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.

1.6.3.3.3 Data Submission

Collect required data submittals for each specific material, product, unit of work, or system into a single submittal that is marked for choices, options, and portions applicable to the submittal. Mark each copy of the product data identically. Partial submittals will be accepted **if necessary, with prior approval** for expedition of the construction effort.

Submit the manufacturer's instructions before installation.

1.6.3.4 Format of SD-04 Samples

1.6.3.4.1 Sample Characteristics

Furnish samples in the following sizes, unless otherwise specified or unless the manufacturer has prepackaged samples of approximately the same size as specified:

- a. Sample of Equipment or Device: Full size.
- b. Sample of Materials Less Than **2 by 3 inches**: Built up to **8 1/2 by 11 inches**.
- c. Sample of Materials Exceeding **8 1/2 by 11 inches**: Cut down to **8 1/2 by 11 inches** and adequate to indicate color, texture, and material variations.
- d. Sample of Linear Devices or Materials: **10 inch** length or length to be supplied, if less than **10 inches**. Examples of linear devices or materials are conduit and handrails.
- e. Sample Volume of Nonsolid Materials: **Pint**. Examples of nonsolid

materials are sand and paint.

- f. Color Selection Samples: **2 by 4 inches**. Where samples are specified for selection of color, finish, pattern, or texture, submit the full set of available choices for the material or product specified. Sizes and quantities of samples are to represent their respective standard unit.
- g. Sample Panel: **4 by 4 feet**.
- h. Sample Installation: **100 square feet**.

1.6.3.4.2 Sample Incorporation

Reusable Samples: Incorporate returned samples into work only if so specified or indicated. Incorporated samples are to be in undamaged condition at the time of use.

Recording of Sample Installation: Note and preserve the notation of any area constituting a sample installation, but remove the notation at the final clean-up of the project.

1.6.3.4.3 Comparison Sample

Samples Showing Range of Variation: Where variations in color, finish, pattern, or texture are unavoidable due to nature of the materials, submit sets of samples of not less than three units showing extremes and middle of range. Mark each unit to describe its relation to the range of the variation.

When color, texture, or pattern is specified by naming a particular manufacturer and style, include one sample of that manufacturer and style, for comparison.

1.6.3.5 Format of SD-05 Design Data

Provide design data and certificates on **8 1/2 by 11 inch** paper. **Provide a bound volume for submittals containing numerous pages.**

1.6.3.6 Format of SD-06 Test Reports

Provide reports on 8 1/2 by 11 inch paper in a complete bound volume.

By prominent notation, indicate each report in the submittal. Indicate the specification number and paragraph number to which each report pertains.

1.6.3.7 Format of SD-07 Certificates

Provide design data and certificates on **8 1/2 by 11 inch** paper. **Provide a bound volume for submittals containing numerous pages.**

1.6.3.8 Format of SD-08 Manufacturer's Instructions

Present manufacturer's instructions submittals for each section **as a complete, bound volume**. Include the manufacturer's name, trade name, place of manufacture, and catalog model or number on product data. Also include applicable federal, military, industry, and technical-society publication references. If supplemental information is needed to clarify

the manufacturer's data, submit it as specified for SD-07 Certificates.

Submit the manufacturer's instructions before installation.

1.6.3.8.1 Standards

Where equipment or materials are specified to conform to industry or technical-society reference standards of such organizations as the American National Standards Institute (ANSI), ASTM International (ASTM), National Electrical Manufacturer's Association (NEMA), Underwriters Laboratories (UL), or 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. 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. State on the certificate 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.

1.6.3.9 Format of SD-09 Manufacturer's Field Reports

Provide reports on 8 1/2 by 11 inch paper in a complete bound volume.

By prominent notation, indicate each report in the submittal. Indicate the specification number and paragraph number to which each report pertains.

1.6.3.10 Format of SD-10 Operation and Maintenance Data (O&M)

Comply with the requirements specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA for O&M Data format.

1.6.3.11 Format of SD-11 Closeout Submittals

When the submittal includes a document that is to be used in the project or is to become part of the project record, other than as a submittal, do not apply the Contractor's approval stamp to the document itself, but to a separate sheet accompanying the document.

Provide data in the unit of measure used in the contract documents.

1.6.4 Source Drawings for Shop Drawings

1.6.4.1 Source Drawings

The entire set of source drawing files (DWG) will not be provided to the Contractor. Request the specific Drawing Number for the preparation of shop drawings. Only those drawings requested to prepare shop drawings will be provided. These drawings are provided only after award.

1.6.4.2 Terms and Conditions

Data contained on these electronic files must not be used for any purpose other than as a convenience in the preparation of construction data for the referenced project. Any other use or reuse is at the sole risk of the Contractor and without liability or legal exposure to the Government. The Contractor must make no claim, and waives to the fullest extent permitted by law any claim or cause of action of any nature against the Government,

its agents, or its subconsultants that may arise out of or in connection with the use of these electronic files. The Contractor must, to the fullest extent permitted by law, indemnify and hold the Government harmless against all damages, liabilities, or costs, including reasonable attorney's fees and defense costs, arising out of or resulting from the use of these electronic files.

These electronic source drawing files are not construction documents. Differences may exist between the source drawing files and the corresponding construction documents. The Government makes no representation regarding the accuracy or completeness of the electronic source drawing files, nor does it make representation to the compatibility of these files with the Contractor hardware or software. The Contractor is responsible for determining if any conflict exists. In the event that a conflict arises between the signed and sealed construction documents prepared by the Government and the furnished source drawing files, the signed and sealed construction documents govern. Use of these source drawing files does not relieve the Contractor of the duty to fully comply with the contract documents, including and without limitation the need to check, confirm and coordinate the work of all contractors for the project. If the Contractor uses, duplicates or modifies these electronic source drawing files for use in producing construction data related to this contract, remove all previous indication of ownership (seals, logos, signatures, initials and dates).

1.6.5 Electronic File Format

Provide submittals in electronic format, with the exception of material samples required for SD-04 Samples items. Compile the submittal file as a single, complete document, to include the Transmittal Form described within. Name the electronic submittal file specifically according to its contents, and coordinate the file naming convention with the Contracting Officer. Electronic files must be of sufficient quality that all information is legible. Use PDF as the electronic format, unless otherwise specified or directed by the Contracting Officer. Generate PDF files from original documents with bookmarks so that the text included in the PDF file is searchable and can be copied. If documents are scanned, optical character resolution (OCR) routines are required. Index and bookmark files exceeding 30 pages to allow efficient navigation of the file. When required, the electronic file must include a valid electronic signature or a scan of a signature.

E-mail electronic submittal documents smaller than 10MB to an e-mail address as directed by the Contracting Officer. Provide electronic documents over 10 MB on an optical disc or through an electronic file sharing system such as the DOD SAFE Web Application located at the following website: <https://safe.apps.mil/>.

1.7 QUANTITY OF SUBMITTALS

1.7.1 Number of SD-01 Preconstruction Submittal Copies

Unless otherwise specified, submit two sets of administrative submittals.

1.7.2 Number of SD-02 Shop Drawing Copies

Submit 2 copies of shop drawings requiring review and approval by the Contracting Officer.

1.7.3 Number of SD-03 Product Data Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.4 Number of SD-04 Samples

- a. Submit two samples, or two sets of samples showing the range of variation, of each required item. One approved sample or set of samples will be retained by the approving authority and one will be returned to the Contractor.
- b. Submit one sample panel or provide one sample installation where directed. Include components listed in the technical section or as directed.
- c. Submit one sample installation, where directed.
- d. Submit one sample of nonsolid materials.

1.7.5 Number of SD-05 Design Data Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.6 Number of SD-06 Test Report Copies

Submit in compliance with quantity and quality requirements specified for shop drawings, other than field test results that will be submitted with QC reports.

1.7.7 Number of SD-07 Certificate Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.8 Number of SD-08 Manufacturer's Instructions Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.9 Number of SD-09 Manufacturer's Field Report Copies

Submit in compliance with quantity and quality requirements specified for shop drawings other than field test results that will be submitted with QC reports.

1.7.10 Number of SD-10 Operation and Maintenance Data Copies

Submit three copies of O&M data to the Contracting Officer for review and approval.

1.7.11 Number of SD-11 Closeout Submittals Copies

Unless otherwise specified, submit two sets of administrative submittals.

1.8 INFORMATION ONLY SUBMITTALS

Submittals without a "G" designation must be certified by the QC manager

and submitted to the Contracting Officer for information-only. Provide information-only submittals to the Contracting Officer a minimum of 14 calendar days prior to the Preparatory Meeting for the associated Definable Feature of Work (DFOW). Approval of the Contracting Officer is not required on information only submittals. The Contracting Officer will mark "receipt acknowledged" on submittals for information and will return only the transmittal cover sheet to the Contractor. Normally, submittals for information only will not be returned. However, the Government reserves the right to return unsatisfactory submittals and 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.

1.9 PROJECT SUBMITTAL REGISTER AND DATABASE

A sample Project Submittal Register showing items of equipment and materials for when submittals are required by the specifications is provided as "Appendix A - Submittal Register."

1.9.1 Submittal Management

Prepare and maintain a submittal register, as the work progresses. Use an electronic submittal register program furnished by the Government. Do not change data that is output in columns (c), (d), (e), and (f) as delivered by Government; retain data that is output in columns (a), (g), (h), and (i) as approved. As an attachment, provide a submittal register showing 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. Maintain a submittal register for the project in accordance with Section 01 45 00.15 10 RESIDENT MANAGEMENT SYSTEM CONTRACTOR MODE(RMS CM).

Column (c): Lists specification section in which submittal is required.

Column (d): Lists each submittal description (SD Number. and type, e.g., SD-02 Shop Drawings) required in each specification section.

Column (e): Lists one principal paragraph in each specification section where a material or product is specified. This listing is only to facilitate locating submitted requirements. Do not consider entries in column (e) as limiting the project requirements.

Column (f): Lists the approving authority for each submittal.

The database and submittal management program will be furnished to the Contractor on a writable compact disk (CD-R), for operation on a Windows-based personal computer.

Thereafter, the Contractor is to track all submittals by maintaining a complete list, including completion of all data columns and all dates on which submittals are received by and returned by the Government.

1.9.2 Preconstruction Use of Submittal Register

Submit the submittal register [as an electronic database, using the submittal management program furnished to Contractor](#). Include the QC plan and the project schedule. Verify that all submittals required for the project are listed and add missing submittals. Coordinate and complete the following fields on the register [database](#) submitted with the QC plan and the project schedule:

Column (a) Activity Number: Activity number from the project schedule.

Column (g) Contractor Submit Date: Scheduled date for the approving authority to receive submittals.

Column (h) Contractor Approval Date: Date that Contractor needs approval of submittal.

Column (i) Contractor Material: Date that Contractor needs material delivered to Contractor control.

1.9.3 Contractor Use of Submittal Register

Update the following fields [in the Government-furnished submittal register program or equivalent fields in the program used by the Contractor](#) with each submittal throughout the contract.

Column (b) Transmittal Number: List of consecutive, Contractor-assigned numbers.

Column (j) Action Code (k): Date of action used to record Contractor's review when forwarding submittals to QC.

Column (l) Date submittal transmitted.

Column (q) Date approval was received.

1.9.4 Approving Authority Use of Submittal Register

Update the following fields:

Column (b) Transmittal Number: List of consecutive, Contractor-assigned numbers.

Column (l) Date submittal was received.

Column (m) through (p) Dates of review actions.

Column (q) Date of return to Contractor.

1.9.5 Action Codes

[Entries for columns \(j\) and \(o\) are to be used as follows \(others may be prescribed by the Transmittal Form\):](#)

1.9.5.1 Government Review Action Codes

["A" - "Approved as submitted"; "Completed"](#)

"B" - "Approved, except as noted on drawings"; "Completed"

"C" - "Approved, except as noted on drawings; resubmission required"; "Resubmit"

"D" - "Returned by separate correspondence"; "Completed"

"E" - "Disapproved (See attached)"; "Resubmit"

"F" - "Receipt acknowledged"; "Completed"

"G" - "Other (Specify)"; "Resubmit"

"X" - "Receipt acknowledged, does not comply with contract requirements"; "Resubmit"

1.9.5.2 Government Review Action Codes

"A" - "Approved as submitted"

"AN" - "Approved as noted"

"RR" - "Disapproved as submitted"; "Completed"

"NR" - "Not Reviewed"

"RA" - "Receipt Acknowledged"

1.9.5.3 Contractor Action Codes

DESIGN BID BUILD SUBMITTALS			
Submittal Classifications shown in UFGS Sections	Submittal Classification	Corresponding SpecsIntact Submittal Register Code which is populated in the SI Submittal Register. Software Limitations: (The software shows one character delineation in the SpecsIntact Submittal Register)	RMS - The following Submittal Classifications are populated in RMS when the SpecsIntact Submittal Data File is pulled into RMS)
G	Submittal requires Government Approval	G	GA
BLANK	Submittal is For Information Only (FIO)	BLANK	FIO

DESIGN BID BUILD SUBMITTALS			
S	Submittal is for documentation of Sustainable requirements	S	S/FIO

1.9.5.4 Contractor Action Codes

DESIGN BUILD SUBMITTALS			
Submittal Classifications shown in UFGS Sections	Submittal Classification	Corresponding SpecsIntact Submittal Register Code which is populated in the SI Submittal Register. Software Limitations: (The software shows one character delineation in the SpecsIntact Submittal Register)	RMS - The following Submittal Classifications are populated in RMS when the SpecsIntact Submittal Data File is pulled into RMS)
G	Submittal requires Government Approval	G	GA
BLANK	Submittal is For Information Only(FIO)	BLANK	FIO
DA	Submittal requires Designer of Record Approval	D	DA
CR	Submittal requires Government Conformance Review	C	CR
DA/CR	Submittal requires Designer of Record Approval and Government Conformance Review	R	DA/CR
DA/GA	Submittal requires Designer of Record Approval and Government Approval	A	DA/GA

1.9.6 Delivery of Copies

Submit an updated electronic copy of the submittal register to the Contracting Officer with each invoice request , unless a paper copy is requested by the Contracting Officer. Provide an updated Submittal Register monthly regardless of whether an invoice is submitted.

1.10 VARIATIONS

Variations from contract requirements require Contracting Officer approval pursuant to contract Clause FAR 52.236-21 Specifications and Drawings for Construction, and will be considered where advantageous to the Government.

1.10.1 Considering Variations

Discussion of variations with the Contracting Officer before submission of a variation submittal will help ensure that functional and quality requirements are met and minimize rejections and resubmittals. For variations that include design changes or some material or product substitutions, the Government may require an evaluation and analysis by a licensed professional engineer hired by the contractor.

Specifically point out variations from contract requirements in a variation submittal. Failure to point out variations may cause the Government to require rejection and removal of such work at no additional cost to the Government.

1.10.2 Proposing Variations

Check the column "variation" of ENG Form 4025 for submittals that include variations proposed by the Contractor. Set forth in writing the reason for any variations and note such variations on the submittal. The Government reserves the right to rescind inadvertent approval of submittals containing unnoted variations.

1.10.3 Warranting that Variations are Compatible

When delivering a variation for approval, the Contractor warrants that this contract has been reviewed to establish that the variation, if incorporated, will be compatible with other elements of work.

1.10.4 Review Schedule Extension

In addition to the normal submittal review period, a period of 14 calendar working days will be allowed for the Government to consider submittals with variations.

1.11 SCHEDULING

Schedule and submit concurrently product data and shop drawings covering component items forming a system or items that are interrelated. Submit pertinent certifications at the same time. No delay damages or time extensions will be allowed for time lost in late submittals. Allow an additional 5 calendar working days for review and approval of submittals for HVAC control systems.

- a. Coordinate scheduling, sequencing, preparing, and processing of submittals with performance of work so that work will not be delayed by submittal processing. The Contractor is responsible for additional

time required for Government reviews resulting from required resubmittals. The review period for each resubmittal is the same as for the initial submittal.

- b. Submittals required by the contract documents are listed on the submittal register. If a submittal is listed in the submittal register but does not pertain to the contract work, the Contractor is to include the submittal in the register and annotate it "N/A" with a brief explanation. Approval by the Contracting Officer does not relieve the Contractor of supplying submittals required by the contract documents but that have been omitted from the register or marked "N/A."
- c. Resubmit the submittal register and annotate it monthly with actual submission and approval dates. When all items on the register have been fully approved, no further resubmittal is required.

Contracting Officer review will be completed within 15 calendar working days after the date of submission.

- d. Except as specified otherwise, allow a review period, beginning with receipt by the approving authority, that includes at least 10 working days for submittals for QC manager approval and 15 working days for submittals where the Contracting Officer is the approving authority. The period of review for submittals with Contracting Officer approval begins when the Government receives the submittal from the QC organization.
- e. For submittals requiring review by a Government fire protection engineer, allow a review period, beginning when the Government receives the submittal from the QC organization, of 20 working days for return of the submittal to the Contractor.

Within 30 calendar days of Notice To ProceedAt the Preconstruction conference, provide the following schedule of submittals for approval by the Contracting Officer:

- d. A schedule of shop drawings and technical submittals required by the specifications and drawings. Indicate the specification or drawing reference requiring the submittal; the material, item, or process for which the submittal is required; the "SD" number and identifying title of the submittal; the anticipated submission date, and the approval need date.
- e. A separate schedule of other submittals required under the contract but not listed in the specifications or drawings. Indicate the contract requirement reference, the type or title of the submittal, the anticipated submission date, and the approval need date (if approval is required).

1.11.1 Reviewing, Certifying, and Approving Authority

The QC Manager is responsible for reviewing all submittals and certifying that they are in compliance with contract requirements. The approving authority on submittals is the QC Manager unless otherwise specified. At each "Submittal" paragraph in individual specification sections, a notation "G" following a submittal item indicates that the Contracting Officer is the approving authority for that submittal item. Provide an additional copy of the submittal to the Government Approving authority

1.11.2 Constraints

Conform to provisions of this section, unless explicitly stated otherwise for submittals listed or specified in this contract.

Submit complete submittals for each definable feature of the work. At the same time, submit components of definable features that are interrelated as a system.

When acceptability of a submittal is dependent on conditions, items, or materials included in separate subsequent submittals, the submittal will be returned without review.

Approval of a separate material, product, or component does not imply approval of the assembly in which the item functions.

1.11.3 QC Organization Responsibilities

- a. Review submittals for conformance with project design concepts and compliance with contract documents.
- b. Process submittals based on the approving authority indicated in the submittal register.
 - (1) When the QC manager is the approving authority, take appropriate action on the submittal from the possible actions defined in paragraph APPROVED SUBMITTALS.
 - (2) When the Contracting Officer is the approving authority or when variation has been proposed, forward the submittal to the Government, along with a certifying statement, or return the submittal marked "not reviewed" or "revise and resubmit" as appropriate. The QC organization's review of the submittal determines the appropriate action.
- c. Ensure that material is clearly legible.
- d. Stamp each sheet of each submittal with a QC certifying statement or an approving statement, except that data submitted in a bound volume or on one sheet printed on two sides may be stamped on the front of the first sheet only.
 - (1) When the approving authority is the Contracting Officer, the QC organization will certify submittals forwarded to the Contracting Officer with the following certifying statement:

"I hereby certify that the (equipment) (material) (article) shown and marked in this submittal is that proposed to be incorporated with Contract Number _____ is in compliance with the contract drawings and specification, can be installed in the allocated spaces, and is submitted for Government approval.

Certified by Submittal Reviewer _____, Date _____
(Signature when applicable)

Certified by QC Manager _____, Date _____"
(Signature)

(2) When approving authority is the QC manager, the QC manager will use the following approval statement when returning submittals to the Contractor as "Approved" or "Approved as Noted."

"I hereby certify that the (material) (equipment) (article) shown and marked in this submittal and proposed to be incorporated with Contract Number _____ is in compliance with the contract drawings and specification, can be installed in the allocated spaces, and is approved for use.

Certified by Submittal Reviewer _____, Date _____
(Signature when applicable)

Approved by QC Manager _____, Date _____"
(Signature)

- e. Sign the certifying statement or approval statement. The QC organization member designated in the approved QC plan is the person signing certifying statements. The use of original ink for signatures is required. Stamped signatures are not acceptable.
- f. Update the submittal register as submittal actions occur, and maintain the submittal register at the project site until final acceptance of all work by the Contracting Officer.
- g. Retain a copy of approved submittals and approved samples at the project site.
- h. For "S" submittals, provide a copy of the approved submittal to the Government Approving authority.

1.11.4 Government Reviewed Design

The Government will review design submittals for conformance with the technical requirements of the Solicitation. Government review is required for variations from the completed design. Review will be only for conformance with the contract requirements. Included are only those construction submittals for which the DOR's design documents do not include enough detail to ascertain contract compliance. The Government may, but is not required to, review extensions of design such as structural steel or reinforcement shop drawings.

1.12 GOVERNMENT APPROVING AUTHORITY

When the approving authority is the Contracting Officer, the Government will:

- a. Note the date on which the submittal was received from the QC manager.
- b. Review submittals for approval within the scheduling period specified and only for conformance with project design concepts and compliance with contract documents.
- c. Identify returned submittals with one of the actions defined in paragraph REVIEW NOTATIONS and with comments and markings appropriate for the action indicated.

Upon completion of review of submittals requiring Government approval, stamp and date submittals. 1 copy of the submittal will be retained by

the Contracting Officer and 1 copy of the submittal will be returned to the Contractor. If the Government performs a conformance review of other Designer of Record approved submittals, the submittals will be identified and returned, as described above.

1.12.1 Review Notations

Submittals will be returned to the Contractor with the following notations:

- a. Submittals marked "approved" or "accepted" authorize proceeding with the work covered.
- b. Submittals marked "approved as noted" or "approved, except as noted, resubmittal not required," authorize proceeding with the work covered provided that the Contractor takes no exception to the corrections.
- c. Submittals marked "not approved," "disapproved," or "revise and resubmit" indicate incomplete submittal or noncompliance with the contract requirements or design concept. Resubmit with appropriate changes. Do not proceed with work for this item until the resubmittal is approved.
- d. Submittals marked "not reviewed" indicate that the submittal has been previously reviewed and approved, is not required, does not have evidence of being reviewed and approved by Contractor, or is not complete. A submittal marked "not reviewed" will be returned with an explanation of the reason it is not reviewed. Resubmit submittals returned for lack of review by Contractor or for being incomplete, with appropriate action, coordination, or change.
- e. Submittals marked "receipt acknowledged" indicate that submittals have been received by the Government. This applies only to "information-only submittals" as previously defined.

1.13 DISAPPROVED SUBMITTALS

Make corrections required by the Contracting Officer. If the Contractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications, give notice to the Contracting Officer as required under the FAR clause titled CHANGES. The Contractor is responsible for the dimensions and design of connection details and the construction of work. Failure to point out variations may cause the Government to require rejection and removal of such work at the Contractor's expense.

If changes are necessary to submittals, make such revisions and resubmit in accordance with the procedures above. No item of work requiring a submittal change is to be accomplished until the changed submittals are approved.

1.14 APPROVED SUBMITTALS

The Contracting Officer's approval of submittals is not to be construed as a complete check, and indicates only that the general method of construction, materials, detailing, and other information are satisfactory. the design, general method of construction, materials, detailing, and other information appear to meet the Solicitation and Accepted Proposal.

Approval or acceptance by the Government for a submittal does not relieve

the Contractor of the responsibility for meeting the contract requirements or for any error that may exist, because under the Quality Control (QC) requirements of this contract, the Contractor is responsible for ensuring information contained within each submittal accurately conforms with the requirements of the contract documents.

After submittals have been approved or accepted 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.

1.15 APPROVED SAMPLES

Approval of a sample is only for the characteristics or use named in such approval and is not to be construed to change or modify any contract requirements. Before submitting samples, provide assurance that the materials or equipment will be available in quantities required in the project. No change or substitution will be permitted after a sample has been approved.

Match the approved samples for materials and equipment incorporated in the work. If requested, approved samples, including those that may be damaged in testing, will be returned to the Contractor, at its expense, upon completion of the contract. Unapproved samples will also be returned to the Contractor at its expense, if so requested.

Failure of any materials to pass the specified tests will be sufficient cause for refusal to consider, under this contract, any further samples of the same brand or make as that material. The Government reserves the right to disapprove any material or equipment that has previously proved unsatisfactory in service.

Samples of various materials or equipment delivered on the site or in place may be taken by the Contracting Officer for testing. Samples failing to meet contract requirements will automatically void previous approvals. Replace such materials or equipment to meet contract requirements.

1.16 WITHHOLDING OF PAYMENT

Payment for materials incorporated in the work will not be made if required approvals have not been obtained. No payment for materials incorporated in the work will be made unless all required DOR approvals or required Government approvals have been obtained. No payment will be made for any materials incorporated into the work for any conformance review submittals or information-only submittals found to contain errors or deviations from the Solicitation or Accepted Proposal.

1.17 CERTIFICATION OF SUBMITTAL DATA

Certify the submittal data as follows on Form ENG 4025: "I certify that the above submitted items had been reviewed in detail and are correct and in strict conformance with the contract drawings and specifications except as otherwise stated.

____NAME OF CONTRACTOR _____ SIGNATURE OF CONTRACTOR

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
1220654

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH	GOVT CLASSIFICATION	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION		DATE FWD TO APPR AUTH/	APPROVING AUTHORITY				MAILED TO CONTR/	REMARKS
						SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	ACTION CODE	DATE OF ACTION	DATE RCD FROM CONTR	DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION	DATE RCD FRM APPR AUTH	
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		01 11 00	SD-01 Preconstruction Submittals														
			Welding Permits	1.5.2													
			Salvage Plan	1.7	G												
		01 33 00	SD-01 Preconstruction Submittals														
			Submittal Register	1.9	G												
		01 45 00.00 40	SD-01 Preconstruction Submittals														
			Quality Assurance (QA) Plan	2.1.1	G												
			SD-06 Test Reports														
			Quality Control Data	2.1.2	G												
			Quality Control Coordinating	2.1.2	G												
			Actions														
			Quality Control Training	2.1.2	G												
			Inspection Records	2.1.2	G												
			Letters of Authority or Delegation	2.1.2.3	G												
			Field Tests	2.1.2	G												
			Factory Tests	2.1.2	G												
			SD-07 Certificates														
			Quality Representative	1.4.1													
			Qualifications														
			Special Certifications	1.4.1													
			Monthly Performance Report	2.1.2.2													
		01 45 35	SD-01 Preconstruction Submittals														
			SIOR Letter of Acceptance	3.1.1	G												
			Project Manual	3.1.1	G												
			Project Manual	3.1.1	G												
			SD-06 Test Reports														

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
1220654

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH	GOVT CLASS OR FIC ATT ION	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION		DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	APPROVING AUTHORITY				MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
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		01 45 35	Daily Reports	3.1.1													
			Daily Reports	3.1.3													
			Biweekly Reports	3.1.1													
			Biweekly Reports	3.1.2													
			SD-07 Certificates														
			AISC Certified Steel Fabricator	2.1													
			Steel Truss Plant Quality Assurance Program	2.1													
			Steel Joist Institute Membership	2.1													
			Certified Plant	2.1													
			Certificate of Compliance	2.1													
			Special Inspector of Record	1.5	G												
			Special Inspector	1.5	G												
			Qualification Records	3.1.3													
			SD-11 Closeout Submittals														
			Comprehensive Final Report	3.1.1	G												
		01 74 19	SD-01 Preconstruction Submittals														
			Construction Waste Management Plan	1.5	G												
			SD-11 Closeout Submittals														
			Final Construction Waste Diversion Report	1.1.6	S												
		01 78 23	SD-10 Operation and Maintenance Data														
			O&M Database	1.4	G												
			Training Plan	3.1.1	G												

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		01 78 23	Training Outline	3.1.3	G												
			Training Content	3.1.2	G												
			SD-11 Closeout Submittals														
			Training Video Recording	3.1.4	G												
			Validation of Training Completion	3.1.6	G												
		02 41 00	SD-01 Preconstruction Submittals														
			Demolition Plan	1.2.2	G												
			Existing Conditions	1.11													
			SD-07 Certificates														
			Notification	1.7	G												
		03 30 00	SD-01 Preconstruction Submittals														
			Concrete Curing Plan	1.6.3.1													
			Quality Control Plan	1.6.5	G												
			Quality Control Personnel	1.6.6	G												
			Certifications														
			Quality Control Organizational	1.6.6													
			Chart														
			Laboratory Accreditation	1.6.8	G												
			Form Removal Schedule	1.6.2.1	G												
			Maturity Method Data	3.3.10													
			SD-02 Shop Drawings														
			Formwork	1.6.2.1													
			Reinforcing Steel	1.6.2.2	G												
			SD-03 Product Data														
			Joint Sealants	2.4.5													
			Joint Filler	2.4.4													

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		03 30 00	Formwork Materials	2.1													
			Cementitious Materials	2.3.1													
			Vapor Retarder	2.4.6													
			Concrete Curing Materials	2.4.1													
			Reinforcement	2.6													
			Sealers	2.4.3.1													
			Admixtures	2.3.4													
			Biodegradable Form Release Agent	2.2.2													
			Pumping Concrete	1.6.3.2													
			Finishing Plan	1.6.3.3													
			Nonshrink Grout	2.4.2													
			SD-05 Design Data														
			Concrete Mix Design	1.6.1.2	G												
			Formwork Calculations	1.6.1.1													
			SD-06 Test Reports														
			Concrete Mix Design	1.6.1.2	G												
			Fly Ash	1.6.4.1													
			Slag Cement	1.6.4.2													
			Aggregates	1.6.4.3													
			Tolerance Report	3.9.2.1													
			Compressive Strength Tests	3.13.3.3	G												
			Unit Weight of Structural Concrete	3.13.3.5													
			Air Content	3.13.3.4													
			Slump Tests	3.13.3.1													

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		03 30 00	Water	2.3.2													
			SD-07 Certificates														
			Reinforcing Bars	2.6.1													
			VOC Content for Form Release	1.6.3.4													
			Agents, Curing Compounds, and														
			Concrete Penetrating Sealers														
			Safety Data Sheets	1.6.3.5													
			Field Testing Technician and	1.6.6.2													
			Testing Agency														
			SD-08 Manufacturer's Instructions														
			Sealers	2.4.3.1													
			Joint Sealants	2.4.5													
			Curing Compound	2.4.1													
		04 20 00	SD-02 Shop Drawings														
			Detail Drawings	3.4.1.1	G												
			SD-03 Product Data														
			Hot Weather Procedures	1.5.1	G												
			Cold Weather Procedures	1.5.2	G												
			Cement	2.2.2.2.1	G												
			Cementitious Materials	2.4.1.1	G												
			Insulation	2.6.7	G												
			SD-05 Design Data														
			Masonry Compressive Strength	2.1.2	G												
			Fire-Rated Concrete Masonry	2.2.2.4													
			Units														
			SD-06 Test Reports														

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		04 20 00	Fire-Rated Concrete Masonry Units	2.2.2.4													
			SD-07 Certificates														
			Concrete Masonry Units (CMU)	2.2.2.2													
			Admixtures for Masonry Mortar	2.4.1.3													
			Admixtures for Grout	2.4.2.2													
			Anchors, Ties, and Bar Positioners	2.6.2													
			Joint Reinforcement	2.6.3													
			Insulation	2.6.7													
			SD-08 Manufacturer's Instructions														
			Admixtures for Masonry Mortar	2.4.1.3													
			Admixtures for Grout	2.4.2.2													
			SD-10 Operation and Maintenance Data														
			Take-Back Program	3.7													
		05 05 20	SD-01 Preconstruction Submittals														
			Installer Qualifications	1.5.1.1	G												
			Post-Installed Anchor Special Inspector Qualifications	1.5.1.2	G												
			SD-03 Product Data														
			Mechanical Anchors in Concrete	2.1.1.3	G												
			Adhesive Anchor System in Concrete	2.1.1.4	G												
			Mechanical and Adhesive Anchors in Masonry	2.1.1.5	G												

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		05 05 20	Non-Shrink, Non-Metallic Grout	3.1.3	G												
			SD-06 Test Reports														
			Post-Installed Anchor Special	3.3.4	G												
			Inspections Report														
			SD-07 Certificates														
			Post-Installed Anchor	2.1.1.1	G												
			Certification														
			SD-08 Manufacturer's Instructions														
			Manufacturer's Printed	2.1.1.2	G												
			Installation Instructions														
			Non-Shrink, Non-Metallic Grout	3.1.3	G												
			Manufacturer's Safety Data	1.5													
			Sheets														
		05 05 23.16	SD-01 Preconstruction Submittals														
			Welding Quality Assurance Plan	3.2	G												
			SD-03 Product Data														
			Welding Procedure Qualifications	1.3	G												
			Welder, Welding Operator, and	1.3.4													
			Tacker Qualification														
			Previous Qualifications	1.3.2													
			Pre-Qualified Procedures	1.3.3	G												
			Welding Electrodes and Rods	2.2													
			SD-06 Test Reports														
			Nondestructive Testing	3.3													
			Weld Inspection Log	3.2													
			SD-07 Certificates														

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		05 05 23.16	Certified Welding Inspector	1.3.5													
			Nondestructive Testing Personnel	1.3.5													
		05 12 00	SD-01 Preconstruction Submittals														
			Erection and Erection Bracing	1.5.1.1	G												
			Drawings														
			SD-02 Shop Drawings														
			Fabrication Drawings	1.5.2	G												
			SD-03 Product Data														
			Welding Electrodes and Rods	2.4.1													
			Direct Tension Indicator Washers	2.3.1.3													
			Non-Shrink Grout	2.4.2													
			Tension Control Bolts	2.3.2													
			SD-05 Design Data														
			Shoring and Temporary Bracing	1.5.2	G												
			SD-06 Test Reports														
			Weld Inspection Reports	3.7.1.2													
			Bolt Testing Reports	3.7.2.1													
			SD-07 Certificates														
			MLIT Structural Steel Fabricator	1.3													
			Quality Certification														
			MLIT Structural Steel Erector	1.3													
			Quality Certification														
			Welding Procedure Specifications	3.4													
			(WPS)														
		05 21 00	SD-01 Preconstruction Submittals														
			Welder Qualification	1.3.2													

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		05 21 00	SD-02 Shop Drawings														
			Steel Joist Framing	1.3.1	G												
			SD-05 Design Data														
			Design Calculations	2.2	G												
			SD-06 Test Reports														
			Erection Inspection	3.4													
			Welding Inspections	3.4													
			SD-07 Certificates														
			Certification of Compliance	1.3.2													
		05 30 00	SD-02 Shop Drawings														
			Fabrication Drawings	1.3.4	G												
			SD-03 Product Data														
			Accessories	2.2													
			Deck Units	2.1													
			Galvanizing Repair Paint	2.1.3													
			Mechanical Fasteners	2.2.14													
			Touch-Up Paint	2.1.3													
			SD-05 Design Data														
			Deck Units	2.1	G												
			SD-07 Certificates														
			Powder-Actuated Tool Operator	1.3.2													
			Wind Storm Resistance	1.3.3.1													
			Manufacturer's Certificate	1.3.1													
		05 50 13	SD-02 Shop Drawings														
			Angles and Plates	2.3	G												
			SD-07 Certificates														

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		05 50 13	Certified Mill	2.1	G												
		05 51 00	SD-02 Shop Drawings														
			Iron and Steel Hardware	2.1	G												
			Steel Shapes, Plates, Bars, and Strips	2.1	G												
			Metal Stair System	2.2.1	G												
			SD-03 Product Data														
			Structural Steel Plates, Shapes, and Bars	2.4.1	G												
			Structural Steel Tubing	2.4.2	G												
			Hot-Rolled Carbon Steel Sheets and Strips	2.4.5	G												
			Cold-Finished Steel Bars	2.4.4	G												
			Hot-Rolled Carbon Steel Bars	2.4.3	G												
			Cold-Rolled Carbon Steel Sheets	2.4.6	G												
			Protective Coating	2.2.3	G												
			Steel Stairs	2.3.1	G												
			SD-07 Certificates														
			Welder Qualification	1.3.1	G												
			SD-08 Manufacturer's Instructions														
			Protective Coating	2.2.3	G												
		05 52 00	SD-02 Shop Drawings														
			Fabrication Drawings	1.2.1	G												
			Iron and Steel Hardware	3.2													
			Steel Shapes, Plates, Bars and Strips	3.2													

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		05 52 00	SD-07 Certificates														
			Welder Qualification	1.4.2	G												
			SD-08 Manufacturer's Instructions														
			Installation Instructions	3.2													
		06 10 00	SD-02 Shop Drawings														
			Modifications of Structural	1.9.1	G												
			Members														
			SD-03 Product Data														
			Plastic Lumber	2.1.1													
			Fire-retardant Treatment	1.8													
			Adhesives	2.4.3													
			SD-06 Test Reports														
			Preservative-treated	1.4.2													
			SD-07 Certificates														
			Certificates of Grade	1.11.1													
			Preservative Treatment	1.7													
			SD-10 Operation and Maintenance														
			Data														
			Take-back Program	3.3													
		07 21 13	SD-03 Product Data														
			Manufacturer's Standard Details	1.3	G												
			Block or Board Insulation	2.1	G												
			Vapor Retarder	2.2	G												
			Pressure Sensitive Tape	2.3	G												
			Protection Board or Coatings	1.4	G												
			Accessories	2.5	G												

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		07 21 13	Recycled Content for Block or Board Insulation	2.1.4	S												
			SD-07 Certificates														
			Block or Board Insulation	2.1	G												
			Vapor Retarder	2.2	G												
			Protection Board or Coating	2.4	G												
			Special Warranties	1.8	G												
			Special Warranties	1.8	G												
			Indoor Air Quality For Block Or Board Insulation	2.1.5	S												
			SD-08 Manufacturer's Instructions														
			Block or Board Insulation	2.1													
			Adhesive	2.5.1													
		07 21 16	SD-03 Product Data														
			Blanket Insulation	2.1	G												
			Recycled Content for Insulation Materials	2.1.2	S												
			Accessories	2.3													
			SD-07 Certificates														
			Indoor Air Quality for Insulation Materials	2.1.4	S												
			SD-08 Manufacturer's Instructions														
			Insulation	3.3.1													
		07 22 00	SD-02 Shop Drawings														
			Insulation Board Layout	1.3	G												
			Verification of Existing Conditions	1.3	G												

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		07 22 00	SD-03 Product Data														
			Insulation	2.1	G												
			Cover Board	1.4	G												
			Fasteners	2.3	G												
			Recycled Content For Insulation	2.1.2	S												
			SD-07 Certificates														
			Installer Qualifications	1.6	G												
			Indoor Air Quality For Insulation	2.1.3	S												
			SD-08 Manufacturer's Instructions														
			Insulation	2.1	G												
		07 27 19.01	SD-01 Preconstruction Submittals														
			Qualifications of Manufacturer	1.7.1	G												
			Qualifications of Installer	1.7.2	G												
			SD-02 Shop Drawings														
			Self-adhering Air Barrier	1.4	G												
			SD-03 Product Data														
			Self-adhering Air Barrier	1.4	G												
			Primers, Adhesives, and Mastics	2.2	G												
			Safety Data Sheets	1.4.2	G												
			SD-04 Samples														
			Self-adhering Air Barrier	1.4	G												
			SD-06 Test Reports														
			Field Peel Adhesion Test	1.6	G												
			Flame Propagation of Wall Assemblies	1.4.4	G												

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		07 27 19.01	Flame Spread and Smoke Developed Index Ratings	1.4.4	G												
			Site Inspections and Testing	3.4.1	G												
			SD-07 Certificates														
			Self-adhering Air Barrier	1.4	G												
			SD-08 Manufacturer's Instructions														
			Self-adhering Air Barrier	1.4	G												
			Primers, Adhesives, and Mastics	2.2	G												
		07 27 26	SD-01 Preconstruction Submittals														
			Qualifications of Manufacturer	1.8.1	G												
			Qualifications of Installer	1.8.2	G												
			SD-02 Shop Drawings														
			Fluid-Applied Membrane Air Barrier	1.4	G												
			SD-03 Product Data														
			Fluid-Applied Membrane Air Barrier	1.4	G												
			Transition Membrane	2.3	G												
			Primers, Adhesives, and Mastics	2.2	G												
			Reinforcement	2.6	G												
			Safety Data Sheets	1.4.2	G												
			SD-04 Samples														
			Mockup	1.4.3	G												
			SD-06 Test Reports														
			Capillary Moisture Test	1.6	G												
			Field Peel Adhesion Test	1.4.4	G												

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		07 27 26	Flame Propagation of Wall Assemblies	1.4.4	G												
			Flame Spread and Smoke Developed Index Ratings	1.4.4	G												
			Site Inspections	3.4.1	G												
			SD-07 Certificates														
			Fluid-Applied Membrane Air Barrier	1.4	G												
			Transition Membrane	2.3	G												
			SD-08 Manufacturer's Instructions														
			Fluid-Applied Membrane Air Barrier	1.4	G												
			Transition Membrane	2.3	G												
			Primers, Adhesives, and Mastics	2.2	G												
		07 54 23	SD-02 Shop Drawings														
			Detail Drawings	1.6	G												
			Roof Plan	1.6	G												
			SD-03 Product Data														
			TPO Roofing Membrane	3.2.2	G												
			Bonding Adhesive	2.1.2													
			Flashing	1.5.4													
			Flashing	3.2.2.2													
			Membrane Fasteners and Plates	2.1.5													
			Roof Insulation	2.1.7													
			Pre-Manufactured Accessories	2.1.6													
			Water Cutoffs	3.5.1													

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		07 54 23	Information Card	2.1.1													
			SD-05 Design Data														
			Wind Uplift Resistance	1.3.2	G												
			SD-07 Certificates														
			Qualification of Manufacturer	1.5.1													
			Qualifications of Applicator	1.5.2													
			Qualification of Engineer of	1.5.3													
			Record														
			Wind Uplift Resistance	1.3.2													
			Fire Resistance	1.3.1													
			Minimum Polymer Thickness	2.1.1													
			Minimum Polymer Thickness	2.1.4													
			Sample	1.10	G												
			SD-08 Manufacturer's Instructions														
			Application Method	3.2	G												
			Membrane Flashing	2.1.4	G												
			Membrane Flashing	3.3.2	G												
			Perimeter Attachment	3.2.4													
			Auxiliary Fasteners	2.1.5.2													
			Pre-Manufactured Accessories	2.1.6													
			Cold Weather	1.8	G												
			SD-11 Closeout Submittals														
			Warranty	1.10	G												
			Information Card	2.1.1	G												
			Instructions to Government	3.8	G												
			Personnel														

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		07 60 00	SD-02 Shop Drawings														
			Exposed Sheet Metal	2.2.1	G												
			Base Flashing	3.1.9	G												
			Counterflashing	3.1.10	G												
			Reglets	2.2.8	G												
			Flashing at Roof Penetrations and Equipment Supports	3.1.15	G												
			Recycled Content	2.1	S												
			SD-04 Samples														
			Finish Samples	1.4.2	G												
			SD-08 Manufacturer's Instructions														
			Instructions for Installation	1.4.3	G												
			SD-10 Operation and Maintenance Data														
			Cleaning and Maintenance	1.4.3	G												
		07 84 00	SD-02 Shop Drawings														
			Firestopping System	2.1	G												
			SD-03 Product Data														
			Firestopping Materials	2.2	G												
			SD-06 Test Reports														
			Inspection	3.3	G												
			SD-07 Certificates														
			Inspector Qualifications	1.5.2													
			Firestopping Materials	2.2													
			Installer Qualifications	1.5.1	G												
		07 92 00	SD-03 Product Data														

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		07 92 00	Sealants	2.1	G												
			Primers	2.2	G												
			Bond Breakers	2.3	G												
			Field Adhesion	3.1	G												
			SD-07 Certificates														
			Indoor Air Quality For Interior Sealants	2.1.1	S												
			Indoor Air Quality For Interior Floor Joint Sealants	2.1.3	S												
			Indoor Air Quality For Interior Acoustical Sealants	2.1.4	S												
		08 11 13	SD-02 Shop Drawings														
			Doors	2.1	G												
			Doors	2.1	G												
			Frames	2.5	G												
			Frames	2.5	G												
			Accessories	2.3													
			SD-03 Product Data														
			Doors	2.1	G												
			Recycled Content for Steel Door Product	2.1	S												
			Frames	2.5	G												
			Recycled Content for Steel Frame Product	2.5	S												
			Accessories	2.3													
		08 31 00	SD-02 Shop Drawings														

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		08 31 00	Access Doors And Panels	1.3													
			SD-03 Product Data														
			Access Doors And Panels	1.3													
			Hardware	1.3.1													
			Accessories	2.2.8													
			Recycled Content	2.1	S												
			SD-04 Samples														
			Finishes	2.5													
			SD-06 Test Reports														
			Acoustical Ratings of Assemblies	1.3.1	G												
		08 71 00	SD-02 Shop Drawings														
			Manufacturer's Detail Drawings	1.3	G												
			Verification of Existing Conditions	1.3	G												
			Hardware Schedule	1.5	G												
			Keying System	2.3.11	G												
			SD-03 Product Data														
			Hardware Items	2.3	G												
			SD-08 Manufacturer's Instructions														
			Installation	3.1													
			SD-10 Operation and Maintenance Data														
			Hardware Schedule	1.5	G												
			SD-11 Closeout Submittals														
			Key Bitting	1.6.1													
		08 91 00	SD-02 Shop Drawings														
			Wall Louvers	1.4													

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		08 91 00	SD-03 Product Data														
			Metal Wall Louvers	2.2													
			SD-04 Samples														
			Wall Louver Samples	1.5	G												
		09 22 00	SD-02 Shop Drawings														
			Metal Support Systems	2.1	G												
			SD-03 Product Data														
			Metal Support Systems	2.1													
			Recycled Content for Metal	2.1	S												
			Support Systems														
		09 24 23	SD-02 Shop Drawings														
			Lath	3.4													
			SD-03 Product Data														
			Proportions and Mixing	3.7													
			Recycled percentage of fly ash in	2.1	S												
			Portland cement														
			Recycled Content for steel	2.6	S												
			framing														
			Recycled Content for metal lath	2.7	S												
			SD-04 Samples														
			Colored Stucco Finish Coat	2.2													
			Sample Panel	1.3	G												
		09 29 00	SD-03 Product Data														
			Cementitious Backer Units	2.1.3													
			Abuse Resistant Gypsum Board	2.1.2													
			Accessories	2.1.8													

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		09 29 00	Gypsum Board	2.1.1													
			Recycled Content for Gypsum Board	2.1.1	S												
			VOC Content of Joint Compound	2.1.4	S												
			SD-06 Test Reports														
			ASTM E90 Factory Test Report	3.7	G												
			ASTM E90 Factory Test Report	3.9	G												
			ASTM E336 Field Test Report	3.9	G												
			SD-07 Certificates														
			Asbestos Free Materials	2.1	G												
			Indoor Air Quality for Gypsum Board	2.1.1	S												
			Indoor Air Quality for Non-aerosol Adhesives	2.1.6	S												
			Indoor Air Quality for Aerosol Adhesives	2.1.6	S												
			SD-08 Manufacturer's Instructions														
			Safety Data Sheets	2.1													
			SD-10 Operation and Maintenance Data														
			Manufacturer Maintenance Instructions	2.1													
		09 51 00	SD-03 Product Data														
			Recycled Content for Suspension Systems	2.2	S												
			Acoustical Performance	2.1.1	G												

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		09 51 00	SD-04 Samples														
			Acoustical Ceiling Tiles	1.3.1.1	G												
			SD-07 Certificates														
			Indoor Air Quality for Adhesives	2.5	S												
			Indoor Air Quality for Sealants	2.8	S												
		09 90 00	SD-02 Shop Drawings														
			Piping Identification	3.10													
			SD-03 Product Data														
			Coating	2.1	G												
			Product Data Sheets	2.1													
			Sealant	3.2.4													
			SD-04 Samples														
			Color	2.2	G												
			SD-07 Certificates														
			Qualification Testing	1.6.6.2	G												
			SD-08 Manufacturer's Instructions														
			Mixing	2.1													
			Manufacturer's Safety Data	1.8.1													
			Sheets														
			SD-10 Operation and Maintenance														
			Data														
			Coatings	2.1	G												
		10 14 00.20	SD-02 Shop Drawings														
			Detail Drawings	1.3.2	G												
			SD-03 Product Data														

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		10 14 00.20	Room Identification And Directional Signage System	2.1	G												
			Exit Door Tactile Sign	2.2	G												
			SD-04 Samples														
			Interior Signage	1.3.1	G												
			Room Identification And Directional Signage System	2.1	G												
			Exit Door Tactile Sign	2.2	G												
			SD-10 Operation and Maintenance Data														
			Approved Manufacturer's Instructions	3.1	G												
			Protection and Cleaning	3.1.2	G												
		10 44 16	SD-02 Shop Drawings														
			Fire Extinguishers	2.1.1	G												
			Accessories	Part 2	G												
			Schedule	1.5	G												
			SD-03 Product Data														
			Fire Extinguishers	2.1.1	G												
			Accessories	Part 2	G												
			Replacement Parts List	3.2.1	G												
			SD-07 Certificates														
			Fire Extinguishers Certifications	2.1.1	G												
			Manufacturer's Warranty with Inspection Tag	1.4	G												
		21 13 13	SD-01 Preconstruction Submittals														

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		21 13 13	Qualified Fire Protection Engineer (QFPE)	1.2.3	G												
			Sprinkler System Designer	1.4.2.1	G												
			Sprinkler System Installer	1.4.2.2	G												
			SD-02 Shop Drawings														
			Shop Drawing	1.2.1.1	G												
			SD-03 Product Data														
			Pipe	2.2.1.1	G												
			Fittings	2.2.1.2	G												
			Sprinklers	2.3	G												
			Pipe Hangers and Supports	2.2.3	G												
			Seismic Bracing	2.2.3	G												
			SD-05 Design Data														
			Seismic Bracing	2.2.3	G												
			Hydraulic Calculations	1.2.1.2	G												
			SD-06 Test Reports														
			Test Procedures	3.5.1	G												
			SD-07 Certificates														
			Verification of Compliant Installation	3.5.2.1	G												
			Request for Government Final Test	3.5.2.2	G												
			SD-10 Operation and Maintenance Data														
			Operating and Maintenance (O&M) Instructions	3.7	G												

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		21 13 13	Spare Parts	1.6	G												
			SD-11 Closeout Submittals														
			As-built drawings	3.7													
		22 00 00	SD-02 Shop Drawings														
			Plumbing System	3.5.1	G												
			SD-03 Product Data														
			Recycled Content for Cast Iron	2.1	S												
			Pipe														
			SD-06 Test Reports														
			Tests	3.5													
			SD-07 Certificates														
			Materials and Equipment	1.3													
			Bolts	2.1.1													
			SD-10 Operation and Maintenance														
			Data														
			Plumbing System	3.5.1	G												
		23 05 15	SD-01 Preconstruction Submittals														
			Material, Equipment, and Fixture	1.2													
			Lists														
			SD-02 Shop Drawings														
			Record Drawings	1.2													
			Connection Diagrams	1.2													
			Coordination Drawings	1.2													
			Fabrication Drawings	1.2													
			Installation Drawings	3.1													
			SD-03 Product Data														

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		23 05 15	Pipe and Fittings	2.1													
			Piping Specialties	2.2													
			Valves	2.3													
			Miscellaneous Materials	2.4													
			Supporting Elements	2.5													
			Equipment Foundation Data	1.2													
			SD-04 Samples														
			Manufacturer's Standard Color Charts	1.2													
			SD-05 Design Data														
			Pipe and Fittings	2.1													
			Piping Specialties	2.2													
			Valves	2.3													
			SD-06 Test Reports														
			Hydrostatic Tests	3.1													
			Air Tests	3.1													
			Valve-Operating Tests	3.1													
			Drainage Tests	3.1													
			Pneumatic Tests	3.1													
			Non-Destructive Electric Tests	3.1													
			System Operation Tests	3.1													
			SD-07 Certificates														
			Record of Satisfactory Field Operation	1.4.2													
			List of Qualified Permanent Service Organizations	1.4.3													

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		23 05 15	Listing of Product Installations	1.2													
			Records of Existing Conditions	1.2													
			Surface Resistance	3.1													
			Shear and Tensile Strengths	3.1													
			Temperature Ratings	3.1													
			Bending Tests	3.1													
			Flattening Tests	3.1													
			Transverse Guided Weld Bend Tests	3.1													
			SD-10 Operation and Maintenance Data														
			Operation and Maintenance Manuals	3.11													
		23 05 93	SD-01 Preconstruction Submittals														
			Records of Existing Conditions	1.3.3	G												
			TAB Firm	1.5.3.1	G												
			TAB Team Assistants	1.2	G												
			TAB Team Engineer	1.2	G												
			TAB Specialist	1.5.3.2	G												
			TAB Team Field Leader	1.2	G												
			SD-02 Shop Drawings														
			TAB Schematic Drawings and Report Forms	1.3.3	G												
			SD-03 Product Data														
			Equipment and Performance Data	1.3	G												

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						SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	ACTION CODE	DATE OF ACTION		DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION		
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 05 93	TAB Related HVAC Submittals	1.5.3.4	G												
			TAB Procedures	1.5.2	G												
			Calibration	1.5.2	G												
			Systems Readiness Check	1.3.3	G												
			TAB Execution	1.5.4	G												
			TAB Verification	1.5.4.3	G												
			SD-06 Test Reports														
			Completed Pre-Final DALT Report	3.3.5	G												
			Certified Final DALT Report	3.3.8	G												
			TAB Design Review Report	1.6.2.1	G												
			TAB Report for Season 1	1.5.5.2	G												
			TAB Report for Season 2	1.5.5.2	G												
			SD-07 Certificates														
			Independent TAB Agency and Personnel Qualifications	1.5.1	G												
			DALT and TAB Submittal and Work Schedule	1.6.2	G												
			TAB Pre-Field Engineering Report	1.6.2.3	G												
			TAB Firm	1.5.3.1	G												
			Design Review Report	1.3.3	G												
			Pre-field DALT Preliminary Notification	1.6.2.2	G												
			Advanced Notice for Season 1 TAB Field Work	1.6.2	G												

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		23 05 93	Prerequisite HVAC Work Check Out List For Season 1	1.6.2	G												
			Advanced Notice for Season 2 TAB Field Work	1.6.2	G												
			Prerequisite HVAC Work Check Out List For Season 2	1.6.2	G												
		23 07 00	SD-02 Shop Drawings														
			MICA Plates	3.2.2.4	G												
			Pipe Insulation Systems	2.3													
			Pipe Insulation Systems	3.2													
			Duct Insulation Systems	3.3													
			Equipment Insulation Systems	3.4													
			Recycled content for insulation materials	2.3.1	S												
			SD-03 Product Data														
			Pipe Insulation Systems	2.3	G												
			Pipe Insulation Systems	3.2	G												
			Duct Insulation Systems	3.3	G												
			Equipment Insulation Systems	3.4	G												
			SD-04 Samples														
			Thermal Insulation	2.2.1.3	G												
			SD-07 Certificates														
			Indoor air quality for adhesives	2.2.1	S												
			SD-08 Manufacturer's Instructions														
			Pipe Insulation Systems	2.3	G												
			Pipe Insulation Systems	3.2	G												

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 07 00	Duct Insulation Systems	3.3	G												
			Equipment Insulation Systems	3.4	G												
		23 09 00	SD-02 Shop Drawings														
			DDC Contractor Design Drawings	3.3	G												
			Draft As-Built Drawings	3.3	G												
			Final As-Built Drawings	3.3	G												
			SD-03 Product Data														
			Programming Software	1.8.3	G												
			Controller Application Programs	1.8.4	G												
			Configuration Software	1.8.1	G												
			Controller Configuration Settings	1.8.2	G												
			Proprietary Multi-Split	1.1.1.3	G												
			Engineering Tool Software														
			Manufacturer's Product Data	2.2	G												
			SD-05 Design Data														
			Boiler Or Chiller Plant Gateway Request	1.9													
			SD-06 Test Reports														
			Existing Conditions Report	3.1.1													
			Pre-Construction Quality Control (QC) Checklist	1.10.1	G												
			Post-Construction Quality Control (QC) Checklist	1.10.2	G												
			Start-Up Testing Report	3.5.2	G												
			PVT Procedures	3.6.1	G												
			PVT Report	3.6.3	G												

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						SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	ACTION CODE	DATE OF ACTION	DATE RCD FROM CONTR	DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION		
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 09 00	SD-10 Operation and Maintenance Data														
			Operation and Maintenance (O&M) Instructions	3.7	G												
			Training Documentation	3.8.1	G												
			SD-11 Closeout Submittals														
			Enclosure Keys	2.5	G												
			Password Summary Report	3.2.6.1	G												
			Closeout Quality Control (QC) Checklist	1.10.3	G												
		23 11 20	SD-02 Shop Drawings														
			Gas Piping System	1.5.3	G												
			Gas Piping System	2.2	G												
			Gas Piping System	3.3	G												
			SD-03 Product Data														
			Pipe and Fittings	1.6.1	G												
			Gas Equipment Connectors	1.5.3	G												
			Gas Piping System	1.5.3	G												
			Gas Piping System	2.2	G												
			Gas Piping System	3.3	G												
			Pipe Coating Materials	2.1	G												
			Pressure Regulators	2.6	G												
			Risers	2.4	G												
			Transition Fittings	2.2.9	G												
			Valves	2.3	G												
			Warning and Identification Tape	2.2.5	G												

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 11 20	SD-06 Test Reports														
			Testing	3.18	G												
			Pressure Tests	3.18.1	G												
			Test with Gas	3.18.2	G												
			SD-07 Certificates														
			Welders Procedures and	1.5.1	G												
			Qualifications														
			Assigned Number, Letter, or	1.5.1	G												
			Symbol														
			SD-08 Manufacturer's Instructions														
			PE Pipe and Fittings	1.5.2	G												
			Pipe Coating Materials	2.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Gas Facility System and	1.3.1	G												
			Equipment Operation														
			Gas Facility System Maintenance	1.3.2	G												
			Gas Facility Equipment	1.3.3	G												
			Maintenance														
		23 21 23	SD-02 Shop Drawings														
			System Coordination	2.1.2	G												
			SD-03 Product Data														
			Instructions	2.2.2	G												
			Equipment Data	2.2.5	G												
			Training Period	3.5.2	G												
			SD-06 Test Reports														

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 21 23	Factory Tests	2.8													
			Field Quality Control	3.3													
			SD-07 Certificates														
			Manufacturer's Representative	1.3.1													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.5.1	G												
			Manuals														
			Training	3.5.2	G												
		23 23 00	SD-02 Shop Drawings														
			Refrigerant Piping System	2.3	G												
			SD-03 Product Data														
			Refrigerant Piping System	2.3													
			Spare Parts	1.5.2													
			Qualifications	1.3.1													
			Refrigerant Piping Tests	3.5													
			Verification of Dimensions	3.1													
			SD-06 Test Reports														
			Refrigerant Piping Tests	3.5													
			SD-07 Certificates														
			Service Organization	2.1													
			SD-10 Operation and Maintenance														
			Data														
			Maintenance	1.5	G												
			Operation and Maintenance	3.4	G												
			Manuals														

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 23 00	Demonstrations	3.4	G												
		23 25 00	SD-03 Product Data														
			Water Treatment System	2.3.1.4.1	G												
			Spare Parts	1.3													
			Field Instructions	3.4.1													
			Tests	3.3.1	G												
			Training Course	3.4.1	G												
			SD-06 Test Reports														
			Condenser Water QA Tests	3.3.5.1													
			SD-10 Operation and Maintenance Data														
			Water Treatment System	2.3.1.4.1													
		23 30 00	SD-02 Shop Drawings														
			Detail Drawings	1.4.4	G												
			SD-03 Product Data														
			Insulated Nonmetallic Flexible Duct Runouts	2.8.1.1													
			Duct Connectors	2.8.1.1													
			Duct Access Doors	2.8.2	G												
			Fire Dampers	2.8.3													
			Manual Balancing Dampers	2.8.4	G												
			Diffusers	2.8.7.1													
			Registers and Grilles	2.8.7.2													
			Louvers	2.8.8													
			In-Line Centrifugal Fans	2.9.1.1													

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 30 00	Centrifugal Type Power Roof Ventilators	2.9.1.2													
			Air Handling Units	2.10	G												
			Variable Volume, Single Duct Terminal Units	2.11.1.1	G												
			Reheat Units	2.11.1.2	G												
			Test Procedures	1.4.5													
			Diagrams	1.2.1.2	G												
			Indoor Air Quality for Duct Sealants	2.8.1	S												
			SD-06 Test Reports														
			Performance Tests	3.10	G												
			SD-07 Certificates														
			Ozone Depleting Substances Technician Certification	1.4.3													
			SD-08 Manufacturer's Instructions														
			Manufacturer's Installation Instructions	3.2													
			Operation and Maintenance Training	3.12.2													
			SD-10 Operation and Maintenance Data														
			Operation and Maintenance Manuals	3.12.1	G												
			Fire Dampers	2.8.3	G												
			Manual Balancing Dampers	2.8.4	G												

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 30 00	In-Line Centrifugal Fans	2.9.1.1	G												
			Centrifugal Type Power Roof Ventilators	2.9.1.2	G												
			Air Handling Units	2.10	G												
			Variable Volume, Single Duct Terminal Units	2.11.1.1	G												
			Reheat Units	2.11.1.2	G												
			SD-11 Closeout Submittals														
			Indoor Air Quality During Construction	3.11	S												
		23 52 00	SD-02 Shop Drawings														
			Detail Drawings	1.5													
			SD-03 Product Data														
			Materials and Equipment	2.1.1													
			Spare Parts	1.5													
			Water Treatment System	2.11													
			Boiler Water Treatment	2.11													
			Fuel System Tests	3.10													
			Welding	1.3													
			Field Instructions	3.9													
			Tests	3.4													
			SD-06 Test Reports														
			Fuel System Tests	3.10													
			SD-10 Operation and Maintenance Data														

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 52 00	Operation and Maintenance Instructions	3.9	G												
		23 64 10	SD-03 Product Data														
			Water Chiller	2.4	G												
			Verification of Dimensions	1.6.1													
			System Performance Tests	3.5													
			Demonstrations	3.6													
			Refrigerant	2.5.1													
			Water Chiller - Field Acceptance Test Plan	3.4.1													
			SD-06 Test Reports														
			Field Acceptance Testing	3.4													
			Water Chiller - Field Acceptance Test Report	3.4.2													
			System Performance Tests	3.5													
			SD-07 Certificates														
			Refrigeration System	3.1.8	G												
			Ozone Depleting Substances Technician Certification	1.3.1													
			SD-08 Manufacturer's Instructions														
			Water Chiller - Installation Instructions	3.1	G												
			SD-10 Operation and Maintenance Data														
			Operation and Maintenance Manuals	3.6	G												

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 64 10	SD-11 Closeout Submittals														
			Indoor Air Quality During Construction	3.3	S												
		23 64 26	SD-03 Product Data														
			Grooved Mechanical Connections For Steel	2.2.2.4	G												
			Grooved Mechanical Connections For Copper	2.6.3	G												
			Calibrated Balancing Valves	2.7.8	G												
			Automatic Flow Control Valves	2.7.9	G												
			Pump Discharge Valve	2.7.10													
			Water Temperature Mixing Valve	2.7.11	G												
			Water Temperature Regulating Valves	2.7.12	G												
			Water Pressure Reducing Valve	2.7.13													
			Pressure Relief Valve	2.7.14													
			Combination Pressure and Temperature Relief Valves	2.7.15													
			Expansion Joints	2.8.9	G												
			Pumps	2.9	G												
			Combination Strainer and Pump Suction Diffuser	2.8.3													
			Expansion Tanks	2.10													
			Air Separator Tanks	2.11													
			Water Treatment Systems	2.12	G												
			SD-06 Test Reports														

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		23 64 26	Piping Welds NDE Report	3.1.1.3													
			Pressure Tests Reports	3.5.2	G												
			Condenser Water Quality Test Reports	3.5.3	G												
			Condenser Water Quality Test Reports	3.5.3	G												
			One-Year Inspection Report For Cooling Water	3.7	G												
			SD-07 Certificates														
			Employer's Record Documents (For Welding)	3.1.1.1													
			Welding Procedures and Qualifications	3.1.1.2													
			Piping for Steam and Condensate	2.4													
			Piping for High-Pressure Compressed-Air Systems	2.5													
			Fittings	2.4													
			Fittings	2.5													
			Unions	2.4													
			Unions	2.5													
			Flanges	2.4													
			Flanges	2.5													
			Gaskets	2.4													
			Gaskets	2.5													
			Bolting	2.4													
			Bolting	2.5													

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 64 26	SD-08 Manufacturer's Instructions														
			Lesson plan for the Instruction	3.6	G												
			Course														
			SD-10 Operation and Maintenance														
			Data														
			Water Treatment Systems	2.12	G												
			Calibrated Balancing Valves	2.7.8	G												
			Automatic Flow Control Valves	2.7.9	G												
			Pump Discharge Valve	2.7.10	G												
			Water Temperature Mixing Valve	2.7.11	G												
			Water Temperature Regulating	2.7.12	G												
			Valves														
			Water Pressure Reducing Valve	2.7.13	G												
			Pressure Relief Valve	2.7.14	G												
			Combination Pressure and	2.7.15	G												
			Temperature Relief Valves														
			Expansion Joints	2.8.9	G												
			Pumps	2.9	G												
			Combination Strainer and Pump	2.8.3	G												
			Suction Diffuser														
			Expansion Tanks	2.10	G												
			Air Separator Tanks	2.11	G												
		23 65 00	SD-03 Product Data														
			Cooling Towers	2.5	G												
			Demonstrations	3.1	G												
			Verification of Dimensions	1.5.1	G												

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						SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	ACTION CODE	DATE OF ACTION	DATE RCD FROM CONTR	DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION		
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		23 65 00	Remote Evaporatively-Cooled Condensers	2.6													
			SD-06 Test Reports														
			Packaged Cooling Tower - Installation Instructions	3.2	G												
			Packaged Cooling Tower - Field Acceptance Test Plan	3.3.1	G												
			Packaged Cooling Tower - Field Acceptance Test Report	3.4	G												
			SD-07 Certificates														
			Service Organization	2.1													
			Cooling Tower	2.5.1.11													
			Remote Evaporatively-Cooled Condensers	2.6													
			SD-08 Manufacturer's Instructions														
			Packaged Cooling Tower - Installation Instructions	3.2													
			Remote Evaporatively-Cooled Condensers	2.6													
			SD-10 Operation and Maintenance Data														
			Operation and Maintenance Manuals	3.1													
			Remote Evaporatively-Cooled Condensers	2.6													
		23 81 00	SD-03 Product Data														

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		23 81 00	Training	3.4	G												
			Inventory	1.4													
			Supplied Products	2.1													
			Manufacturer's Standard Catalog	2.2													
			Data														
			SD-06 Test Reports														
			Refrigerant Tests, Charging, and	3.5	G												
			Start-Up														
			SD-07 Certificates														
			Service Organizations	3.6.1													
			SD-10 Operation and Maintenance														
			Data														
			Operation and Maintenance	3.4	G												
			Manuals														
			SD-11 Closeout Submittals														
			Ozone Depleting Substances	2.2.2.3	S												
		25 05 11.01	SD-01 Preconstruction Submittals														
			Wireless and Wired Broadcast	3.2.1.3	G												
			Communication Request														
			Device Account Lock Exception	3.3.2	G												
			Request														
			Multiple Ethernet Connection	3.2.3.2	G												
			Device Request														
			Contractor Computer	1.9.1.6	G												
			Cybersecurity Compliance														
			Statements														

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		25 05 11.01	Contractor Temporary Network Cybersecurity Compliance Statements	1.9.6	G												
			Cybersecurity Interconnection Schedule	1.7.2	G												
			Proposed STIG and SRG Applicability Report	1.7.1	G												
			SD-02 Shop Drawings														
			Network Communication Report	1.7.3	G												
			Cybersecurity Riser Diagram	1.7.6	G												
			SD-03 Product Data														
			Control System Cybersecurity Documentation	1.7.8	G												
			SD-06 Test Reports														
			Wireless Communication Test Report	3.2.1.4	G												
			Control System Cybersecurity Testing Procedures	3.14.1	G												
			Control System Cybersecurity Testing Report	3.14.3	G												
			SD-07 Certificates														
			Software Licenses	1.8	G												
			SD-11 Closeout Submittals														
			Password Change Summary Report	3.4.5.5	G												
			Enclosure Keys	3.3.5	G												

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		25 05 11.01	Software and Configuration Backups	1.7.5	G												
			Auditing Front End Software	3.5.3	G												
			Device Audit Record Upload Software	3.5.4.1	G												
			System Maintenance Tool Software	3.9	G												
			Control System Scanning Tools	3.11.2	G												
			STIG, SRG and Vendor Guide	1.7.7	G												
			Compliance Result Report														
			Control System Inventory Report	1.7.4	G												
		25 05 11.02	SD-01 Preconstruction Submittals														
			Device Account Lock Exception Request	3.3.2	G												
			Multiple Ethernet Connection Device Request	3.2.4.2	G												
			Contractor Computer Cybersecurity Compliance Statements	1.9.1.6	G												
			Contractor Temporary Network Cybersecurity Compliance Statements	1.9.6	G												
			Cybersecurity Interconnection Schedule	1.7.2	G												
			Proposed STIG and SRG Applicability Report	1.7.1	G												

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		25 05 11.02	SD-02 Shop Drawings														
			Network Communication Report	1.7.3	G												
			Cybersecurity Riser Diagram	1.7.6	G												
			SD-03 Product Data														
			Control System Cybersecurity	1.7.8	G												
			Documentation														
			SD-06 Test Reports														
			Control System Cybersecurity	3.14.1	G												
			Testing Procedures														
			Control System Cybersecurity	3.14.3	G												
			Testing Report														
			SD-07 Certificates														
			Software Licenses	1.8	G												
			SD-11 Closeout Submittals														
			Password Change Summary	3.4.4.5	G												
			Report														
			Enclosure Keys	3.3.7	G												
			Software and Configuration	1.7.5	G												
			Backups														
			Auditing Front End Software	3.5.3	G												
			Device Audit Record Upload	3.5.4.2	G												
			Software														
			System Maintenance Tool	3.9	G												
			Software														
			Control System Scanning Tools	3.11.1	G												

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		25 05 11.02	STIG, SRG and Vendor Guide	1.7.7	G												
			Compliance Result Report														
			Control System Inventory Report	1.7.4	G												
			Integrity Verification Software	3.13.1	G												
		25 10 10	SD-02 Shop Drawings														
			UMCS Contractor Design	3.3.2	G												
			Drawings														
			Draft As-Built Drawings	3.3.3	G												
			Final As-Built Drawings	3.3.3	G												
			SD-03 Product Data														
			Product Data Sheets	2.1.5	G												
			Computer Software	2.3	G												
			SD-05 Design Data														
			UMCS IP Network Bandwidth	3.3.1	G												
			Usage Estimate														
			SD-06 Test Reports														
			Pre-Construction QC Checklist	1.7	G												
			Post-Construction QC Checklist	1.7	G												
			Factory Test Procedures	3.1	G												
			Factory Test Report	3.1	G												
			Existing Conditions Report	3.2	G												
			Start-Up and Start-Up Testing	3.7	G												
			Report														
			PVT Phase I Procedures	3.8.1	G												
			PVT Phase I Report	3.8.2	G												
			PVT Phase II Report	3.8.3	G												

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		25 10 10	SD-10 Operation and Maintenance Data														
			Operation and Maintenance (O&M) Instructions	1.8	G												
			Preventive Maintenance Work Plan	3.9.7.1	G												
			Basic Training Documentation	3.10.1	G												
			Advanced Training Documentation	3.10.1	G												
			Refresher Training Documentation	3.10.1	G												
			SD-11 Closeout Submittals														
			Closeout QC Checklist	1.7	G												
		26 20 00	SD-02 Shop Drawings														
			Panelboards	2.11	G												
			Transformers	2.13	G												
			Busway	3.1.5	G												
			Cable Trays	3.1.4.14	G												
			Motor Control Centers	2.17	G												
			Wireways	2.24	G												
			Marking Strips	3.1.11.1	G												
			SD-03 Product Data														
			Receptacles	2.10	G												
			Circuit Breakers	2.11.3	G												
			Switches	2.8	G												
			Transformers	2.13	G												

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		26 20 00	Enclosed Circuit Breakers	3.1.9	G												
			Motor Controllers	2.15	G												
			Combination Motor Controllers	2.17.2	G												
			Manual Motor Starters	2.16	G												
			Metering	2.11.5	G												
			Secondary Bonding Busbar	2.19.3	G												
			Surge Protective Devices	2.25	G												
			Cable Trays	3.1.4.14	G												
			SD-06 Test Reports														
			600-volt Wiring Test	3.5.2	G												
			Grounding System Test	3.5.6	G												
			Transformer Tests	3.5.3	G												
			Ground-fault Receptacle Test	3.5.4	G												
			Arc-fault Receptacle Test	3.5.5	G												
			SD-07 Certificates														
			Fuses	2.9	G												
			SD-09 Manufacturer's Field Reports														
			Transformer Factory Tests	2.27.1													
		26 27 13.10 30	SD-03 Product Data														
			Power Meters	2.1	G												
			Current	2.1.3	G												
			Potential Transformer	2.1.2	G												
			Communications Module	2.2.2	G												
			Protocol Modules	1.6.1	G												
			Data Recorder	1.6.2	G												

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		26 27 13.10 30	Modem	1.6.2	G												
			SD-06 Test Reports														
			Acceptance Checks and Tests	3.2.1	G												
			SD-10 Operation and Maintenance														
			Data														
			Power Meters	2.1	G												
			Communications Module	2.2.2	G												
			Protocol Modules	1.6.1	G												
			Data Recorder	1.6.2	G												
			Modem	1.6.2	G												
			SD-11 Closeout Submittals														
			System Function Verification	3.2.2	G												
		26 28 01.00 10	SD-03 Product Data														
			Fault Current Analysis	2.1													
			Protective Device Coordination	2.1													
			Study														
			System Coordinator	1.4.1													
		26 29 23	SD-02 Shop Drawings														
			Schematic Diagrams	1.5.1	G												
			Interconnecting Diagrams	1.5.2	G												
			Installation Drawings	1.5.3	G												
			As-Built Drawings	1.5.3	G												
			SD-03 Product Data														
			Adjustable Speed Drives	2.1	G												
			Wires and Cables	2.3													
			Equipment Schedule	1.5.4													

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		26 29 23	SD-06 Test Reports														
			ASD Test	3.3.1													
			Performance Verification Tests	3.3.2													
			Endurance Test	3.3.3													
			SD-08 Manufacturer's Instructions														
			Installation instructions	1.5.5													
			SD-09 Manufacturer's Field Reports														
			ASD Test Plan	2.5.1	G												
			Standard Products	1.5.6													
			SD-10 Operation and Maintenance Data														
			Adjustable Speed Drives	2.1													
		26 41 00	SD-02 Shop Drawings														
			Overall lightning protection system	1.4.1.1	G												
			Each major component	1.4.1.2	G												
			SD-06 Test Reports														
			Lightning Protection and Grounding System Test Plan	1.4.3	G												
			Lightning Protection and Grounding System Test	3.5.1	G												
			SD-07 Certificates														
			Lightning Protection System	1.2.3	G												
			Installers Documentation														

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		26 41 00	Component UL Listed and Labeled	1.4.2	G												
			Lightning protection system inspection certificate	1.4.4	G												
			Roof manufacturer's warranty	3.1.1	G												
		27 10 00	SD-02 Shop Drawings														
			Telecommunications Drawings	1.6.1.1	G												
			Telecommunications Space Drawings	1.10.1	G												
			SD-03 Product Data														
			Telecommunications Cabling	2.3	G												
			Patch Panels	2.4.3	G												
			Telecommunications Outlet/Connector Assemblies	2.5	G												
			Connector Blocks	2.4.1	G												
			Spare Parts	1.10.3	G												
			SD-06 Test Reports														
			Telecommunications Cabling Testing	3.5.1	G												
			SD-07 Certificates														
			Telecommunications Contractor	1.6.2.1	G												
			Key Personnel	1.6.2.2	G												
			Manufacturer Qualifications	1.6.2.3	G												
			Test Plan	1.6.3	G												
			SD-09 Manufacturer's Field Reports														

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		27 10 00	Factory Reel Tests	2.10.1	G												
			SD-10 Operation and Maintenance Data														
			Telecommunications Cabling and Pathway System	1.10.1	G												
			SD-11 Closeout Submittals														
			Record Documentation	1.10.2	G												
		28 31 76	SD-01 Preconstruction Submittals														
			Qualified Fire Protection Engineer (QFPE)	1.3.2	G												
			Fire alarm system designer	1.9.2.1	G												
			Supervisor	1.9.2.2	G												
			Technician	1.9.2.3	G												
			Installer	1.9.2.4	G												
			Test Technician	1.9.2.5	G												
			Fire Alarm System Site-Specific Software Acknowledgement	1.7	G												
			SD-02 Shop Drawings														
			Nameplates	1.9.1.3	G												
			Wiring Diagrams	1.9.1.4	G												
			System Layout	1.9.1.5	G												
			Initiating devices	1.9.1.6	G												
			Battery Power	1.9.1.7	G												
			Voltage Drop Calculations	1.9.1.8	G												
			SD-03 Product Data														
			Duct Smoke Detectors	2.3.1	G												

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(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		28 31 76	Carbon monoxide detector	2.4	G												
			Addressable Interface Devices	2.5	G												
			Addressable Control Modules	2.6	G												
			Surge Protective Devices	2.8	G												
			Alarm Wiring	2.8	G												
			Back Boxes and Conduit	3.3.3	G												
			Environmental Enclosures or Guards	2.10	G												
			SD-06 Test Reports														
			Test Procedures	3.6.1	G												
			SD-07 Certificates														
			Verification of Compliant Installation	3.6.2.1	G												
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SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
1220654

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH	GOVT CLASS / FIC / REVIEW / WORK	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION		DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	APPROVING AUTHORITY				MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
						SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	ACTION CODE	DATE OF ACTION		DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION		
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		31 00 00	Preconstruction Meeting	1.5.4	G												
			SD-06 Test Reports														
			Material Test Report	3.8													
			Pipe Inspection Report	3.5.1.7													
			Geotechnical Evaluation Report	1.5.1													
		32 16 19	SD-03 Product Data														
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			Biodegradable Form Release Agent	3.2													
			SD-06 Test Reports														
			Field Quality Control	3.8													
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			Aluminum Alloy Coating	1.3.1	G												
			Fabric	2.2.1	G												
			Stretcher Bars	2.2.6	G												

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CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH	GOVT CLASSIFICATION	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION		DATE FWD TO APPR AUTH/	APPROVING AUTHORITY				MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
						SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	ACTION CODE	DATE OF ACTION	DATE RCD FROM CONTR	DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION		
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		32 31 13	Concrete	2.4.2	G												
			SD-07 Certificates														
			Certificates of Compliance	1.3.1													
			SD-08 Manufacturer's Instructions														
			Fence Assembly	2.1													
			Gate Assembly	2.1													
			Hardware Assembly	2.1													
			Accessories	2.1													
		32 92 19	SD-03 Product Data														
			Wood Cellulose Fiber Mulch	2.5.3													
			Fertilizer	2.4													
			SD-06 Test Reports														
			Topsoil Composition Tests	2.2.3													
			SD-07 Certificates														
			Seed	2.1													
		33 30 00	SD-01 Preconstruction Submittals														
			Contractor's License	1.3.1	G												
			SD-02 Shop Drawings														
			Installation Drawings	3.1.1	G												
			SD-03 Product Data														
			Gravity Pipe	2.2.1													
			SD-06 Test Reports														
			Hydrostatic Sewer Test	3.3.1.1	G												
			Low-Pressure Air Tests	3.3.1.2.1	G												
			SD-07 Certificates														

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[illegible]

SECTION 01 42 00

SOURCES FOR REFERENCE PUBLICATIONS

PART 1 GENERAL

1.1 REFERENCES

Various publications are referenced in other sections of the specifications to establish requirements for the work. These references are identified in each section by document number, date and title. The document number used in the citation is the number assigned by the standards producing organization (e.g., ASTM B564 Standard Specification for Nickel Alloy Forgings). However, when the standards producing organization has not assigned a number to a document, an identifying number has been assigned for reference purposes.

1.2 ORDERING INFORMATION

The addresses of the standards publishing organizations whose documents are referenced in other sections of these specifications are listed below, and if the source of the publications is different from the address of the sponsoring organization, that information is also provided.

ACOUSTICAL SOCIETY OF AMERICA (ASA)
1305 Walt Whitman Road, Suite 300
Melville, NY 11747-4300
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AIR BARRIER ASSOCIATION OF AMERICA (ABAA)
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Internet: <https://www.airbarrier.org/>

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)
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Ph: 847-394-0150
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AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)
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Arlington, VA 22201
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ALUMINUM ASSOCIATION (AA)
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Internet: <https://www.aluminum.org/>

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)
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AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)
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AMERICAN CONCRETE INSTITUTE (ACI)
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AMERICAN FOREST FOUNDATION (AFF)
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Email: info@forestfoundation.org
Internet: <https://www.treefarmssystem.org>

AMERICAN GAS ASSOCIATION (AGA)
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AMERICAN HARDBOARD ASSOCIATION (AHA)
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AMERICAN IRON AND STEEL INSTITUTE (AISI)
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AMERICAN LUMBER STANDARDS COMMITTEE (ALSC)
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AMERICAN PETROLEUM INSTITUTE (API)
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Washington, DC 20005-4070
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AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION
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Internet: <https://www.arema.org>

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)
1801 Alexander Bell Drive
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Internet: <https://www.asce.org/>

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING
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AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)
Two Park Avenue
New York, NY 10016-5990
Ph: 800-843-2763
Fax: 973-882-1717
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AMERICAN SOCIETY OF SAFETY PROFESSIONALS (ASSP)
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Park Ridge, IL 60068
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AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)
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Internet: <http://www.asse-plumbing.org>

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AMERICAN WELDING SOCIETY (AWS)
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AMERICAN WOOD COUNCIL (AWC)
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Internet: <https://www.awc.org/>

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APA - THE ENGINEERED WOOD ASSOCIATION (APA)
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ASPHALT ROOFING MANUFACTURER'S ASSOCIATION (ARMA)
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ASSOCIATED AIR BALANCE COUNCIL (AABC)
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BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)
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Internet: <https://www.buildershardware.com/>

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CAST IRON SOIL PIPE INSTITUTE (CISPI)
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Internet: <https://www.cispi.org/>

CENTERS FOR DISEASE CONTROL AND PREVENTION (CDC)
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Internet: <http://www.crsi.org/>

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COPPER DEVELOPMENT ASSOCIATION (CDA)
Internet: <https://www.copper.org/>

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Internet: <https://fluidcontrolsinstitute.org/>

FLUID SEALING ASSOCIATION (FSA)
994 Old Eagle School Rd. #1019
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E-mail: info@fluidsealing.com
Internet: www.fluidsealing.com

FM GLOBAL (FM)
270 Central Avenue
Johnston, RI 02919-4949
Ph: 401-275-3000
Fax: 401-275-3029
Internet: <https://www.fmglobal.com/>

FOREST STEWARDSHIP COUNCIL (FSC)
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E-mail: green seal@green seal.org
Internet: <https://www.green seal.org/>

GYPSUM ASSOCIATION (GA)
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Silver Spring, MD 20910
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Internet: <https://www.gypsum.org/>

HYDRAULIC INSTITUTE (HI)
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INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)
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E-mail: info@icea.net
Internet: <https://www.icea.net/>

INTERNATIONAL CODE COUNCIL (ICC)
500 New Jersey Avenue, NW
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Fax: 202-783-2348
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INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)
3050 Old Centre Ave. Suite 101
Portage, MI 49024
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Internet: <https://www.netaworld.org/>

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)
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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)
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INTERNET ENGINEERING TASK FORCE (IETF)
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5177 Brandin Court
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JAPANESE STANDARDS ASSOCIATION (JSA)
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LONMARK INTERNATIONAL (LonMark)
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MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS
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Internet: <http://www.mpi.net/>

MIDWEST INSULATION CONTRACTORS ASSOCIATION (MICA)
16712 Elm Circle
Omaha, NE 68130
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MODBUS ORGANIZATION, INC (MODBUS)
PO Box 628
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NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)
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NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
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NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)
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NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA)
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SCIENTIFIC CERTIFICATION SYSTEMS (SCS)
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Pittsburgh, PA 15205
Ph: 877-281-7772 or 412-281-2331
Fax: 412-444-3591
E-mail: customerservice@sspc.org
Internet: <http://www.sspc.org>

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)
400 Commonwealth Drive
Warrendale, PA 15096
Ph: 877-606-7323 or 724-776-4841
Fax: 724-776-0790
E-mail: customerservice@sae.org
Internet: <https://www.sae.org/>

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)
21865 Copley Drive
Diamond Bar, CA 91765
Ph: 909-396-2000
E-mail: webinquiry@aqmd.gov
Internet: <http://www.aqmd.gov>

STEEL DECK INSTITUTE (SDI)
P.O. Box 426
Glenshaw, PA 15116
Ph: 412-487-3325
Fax: 412-487-3326
Internet: <https://www.sdi.org/>

STEEL DOOR INSTITUTE (SDI/DOOR)
30200 Detroit Road
Westlake, OH 44145
Ph: 440-899-0010
Fax: 440-892-1404
E-mail: info@steeldoors.org
Internet: <https://www.steeldoors.org/>

STEEL JOIST INSTITUTE (SJI)
234 W. Cheves Street
Florence, SC 29501
Ph: 843-407-4091
Internet: <https://steeljoist.org/>

SUSTAINABLE FOREST INITIATIVE (SFI)
2121 K Street NW
Suite 750
Washington, DC 20037
Ph: 202-596-3450
Fax: 202-596-3451
E-mail: info@sfiprogram.org
Internet: <http://www.sfiprogram.org>

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)
1320 North Courthouse Road, Suite 200
Arlington, VA 22201
Ph: 703-907-7700
Fax: 703-907-7727
E-mail: marketing@tiaonline.org
Internet: <https://www.tiaonline.org/>

THE MASONRY SOCIETY (TMS)
105 South Sunset Street, Suite Q
Longmont, CO 80501-6172
Ph: 303-939-9700
Fax: 303-541-9215
E-mail: info@masonrysociety.org
<https://masonrysociety.org/>

TRIDIUM, INC (TRIDIUM)
3951 Westerre Parkway, Suite 350
Richmond, VA 23233
Ph: 804-747-4771
Fax: 804-747-5204

E-mail: support@tridium.com
Internet: <https://www.tridium.com/>

TRUSS PLATE INSTITUTE (TPI)
218 N. Lee Street, Suite 312
Alexandria, VA 22314
Ph: 703-683-1010
Fax: 866-501-4012
E-mail: info@tpinst.org
Internet: <https://www.tpinst.org/>

U.S. AIR FORCE (USAF)
E-mail: usaf.pentagon.saf-aa.mbx.AFDPO-PPL@mail.mil
Internet: <https://www.e-publishing.af.mil/>

U.S. ARMY CORPS OF ENGINEERS (USACE)
CRD-C DOCUMENTS available on Internet:
<http://www.wbdg.org/ffc/army-coe/standards>
Order Other Documents from:
Official Publications of the Headquarters, USACE
E-mail: hqpublications@usace.army.mil
Internet: <http://www.publications.usace.army.mil/>
or
<https://www.hnc.usace.army.mil/Missions/Engineering-Directorate/TECHINFO/>

U.S. DEPARTMENT OF AGRICULTURE (USDA)
Order AMS Publications from:
AGRICULTURAL MARKETING SERVICE (AMS)
Seed Regulatory and Testing Branch
801 Summit Crossing Place, Suite C
Gastonia, NC 28054-2193
Ph: 704-810-8884
E-mail: PA@ams.usda.gov
Internet: <https://www.ams.usda.gov/>
Order Other Publications from:
USDA Rural Development
Rural Utilities Service
STOP 1510, Rm 5135
1400 Independence Avenue SW
Washington, DC 20250-1510
Phone: (202) 720-9540
Internet:
<https://www.rd.usda.gov/about-rd/agencies/rural-utilities-service>

U.S. DEPARTMENT OF DEFENSE (DOD)
Order DOD Documents from:
Room 3A750-The Pentagon
1400 Defense Pentagon
Washington, DC 20301-1400
Ph: 703-571-3343
Fax: 215-697-1462
E-mail: customerservice@ntis.gov
Internet: <https://www.ntis.gov/>
Obtain Military Specifications, Standards and Related Publications
from:
Acquisition Streamlining and Standardization Information System
(ASSIST)
Department of Defense Single Stock Point (DODSSP)
Document Automation and Production Service (DAPS)

Building 4/D
700 Robbins Avenue
Philadelphia, PA 19111-5094
Ph: 215-697-6396 - for account/password issues
Internet: <https://assist.dla.mil/online/start/>; account
registration required
Obtain Unified Facilities Criteria (UFC) from:
Whole Building Design Guide (WBDG)
National Institute of Building Sciences (NIBS)
1090 Vermont Avenue NW, Suite 700
Washington, DC 20005
Ph: 202-289-7800
Fax: 202-289-1092
Internet:
<https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc>

U.S. DEPARTMENT OF ENERGY (DOE)
1000 Independence Avenue Southwest
Washington, D.C. 20585
Ph: 202-586-5000
Fax: 202-586-4403
E-mail: The.Secretary@hq.doe.gov
Internet: <https://www.energy.gov/>

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)
1200 Pennsylvania Avenue, N.W.
Washington, DC 20004
Ph: 202-564-4700
Internet: <https://www.epa.gov>
--- Some EPA documents are available only from:
National Technical Information Service (NTIS)
5301 Shawnee Road
Alexandria, VA 22312
Ph: 703-605-6060 or 1-800-363-2068
Fax: 703-605-6880
TDD: 703-487-4639
E-mail: info@ntis.gov
Internet: <https://www.ntis.gov/>

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)
Order for sale documents from:
Superintendent of Documents
U.S. Government Publishing Office (GPO)
732 N. Capitol Street, NW
Washington, DC 20401
Ph: 202-512-1800 or 866-512-1800
Bookstore: 202-512-0132
Internet: <https://www.gpo.gov/>
Order free documents from:
U.S. Department of Transportation
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591
Ph: 866-835-5322
Internet: <https://www.faa.gov/>

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)
445 12th Street SW
Washington, DC 20554

Ph: 888-225-5322
TTY: 888-835-5322
Fax: 866-418-0232
Internet: <https://www.fcc.gov/>
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Washington, DC 20401
Ph: 202-512-1800 or 866-512-1800
Bookstore: 202-512-0132
Internet: <https://www.gpo.gov/>

U.S. GENERAL SERVICES ADMINISTRATION (GSA)
General Services Administration
1800 F Street, NW
Washington, DC 20405
Ph: 1-844-472-4111
Internet: <https://www.gsa.gov/ElibMain/home.do>
Obtain documents from:
Acquisition Streamlining and Standardization Information System
(ASSIST)
Internet: <https://assist.dla.mil/online/start/>; account
registration required

U. S. GREEN BUILDING COUNCIL (USGBC)
2101 L St NW, Suite 500
Washington, DC 20037
Ph: 202-828-7422
Internet: <https://new.usgbc.org/>

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)
8601 Adelphi Road
College Park, MD 20740-6001
Ph: 866-272-6272
Internet: <https://www.archives.gov/>
Order documents from:
Superintendent of Documents
U.S. Government Publishing Office (GPO)
732 N. Capitol Street, NW
Washington, DC 20401
Ph: 202-512-1800 or 866-512-1800
Bookstore: 202-512-0132
Internet: <https://www.gpo.gov/>

UNDERWRITERS LABORATORIES (UL)
2600 N.W. Lake Road
Camas, WA 98607-8542
Ph: 877-854-3577 or 360-817-5500
E-mail: CustomerExperienceCenter@ul.com
Internet: <https://www.ul.com/>
UL Directories available through IHS at <https://ihsmarkit.com/>

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)
Corporate Headquarters
2711 LBJ Freeway, Suite 1000
Dallas, TX 75234
Ph: 972-243-3902
Fax: 972-243-3907

E-mail: info@uni-bell.org
Internet: <https://www.uni-bell.org/>

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)
1500 SW First Ave., Suite 870
Portland, OR 97201
Ph: 503-224-3930
E-mail: info@wwpa.org
Internet: <http://www.wwpa.org>

PART 2 PRODUCTS

Not used

PART 3 EXECUTION

Not used

-- End of Section --

SECTION 01 45 00.00 40

QUALITY CONTROL

PART 1 GENERAL

1.1 SUMMARY

The requirements of this section apply to and are a component part of each section of the specifications.

1.2 ADMINISTRATIVE REQUIREMENTS

Notify the Government hours before work will begin at the site.

Notify the Contracting Officer when work is suspended for 2 calendar days or longer. Do not resume work without notifying the Contracting Officer.

Notify the Contracting Officer at least 48 hours before backfilling or encasing any underground utility.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Quality Assurance (QA) Plan; G

SD-06 Test Reports

Quality Control Data; G

Quality Control Coordinating Actions; G

Quality Control Training; G

Inspection Records; G

Letters of Authority or Delegation; G

Field Tests; G

Factory Tests; G

SD-07 Certificates

Quality Representative Qualifications

Special Certifications

Monthly Performance Report

1.4 QUALITY CONTROL

1.4.1 Quality Representative Qualifications

Submit to the Contracting Officer for approval. Quality Representative may be assigned to more than one contract provided that the assigned contracts are located at the same site.

When approval or certification of special processes, operating personnel, and special equipment or procedures is required by the specifications, obtain necessary approvals or [special certifications](#) prior to starting the work.

1.4.2 Quality Control Requirements

Provide a quality control program that includes: selection of construction materials and sources; suppliers; subcontractors; on-site and off-site fabrication of Contractor-furnished assemblies; on-site and off-site assembly; erection; work procedures; workmanship; inspection; and testing.

Provide document systems ensuring that quality provisions of the contract schedule, specifications, and drawings have been performed.

1.4.2.1 Management and Organization

Designate a Quality Program Manager within the on-site organization whose sole responsibility is the day-to-day on-site management and direction of the Quality Program.

Ensure that the Quality Program Manager reports to the Contractor's management and has the necessary authority to discharge contractual responsibilities.

1.4.2.2 Identification and Data Retrieval

Provide an identification and data retrieval system identifying all records, drawings, submittals, and equipment by referencing the following:

- a. Contract Number
- b. Contract Specification Number
- c. Contract Drawing Number
- d. Submittal Document Number
- e. Contract Change Number
- f. Contractor's Drawing Number System

1.4.2.3 Procurement

Assume responsibility for controlling procurement sources and those of the subcontractors to ensure that each purchase meets quality requirements.

1.4.2.4 Receiving Inspection System

Maintain a site receiving inspection system that ensures that procured materials and equipment are inspected and tested.

Ensure that receiving inspection records accompany each procurement delivery to the construction site. Maintain records of site receiving inspections.

Show defects, discrepancies, dispositions, and waivers. Include evidence of Government source inspection within the records.

1.4.2.5 Nonconforming Articles and Material Control

Control nonconformances discovered by the Contractor, subcontractors, suppliers, or Government quality representatives to prevent the use of affected products and to correct deficient operations.

- a. Provide a "nonconformance" report for each instance comprising:
 - (1) A unique and traceable number.
 - (2) Identification of the nonconforming article or material.
 - (3) A description of the nonconformance and the applicable requirement.
 - (4) Cause or reason for the nonconformance.
 - (5) Remedial actions taken or recommended.
 - (6) Disposition of the nonconforming article or material.
- b. Identify and mark each nonconforming article for removal from the work area.
- c. Monitor and correct deficient operations.

1.4.2.6 Fabrication, Process, and Work Control

Ensure compliance of requirements in contract specifications and drawings with procedures and controls.

Establish in-process inspections, to ensure compliance with quality requirements.

Special processes may include plating, anodizing, nondestructive testing, welding, and soldering.

1.4.2.7 Quality Control Records

Maintain Quality Control records at a central on-site location.

Maintenance of quality control records does not provide relief from submitting samples, test data, detail drawings, material certificates, or other information required by each section in the specification.

Ensure that each record is identified and traceable to specific requirements in the specifications and drawings.

1.4.2.8 Drawings and Change Control

Maintain a drawing control system to provide revised drawings and ensure removal of obsolete drawings from work areas. Control changes involving interface with other work areas, or affecting materials controlled by others. Integrate this system with the document requirements of the contract.

Clearly identify drawings needing changes and along with associated drawings that require revision. Maintain the updated drawings. Use for fabrication and inspection drawings that have been approved, or approved as noted, by the Contracting Officer.

1.4.3 Quality Inspections

1.4.3.1 Government Inspections

Work performed under this contract is subject to inspection by the Contracting Officer. Changes to the specifications or drawings will not be allowed without written authorization of the Contracting Officer.

When the Contracting Officer determines that inspected work needs to be corrected, allow the Contracting Officer 24 hours to complete reinspection of the corrected work.

Notify the Contracting Officer in writing before backfilling or encasing any underground utility so that work may be inspected. Failure to notify the Contracting Officer before backfill or encasement occurs will require the work to be uncovered at no additional cost to the Government.

The Contractor's Quality Program is subject to evaluation, review, and verification as determined by the Contracting Officer. Contractor will be notified in writing of any noncompliance and will be given 10 calendar days to correct identified deficiencies.

1.4.3.2 Contractor's Quality Inspections

Implement an inspection system that documents and indicates quality control through records of inspections, tests, and procedures.

Include or identify the following within the Quality Assurance System:

- a. The representative responsible for on-site communication and operation of the inspection program.
- b. Purchasing control system documenting project procurement to drawings, specifications, and approved submittals.
- c. A receiving inspection system documenting inspections for each procurement.
- d. Documentation for handling and disposing of nonconforming components and materials.
- e. Inspection records for each specific section of the specification and drawings.
- f. Identification of tests to be performed, test procedures, records, and independent organizations used.

- g. Documentation that shows certification or recertification of procedures.
- h. Management of Government-furnished equipment, components, and materials.
- i. Calibration of gages, tools, measuring instruments, and independent laboratories used.

Establish a system of scheduled or random audits to ensure task completion.

1.4.4 Field Services

1.4.4.1 Responsibility for Inspection and Testing

Assume responsibility for all inspections and tests and for the accompanying documentation. Use independent inspection and testing laboratories or services as approved by the Contracting Officer.

Assume responsibility for tests of construction materials performed by an approved independent testing laboratory.

1.4.4.2 Inspection and Test Records

Provide on-site records of each inspection and test performed throughout the life of the contract, including factual evidence that the required inspections or tests have been performed, which include the type and number of inspections or tests involved, identification of operators and inspectors, result of inspections or tests, nature of defects, causes for rejection, proposed remedial action, and corrective actions taken.

Ensure that all inspection records, test procedures, test results, and associated forms are verified by and provided to the Contracting Officer. Submit final test data with a cover letter/sheet clearly marked with the system name, date, and the words "Final Test Data."

Notify the Government at least 3 days before scheduled inspections and tests.

1.5 DELIVERY, STORAGE, AND HANDLING

Provide controls, procedures and documentation with each shipment, that meet requirements of each section of the specifications.

With each shipment, include documentation required by the contract along with specifications necessary to identify, store, preserve, operate, and maintain the items shipped.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 [Quality Assurance \(QA\) Plan](#)

Submit a QA Plan that addresses the following:

- a. Description of the authority, responsibilities, and coordinating procedures of on-site/off-site quality assurance personnel, including

those QA personnel not under direct control of the Contractor.

- b. List of personnel designated to accomplish the work required by the contract.
- c. An appendix with a copy of each form, report format, or similar record to be used in the Quality Assurance Plan.
- d. The organization that handles construction contract activities.
- e. The operational plan for establishing and reviewing work controls, fabrication controls, certifications, and documentation of quality control operations, inspections, and test records, including those for subcontractors.
- f. The methods used during the procurement cycle (order to delivery) for those materials or equipment that require source inspections, shop fabrications, or similar operations located separately from the work site.
- g. Description of on-site personnel training.
- h. Certifications of personnel, procedures, processes, and equipment.
- i. Nondestructive testing (NDT) requirements.
- j. Identification of independent certifying and testing laboratories.

2.1.2 Records

Include all [quality control data](#); [factory tests](#) or manufacturer's certifications; [quality control coordinating actions](#); records of [quality control training](#) and certifications; and routine hydrostatic, electrical continuity, grounding, welding, line cleaning, [field tests](#), and similar tests. Ensure that quality records are available for examination by the Contracting Officer.

Furnish legible copies of the test and [inspection records](#) to the Contracting Officer. Ensure that records cover work placement traceable to the contract schedule, specifications and drawings, and that records are verifiable.

2.1.2.1 Narrative Description

Submit for approval, the narrative description of an inspection system that provides for compliance with the quality requirements and technical criteria of the contract within [14](#) calendar days after notice to proceed.

2.1.2.2 [Monthly Performance Report](#)

Submit a monthly summary of the quality operations. Identify inspections made, tests performed, nonconformances found, corrective actions taken, status of plans/procedures being developed, and status of open items/problems in work.

2.1.2.3 Letters of Authority or Delegation

Submit to the Contracting Officer [letters of authority or delegation](#) outlining the authority and responsibilities of quality control personnel

along with a copy of the letter of delegation that defines delegated duties and responsibilities.

PART 3 EXECUTION

Not Used

-- End of Section --

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SECTION 01 45 00.15 10

RESIDENT MANAGEMENT SYSTEM CONTRACTOR MODE (RMS CM)

PART 1 GENERAL

1.1 REFERENCES

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

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1

(2014) Safety -- Safety and Health
Requirements Manual

1.2 MEASUREMENT AND PAYMENT

The work of this section is not measured for payment. The Contractor is responsible for the work of this section, without any direct compensation other than the payment received for contract items.

1.3 CONTRACT ADMINISTRATION

The Government will use the Resident Management System (RMS) to assist in its monitoring and administration of this contract. The Government accesses the system using the Government Mode of RMS (RMS GM) and the Contractor accesses the system using the Contractor Mode (RMS CM). The term RMS will be used in the remainder of this section for both RMS GM and RMS CM. The joint Government-Contractor use of RMS facilitates electronic exchange of information and overall management of the contract. The Contractor accesses RMS to record, maintain, input, track, and electronically share information with the Government throughout the contract period in the following areas:

- Administration
- Finances
- Quality Control
- Submittal Monitoring
- Scheduling
- Closeout
- Import/Export of Data

1.3.1 Correspondence and Electronic Communications

For ease and speed of communications, exchange correspondence and other documents in electronic format to the maximum extent feasible. Some documents such as correspondence, including pay requests and payrolls, may be required in paper format with original signatures. Paper documents will govern in the event of discrepancy with the electronic version. Contracting Officer will determine which documents require submission of paper copies.

1.3.2 Other Factors

Other portions of this document have a direct relationship to the

reporting accomplished through RMS. Particular attention is directed to FAR 52.236-15 Schedules for Construction Contracts; FAR 52.232-27 Prompt Payment for Construction Contracts; FAR 52.232-5 Payments Under Fixed-Priced Construction Contracts; Section 01 33 00 SUBMITTAL PROCEDURES; and Section 01 45 00.00 40 QUALITY CONTROL.

1.4 RMS SOFTWARE

RMS is a web based application. Download, install and be able to utilize the latest version of RMS within 7 calendar days of receipt of the Notice to Proceed. RMS software, user manuals, access and installation instructions, program updates and training information are available from the RMS website (<https://rms.usace.army.mil>). The Government and the Contractor will have different access authorities to the same contract database through RMS. The common database will be updated automatically each time a user finalizes an entry or change.

1.5 CONTRACT DATABASE - GOVERNMENT

The Government will enter the basic contract award data in RMS prior to granting the Contractor access. The Government entries into RMS will generally be related to submittal reviews, correspondence status, and Quality Assurance(QA)comments, as well as other miscellaneous administrative information.

1.6 CONTRACT DATABASE - CONTRACTOR

Contractor entries into RMS establish, maintain, and update data throughout the duration of the contract. Contractor entries generally include prime and subcontractor information, daily reports, submittals, RFI's, schedule updates and payment requests. RMS includes the ability to import attachments and export reports in many of the modules, including submittals. The Contractor responsibilities for entries in RMS typically include the following items:

1.6.1 Administration

1.6.1.1 Contractor Information

Enter all current Contractor administrative data and information into RMS within 7 calendar days of receiving access to the contract in RMS. This includes, but is not limited to, Contractor's name, address, telephone numbers, management staff, and other required items.

1.6.1.2 Subcontractor Information

Enter all missing subcontractor administrative data and information into RMS CM within seven calendar days of receiving access to the Contract in RMS or within seven calendar days of the signing of the subcontractor agreement for agreements signed at a later date. This includes name, trade, address, phone numbers, and other required information for all subcontractors. A subcontractor is listed separately for each trade to be performed.

1.6.1.3 Correspondence

Identify all Contractor correspondence to the Government with a serial number. Prefix correspondence initiated by the Contractor's site office with "S". Prefix letters initiated by the Contractor's home (main) office

with "H". Letters are numbered starting from 0001. (e.g., H-0001 or S-0001). The Government's letters to the Contractor will be prefixed with "C" or "RFP".

1.6.1.4 Equipment

Enter and maintain a current list of equipment planned for use or being used on the jobsite, including the most recent and planned equipment inspection dates in accordance with Section 01 45 00.00 40 QUALITY CONTROL.

1.6.1.5 Reports

Track the status of the project using the reports available in RMS. The value of these reports reflects the quality of the data input. These reports include but are not limited to the Progress Payment Request worksheet, Quality Control (QC) comments, Deficiency Tracking Log, Submittal Register Status, and Three-Phase Control worksheets in accordance with Sections 01 33 00 SUBMITTAL PROCEDURES, and 01 45 00.00 40 QUALITY CONTROL.

1.6.1.6 Request For Information (RFI)

Create and track all Requests For Information (RFI) in the RMS Administration Module for Government review and response. Provide status at weekly progress meeting.

1.6.2 Finances

1.6.2.1 Pay Activity Data

Develop and enter a list of pay activities in conjunction with the project schedule. The sum of pay activities equals the total Contract amount, including modifications. Each pay activity must be assigned to a Contract Line Item Number (CLIN). The sum of the activities assigned to a CLIN equals the amount of each CLIN.

1.6.2.2 Payment Requests

Prepare all progress payment requests using RMS. Update the work completed under the Contract at least monthly, measured as percent or as specific quantities. After the update, generate a payment request and prompt payment certification using RMS. Submit the signed prompt payment certification and payment request as well as supporting data, either electronically or by hard copy.

1.6.3 Quality Control (QC)

Enter and track implementation of the 3-phase QC Control System, QC testing, transferred and installed property and warranties in RMS. Prepare daily reports, identify and track deficiencies, document progress of work, and support other Contractor QC requirements in RMS. Maintain all data on a daily basis. Ensure that RMS reflects all quality control methods, tests and actions contained within the Contractor Quality Control (CQC) Plan and Government review comments. Provide within seven calendar days of Government acceptance of the CQC Plan.

1.6.3.1 Quality Control (QC) Reports

The Contractor's Quality Control (QC) Daily Report in RMS is the official

report. The Contractor can use other supplemental formats to record QC data, but information from any supplemental formats are to be consolidated and entered into the RMS QC Daily Report. Any supplemental information may be entered into RMS as an attachment to the report. QC Daily Reports must be finalized and signed in RMS within 24 hours after the date covered by the report. Provide the Government a printed signed copy of the QC Daily Report, unless waived by the Contracting Officer.

1.6.3.2 Deficiency Tracking.

Use the QC Daily Report Module to enter and track deficiencies. Deficiencies identified and entered into RMS by the Contractor or the Government will be sequentially numbered with a QC or QA prefix for tracking purposes. Enter each deficiency into RMS the same day that the deficiency is identified. Monitor, track and resolve all QC and QA entered deficiencies. A deficiency is not considered to be corrected until the Government indicates concurrence in RMS.

1.6.3.3 Three-Phase Control Meetings

Maintain scheduled and actual dates and times of preparatory and initial control meetings in RMS, and upload meeting minutes of the meetings. Worksheets for the three-phase control meetings are generated within RMS.

1.6.3.4 Labor and Equipment Hours

Enter labor and equipment exposure hours on a daily basis. Roll up the labor and equipment exposure data into a monthly exposure report.

1.6.3.5 Accident/Safety Reporting

Both the Contractor and the Government enter safety related comments in RMS as a deficiency. The Contractor must monitor, track and show resolution for safety issues in the QC Daily Report area of the RMS QC Module. In addition, follow all reporting requirements for accidents and incidents as required in [EM 385-1-1](#), and as required by any other applicable Federal, State or local agencies.

1.6.3.6 Definable Features of Work

Enter each feature of work, as defined in the approved CQC Plan, into the RMS QC Module. A feature of work may be associated with a single or multiple pay activities, however a pay activity is only to be linked to a single feature of work.

1.6.3.7 Activity Hazard Analysis

Import activity hazard analysis electronic document files into the RMS QC Module utilizing the document package manager. Prepare activity hazard analysis.

1.6.4 Submittal Management

Enter all current submittal register data and information into RMS within seven calendar days of receiving access to the Contract in RMS within the time frame directed by the Contracting Officer. Contractor is responsible for entering Activity Numbers for each submittal item corresponding to their Schedule. The Contractor will import the information shown in the submittal register following the specification Section [01 33 00](#) SUBMITTAL

PROCEDURES unless otherwise directed by the Contracting Officer. Group electronic submittal documents into transmittal packages to send to the Government, except very large electronic files, samples, spare parts, mock ups, color boards, or where hard copies are specifically required. Track transmittals and update the submittal register in RMS on a daily basis throughout the duration of the Contract. Submit hard copies of all submittals unless waived by the Contracting Officer.

Enter all submittals as listed in the approved design's submittal register within 14 calendar days of design approval for construction.

Contractor may request submittals to be added to RMS throughout the lifecycle of the project. Approval/disapproval of Contractor requests is at the discretion of the Contracting Officer. Submittals entry into RMS must be updated daily or as practical for performance of the Contract, as approved by the Contracting Officer.

1.6.5 Schedule

Enter and update the contract project schedule in RMS by either manually entering all schedule data or by importing the Standard Data Exchange Format (SDEF) file.

1.6.6 Closeout

Closeout documents, processes and forms are managed and tracked in RMS by both the Contractor and the Government. Ensure that all closeout documents are entered, completed and documented within RMS.

1.7 IMPLEMENTATION

Use of RMS as described in the preceding paragraphs is mandatory. Ensure that sufficient resources are available to maintain contract data within the RMS system. RMS is an integral part of the Contractor's required management of quality control.

1.8 NOTIFICATION OF NONCOMPLIANCE

Take corrective action within seven calendar days after receipt of notice of RMS non-compliance by the Contracting Officer.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

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SECTION 01 45 35

SPECIAL INSPECTIONS

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.

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC

(2021) International Building Code

1.2 GENERAL REQUIREMENTS

Perform Special Inspections in accordance with the Statement of Special Inspections, Schedule of Special Inspections and Chapter 17 of ICC IBC. The Statement of Special Inspections and Schedule of Special Inspections are included as an attachment to this specification. Special Inspections are to be performed by an independent third party and are intended to ensure that the work of the Prime Contractor is in accordance with the Contract Documents and applicable building codes. Special inspections do not take the place of the three phases of control inspections performed by the Contractor's QC Manager or any testing and inspections required by other sections of the specifications.

1.3 DEFINITIONS

1.3.1 Continuous Special Inspections

Continuous Special Inspections is the constant monitoring of specific tasks by a special inspector. These inspections must be carried out continuously over the duration of the particular tasks.

1.3.2 Perform

Perform these Special Inspections tasks for each welded joint or member.

1.3.3 Observe

Observe these Special Inspections items on a periodic daily basis. Operations need not be delayed pending these inspections.

1.3.4 Special Inspector (SI)

A qualified person retained by the Contractor and approved by the Contracting Officer as having the competence necessary to inspect a particular type of construction requiring Special Inspections. The SI must be an independent third party hired directly by the Prime Contractor.

1.3.5 Associate Special Inspector (ASI)

A qualified person who assists the SI in performing Special Inspections but must perform inspection under the direct supervision of the SI and

cannot perform inspections without the SI on site.

1.3.6 Third Party

A Special inspector must not be an employee of the Contractor or of any Sub-Contractor performing the work to be inspected.

1.3.7 Contracting Officer

The Government official having overall authority for administrative contracting actions. Certain contracting actions may be delegated to the Contracting Officer's Representative (COR).

1.3.8 Contractor's Quality Control (QC) Manager

An individual retained by the Prime Contractor and qualified in accordance with the Section having the overall responsibility for the Contractor's QC organization.

1.3.9 Structural Engineer of Record (SER)

A registered design professional **employed by the Government retained by the Prime Contractor** responsible for the overall design and review of submittal documents prepared by others. The SER is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws in the state in which the design professional works. The SER is also referred to as the Engineer of Record (EOR) in design code documents.

1.3.10 Statement of Special Inspections (SSI)

A document developed by the SER identifying the material, systems, components and work required to have Special Inspections. This statement is included at the end of this specification.

1.3.11 Schedule of Special Inspections (SSI)

A schedule which lists each of the required Special Inspections, the extent to which each Special Inspection is to be performed, and the required frequency for each in accordance with **ICC IBC** Chapter 17. This schedule is included at the end of this specification.

1.3.12 Definable Feature of Work (DFOW)

An inspection group that is separate and distinct from other inspection groups, having inspection requirements or inspectors that are unique.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section **01 33 00** SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

SIOR Letter of Acceptance; G

Special Inspections Project Manual; G

SD-06 Test Reports

Special Inspections [Daily Reports](#)

Special Inspections [Biweekly Reports](#)

SD-07 Certificates

[AISC Certified Steel Fabricator](#)

[Steel Truss Plant Quality Assurance Program](#)

[Steel Joist Institute Membership](#)

[Precast Concrete Institute \(PCI\) Certified Plant](#)

[Certificate of Compliance](#)

[Special Inspector of Record Qualifications](#); [G](#)

[Special Inspector Qualifications](#); [G](#)

[Qualification Records](#) for NDT technicians

SD-11 Closeout Submittals

[Comprehensive Final Report](#) of Special Inspections; [G](#)

1.5 SPECIAL INSPECTOR QUALIFICATIONS

Submit qualifications for each [special inspector](#) and the [special inspector of record](#).

1.5.1 Steel Construction and High Strength Bolting

1.5.1.1 Special Inspector

- a. ICC Structural Steel and Bolting Special Inspector certificate with one year of related experience, or
- b. Registered Professional Engineer with three years of related experience

1.5.1.2 Associate Special Inspector

Engineer-In-Training with one year of related experience.

1.5.2 Welding Structural Steel

1.5.2.1 Special Inspector

- a. ICC Structural Welding Special Inspector certificate with one year of related experience, or
- b. AWS Certified Welding Inspector

1.5.2.2 Associate Special Inspector

AWS Certified Associate Welding Inspector

1.5.3 Nondestructive Testing of Welds

1.5.3.1 Special Inspector

NDT Level III Certificate

1.5.3.2 Associate Special Inspector

NDT Level II Certificate plus one year of related experience

1.5.4 Cold Formed Steel Framing

1.5.4.1 Special Inspector

- a. ICC Structural Steel and Bolting Special Inspector certificate with one year of related experience, or
- b. ICC Commercial Building Inspector with one year of experience, or
- c. ICC Residential Building Inspector with one year of experience, or
- d. Registered Professional Engineer with three years related experience

1.5.4.2 Associate Special Inspector

Engineer-In-Training with one year of related experience.

1.5.5 Concrete Construction

1.5.5.1 Special Inspector

- a. ICC Reinforced Concrete Special Inspector Certificate with one year of related experience, or
- b. ACI Concrete Construction Special Inspector, or
- c. Registered Professional Engineer with three years of related experience

1.5.5.2 Associate Special Inspector

- a. ACI Concrete Construction Special Inspector in Training, or
- b. Engineer-In-Training with one year of related experience

1.5.6 Prestressed Concrete Construction

1.5.6.1 Special Inspector

- a. ICC Pre-stressed Special Inspector Certificate with one year of related experience, or
- b. PCI Quality Control Technician/ Inspector Level II Certificate with one year of related experience, or
- c. Registered Professional Engineer with three years of related experience

1.5.6.2 Associate Special Inspector

- a. PCI Quality Control Technician/ Inspector Level I Certificate with one year of related experience, or
- b. Engineer-In-Training with one year of related experience

1.5.7 Post-tensioned Concrete Construction

1.5.7.1 Special Inspector

- a. PTI Level 2 Unbonded PT Inspector Certificate, or
- b. Registered Professional Engineer with three years of related experience

1.5.7.2 Associate Special Inspector

- a. PTI Level 1 Unbonded PT Inspector Certificate with one year of related experience, or
- b. Engineer-In-Training with one year of related experience

1.5.8 Masonry Construction

1.5.8.1 Special Inspector

- a. ICC Structural Masonry Special Inspector Certificate with one year of related experience, or
- b. Registered Professional Engineer with three years of related experience

1.5.8.2 Associate Special Inspector

Engineer-In-Training with one year of related experience.

1.5.9 Wood

1.5.9.1 Special Inspector

- a. ICC Commercial Building Inspector Certificate with one year of related experience, or
- b. ICC Residential Building Inspector with one year of experience, or
- c. Registered Professional Engineer with three years of related experience

1.5.9.2 Associate Special Inspector

Engineer-In-Training with one year of related experience.

1.5.10 Verification of Site Soil Condition, Fill Placement and Load-Bearing Requirements

1.5.10.1 Special Inspector

- a. ICC Soils Special Inspector Certificate with one year of related experience, or
- b. NICET Soils Technician Level II Certificate in Construction Material

Testing, or

- c. Geologist-In-Training with three years of related experience, or
- d. Registered Professional Engineer with three years of related experience

1.5.10.2 Associate Special Inspector

- a. NICET Soils Technician Level I Certificate in Construction Material Testing with one year of related experience, or
- b. Engineer-In-Training with one year of related experience

1.5.11 Sprayed Fire Resistant Material

1.5.11.1 Special Inspector

- a. ICC Spray-applied Fireproofing Special Inspector Certificate, or
- b. ICC Fire Inspector I Certificate with one year of related experience, or
- c. Registered Professional Engineer or Architect with related experience

1.5.11.2 Associate Special Inspector

Engineer-In-Training with one year of related experience

1.5.12 Mastic and Intumescent Fire Resistant Coatings

1.5.12.1 Special Inspector

- a. ICC Spray-applied Fireproofing Special Inspector Certificate, or
- b. ICC Fire Inspector I Certificate with one year of related experience, or
- c. Registered Professional Engineer or Architect with related experience

1.5.12.2 Associate Special Inspector

Engineer-In-Training with one year of related experience.

1.5.13 Exterior Insulation and Finish System (EIFS)

1.5.13.1 Special Inspector

- a. AWCI EIFS Inspector Certificate, or
- b. Exterior Design Institute Certificate, or
- c. Registered Professional Engineer or Architect with related experience

1.5.13.2 Associate Special Inspector

Engineer-In-Training with one year of related experience.

1.5.14 Fire-Resistant Penetrations and Joints

1.5.14.1 Special Inspector

- a. Passed the UL Firestop Exam with one year of related experience, or
- b. Passed the FM Firestop Exam with one year of related experience, or
- c. Registered Professional Engineer with related experience

1.5.14.2 Associate Special Inspector

Engineer-In-Training with one year of related experience.

PART 2 PRODUCTS

2.1 FABRICATOR SPECIAL INSPECTIONS

Special Inspections of fabricator's work performed in the fabricator's shop is required to be inspected in accordance with the Statement of Special Inspections and the Schedule of Special Inspections unless the fabricator is certified by the approved agency to perform such work without Special Inspections. Submit the following certification to the Contracting Officer for information to allow work performed in the fabricator's shop to not be subjected to Special Inspections.

[AISC Certified Steel Fabricator.](#)

Truss Plate Institute (TPI) [steel truss plant quality assurance program](#) certification.

[Steel Joist Institute Membership](#)

Precast Concrete Institute (PCI) [Certified Plant](#), Group C

At the completion of fabrication, submit a [certificate of compliance](#), to be included with the comprehensive final report of Special Inspections, stating that the materials supplied and work performed by the fabricator are in accordance with the construction documents.

PART 3 EXECUTION

3.1 RESPONSIBILITIES

3.1.1 Special Inspector of Record

- a. Supervise all Special Inspectors required by the Contract Documents and the IBC.
- b. Submit a [SIOR Letter of Acceptance](#) to the Contracting Officer attesting to acceptance of the duties of SIOR, signed and sealed by the SIOR.
- c. Verify the qualifications of all of the Special Inspectors.
- d. Verify the qualifications of fabricators.
- e. Prepare a Special Inspections [Project Manual](#), which must cover the

following:

- (1) Roles and responsibilities of the following individuals during Special Inspections: SIOR, SI, ASI, General Contractor's QC Manager and SER.
- (2) Organizational chart or communication plan, indicating lines of communication.
- (3) Contractor's internal plan for scheduling inspections. Address items such as timeliness of inspection requests, who to contact for inspection requests, and availability of alternate inspectors.
- (4) Indicate the Government reporting requirements.
- (5) Propose forms or templates to be used by SI and SIOR to document inspections.
- (6) Indicate procedures for tracking nonconforming work and verification that corrective work is complete.
- (7) Indicate how the SIOR and SI will participate in weekly QC meetings.
- (8) Indicate how Special Inspections of shop fabricated items will be handled when the fabricator's shop is not certified in accordance with paragraph FABRICATOR SPECIAL INSPECTIONS.
- (9) Include a section in the manual that covers each specific item requiring Special Inspections that is indicated on the Schedule of Special Inspections. Provide names and qualifications of each special inspector who will be performing the Special Inspections for each specific item. Provide detail on how the Special Inspections are to be carried out for each item so that the expectations are clear for the General Contractor and the Subcontractor performing the work.

Make a copy of the Special Inspections Project Manual available on the job site during construction. Submit a copy of the Special Inspections [Project Manual](#) for approval.

- i. Attend coordination and mutual understanding meeting where the information in the Special Inspections Project Manual will be reviewed to verify that all parties have a clear understanding of the Special Inspections provisions and the individual duties and responsibilities of each party.
- j. Maintain a 3-ring binder for the Special Inspector's daily and [biweekly reports](#) and the Special Inspections Project Manual. This file must be located in a conspicuous place in the project trailer/office to allow review by the Contracting Officer and the SER.
- k. Submit a copy of the Special Inspector's [daily reports](#) to the QC Manager.
- l. Discrepancies that are observed during Special Inspections must be reported to the QC Manager for correction. If discrepancies are not corrected before the special inspector leaves the site the observed discrepancies must be documented in the daily report.

- m. Submit a biweekly Special Inspections report until all work requiring Special Inspections is complete. A report is required for each biweekly period in which Special Inspections activity occurs, and must include the following:
 - (1) A brief summary of the work performed during the reporting time frame.
 - (2) Changes and discrepancies with the drawings, specifications and mechanical or electrical component certification, that were observed during the reporting period.
 - (3) Discrepancies which were resolved or corrected.
 - (4) A list of nonconforming items requiring resolution.
 - (5) All applicable test results including nondestructive testing reports.
- n. At the completion of the project submit a **comprehensive final report** of Special Inspections that documents the Special Inspections completed for the project including corrections of all discrepancies noted in the daily reports. The comprehensive final report of Special Inspections must be signed, dated and bear the seal of the SIOR.

3.1.2 Quality Control Manager

- a. Supervise all Special Inspectors required by the Contract Documents and the IBC.
- b. Verify the qualifications of all of the Special Inspectors.
- c. Verify the qualifications of fabricators.
- d. Maintain a 3-ring binder for the Special Inspector's daily and **biweekly reports**. This file must be located in a conspicuous place in the project trailer/office to allow review by the Contracting Officer and the SER.
- e. Maintain a rework items list that includes discrepancies noted on the Special Inspectors daily report.

3.1.3 Special Inspectors

- a. Inspect all elements of the project for which the special inspector is qualified to inspect and are identified in the Schedule of Special Inspections.
- b. Attend preparatory phase meetings related to the Definable Feature of Work (DFOW) for which the special inspector is qualified to inspect.
- c. Submit **qualification records** for nondestructive testing (NDT) technicians designated for the project.
- d. Submit NDT procedures and equipment calibration records for NDT to be performed and equipment to be used for the project.
- e. Submit a copy of the **daily reports** to the QC Manager.

- f. Report discrepancies that are observed during Special Inspections to the QC Manager for correction. If discrepancies are not corrected before the special inspector leaves the site the observed discrepancies must be documented in the daily report.
- g. Submit a biweekly Special Inspection Report until all inspections are complete. A report is required for each biweekly period in which Special Inspections activity occurs, and must include the following:
 - (1) A brief summary of the work performed during the reporting time frame.
 - (2) Changes and discrepancies with the drawings, specifications and mechanical or electrical component certification, that were observed during the reporting period.
 - (3) Discrepancies which were resolved or corrected.
 - (4) A list of nonconforming items requiring resolution.
 - (5) All applicable test result including nondestructive testing reports.

3.2 DEFECTIVE WORK

Check work as it progresses, but failure to detect any defective work or materials must in no way prevent later rejection if defective work or materials are discovered, nor obligate the Contracting Officer to accept such work.

-- End of Section --

SECTION 01 74 19

CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

PART 1 GENERAL

1.1 DEFINITIONS

1.1.1 Co-mingle

The practice of placing unrelated materials together in a single container, usually for benefits of convenience and speed.

1.1.2 Construction Waste

Waste generated by construction activities, such as scrap materials, damaged or spoiled materials, temporary and expendable construction materials, and other waste generated by the workforce during construction activities.

1.1.3 Demolition Debris/Waste

Waste generated from demolition activities, including minor incidental demolition waste materials generated as a result of Intentional dismantling of all or portions of a building, to include clearing of building contents that have been destroyed or damaged.

1.1.4 Disposal

Depositing waste in a solid waste disposal facility, usually a managed landfill or incinerator, regulated in the US under the Resource Conservation and Recovery Act (RCRA).

1.1.5 Diversion

The practice of diverting waste from disposal in a landfill or incinerator, by means of eliminating or minimizing waste, or reuse of materials.

1.1.6 [Final Construction Waste Diversion Report](#)

A written assertion by a material recovery facility operator identifying constituent materials diverted from disposal, usually including summary tabulations of materials, weight in short-ton.

1.1.7 Recycling

The series of activities, including collection, separation, and processing, by which products or other materials are diverted from the solid waste stream for use in the form of raw materials in the manufacture of new products sold or distributed in commerce, or the reuse of such materials as substitutes for goods made of virgin materials, other than fuel.

1.1.8 Reuse

The use of a product or materials again for the same purpose, in its

original form or with little enhancement or change.

1.1.9 Salvage

Usable, salable items derived from buildings undergoing demolition or deconstruction, parts from vehicles, machinery, other equipment, or other components.

1.1.10 Source Separation

The practice of administering and implementing a management strategy to identify and segregate unrelated waste at the first opportunity.

1.2 CONSTRUCTION WASTE MANAGEMENT

Implement a Construction Waste Management Program for the project. Take a pro-active, responsible role in the management of construction construction waste, recycling process, disposal of demolition debris/waste, and require all subcontractors, vendors, and suppliers to participate in the Construction Waste Management Program. Establish a process for clear tracking, and documentation of construction waste and demolition debris/waste.

1.2.1 Implementation of Construction Waste Management Program

Develop and document how the Construction Waste Management Program will be implemented in a Construction Waste Management Plan. Submit a Construction Waste Management Plan to the Contracting Officer for approval. Construction waste and demolition debris/waste materials include un-used construction materials not incorporated in the final work, as well as demolition debris/waste materials from demolition activities or deconstruction activities. In the management of waste, consider the availability of viable markets, the condition of materials, the ability to provide material in suitable condition and in a quantity acceptable to available markets, and time constraints imposed by internal project completion mandates.

1.2.2 Oversight

The Quality Control Manager, as specified in Section 01 45 00.00 10 QUALITY CONTROL, is responsible for overseeing and documenting results from executing the Construction Waste Management Plan for the project.

1.2.3 Special Programs

Implement special programs involving rebates or similar incentives related to recycling of construction waste and demolition debris/waste materials. Retain revenue or savings from salvaged or recycling, unless otherwise directed. Ensure firms and facilities used for recycling, reuse, and disposal are permitted for the intended use to the extent required by federal, state, and local regulations.

1.2.4 Special Instructions

Provide on-site instruction of appropriate separation, handling, recycling, salvage, reuse, and return methods to be used by all parties at the appropriate stages of the projects. Designation of single source separating or commingling will be clearly marked on the containers.

1.2.5 Waste Streams

Delineate waste streams and characterization, including estimated material types and quantities of waste, in the Construction Waste Management Plan. Manage all waste streams associated with the project. Typical waste streams are listed below. Include additional waste streams not listed:

- a. Land Clearing Debris
- b. Asphalt
- c. Masonry and CMU
- d. Concrete
- e. Metals (Includes, but is not limited to, banding, stud trim, ductwork, piping, rebar, roofing, other trim, steel, iron, galvanized, stainless steel, aluminum, copper, zinc, bronze.)
- f. Wood (nails and staples allowed)
- g. Glass
- h. Paper
- i. Plastics (PET, HDPE, PVC, LDPE, PP, PS, Other)
- j. Gypsum
- k. Non-hazardous paint and paint cans
- l. Carpet
- m. Ceiling Tiles
- n. Insulation
- o. Beverage Containers

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Construction Waste Management Plan; G

SD-11 Closeout Submittals

Final Construction Waste Diversion Report; S

1.4 MEETINGS

Conduct Construction Waste Management meetings. After award of the

Contract and prior to commencement of work, schedule and conduct a meeting with the Contracting Officer to discuss the proposed Construction Waste Management Plan and to develop a mutual understanding relative to the management of the Construction Waste Management Program and how waste diversion requirements will be met.

The requirements of this meeting may be fulfilled during the coordination and mutual Understanding meeting outlined in Section 01 45 00.00 40 QUALITY CONTROL. At a minimum, discuss and document waste management goals at following meetings:

- a. Preconstruction meeting.
- b. Regular Quality Control meetings.
- c. Work safety meeting (if applicable).

1.5 CONSTRUCTION WASTE MANAGEMENT PLAN

Submit Construction Waste Management Plan within 15 calendar days after contract award. Revise and resubmit Construction Waste Management Plan as necessary, in order for construction to begin. Execute demolition or deconstruction activities in accordance with Section 02 41 00 DEMOLITION AND DECONSTRUCTION. Manage demolition debris/waste or deconstruction materials in accordance with the approved construction waste management plan.

An approved Construction Waste Management Plan will not relieve the Contractor of responsibility for compliance with applicable environmental regulations or meeting project cumulative waste diversion requirement. Ensure all subcontractors receive a copy of the approved Construction Waste Management Plan. The plan demonstrates how to meet the project waste diversion requirement. Also, include the following in the plan:

- a. Identify the names of individuals responsible for waste management and waste management tracking, along with roles and responsibilities on the project..
- b. Actions that will be taken to reduce solid waste generation, including coordination with subcontractors to ensure awareness and participation.
- c. Description of the regular meetings to be held to address waste management.
- d. Description of the specific approaches to be used in recycling/reuse of the various materials generated, including the areas on site and equipment to be used for processing, sorting, and temporary storage of materials.
- e. Name of landfill and incinerator to be used.
- f. Identification of local and regional re-use programs, including non-profit organizations such as schools, local housing agencies, and organization that accept used materials such as material exchange networks and resale stores. Include the name, location, phone number for each re-use facility identified, and provide a copy of the permit or license for each facility.
- g. List of specific materials, by type and quantity, that will be salvaged for resale, salvaged and reused on the current project,

salvaged and stored for reuse on a future project, or recycled.
Identify the recycling facilities by name, address, and phone number.

- h. Identification of materials that cannot be recycled or reused with an explanation or justification, to be approved by the Contracting Officer.
- i. Description of the means by which materials identified in item (g) above will be protected from contamination.
- j. Description of the means of transportation of the recyclable materials (whether materials will be site-separated and self-hauled to designated centers, or whether mixed materials will be collected by a waste hauler and removed from the site).
- k. Copy of training plan for subcontractors and other services to prevent contamination by co-mingling materials identified for diversion and waste materials.

1.6 DISPOSAL

Control accumulation of waste materials and trash. Recycle or dispose of collected materials off-site at intervals approved by the Contracting Officer and in compliance with waste management procedures as described in the waste management plan. Except as otherwise specified in other sections of the specifications, dispose of in accordance with the following:

1.6.1 Reuse

Give first consideration to reusing construction and demolition materials as a disposition strategy. Recover for reuse materials, products, and components as described in the approved Construction Waste Management Plan. Coordinate with the Contracting Officer to identify onsite reuse opportunities or material sales or donation available through Government resale or donation programs. Sale of recovered materials is not allowed on the Installation. Consider the use of surplus industrial supply broker services, who match entities with reusable or repurpose industrial materials with entities with need of such materials.

1.6.2 Recycle

Recycle non-hazardous construction and demolition/debris materials that are not suitable for reuse. Track rejection of contaminated recyclable materials by the recycling facility. Rejected recyclables materials will not be counted as a percentage of diversion calculation. Recycle all fluorescent lamps, HID lamps, mercury (Hg) -containing thermostats and ampoules, and PCBs-containing ballasts and electrical components as directed by the Contracting Officer. Do not crush lamps on site as this creates a hazardous waste stream with additional handling requirements.

1.6.3 Waste

Dispose by landfill or incineration only those waste materials with no practical use, economic benefit, or recycling opportunity.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used. -- End of Section --

SECTION 01 78 23

OPERATION AND MAINTENANCE DATA

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.

ASTM INTERNATIONAL (ASTM)

ASTM E1971

(2005; R 2011) Standard Guide for
Stewardship for the Cleaning of Commercial
and Institutional Buildings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-10 Operation and Maintenance Data

O&M Database; G

Training Plan; G

Training Outline; G

Training Content; G

SD-11 Closeout Submittals

Training Video Recording; G

Validation of Training Completion; G

1.3 OPERATION AND MAINTENANCE DATA

Submit Operation and Maintenance (O&M) Data for the provided equipment, product, or system, defining the importance of system interactions, troubleshooting, and long-term preventive operation and maintenance. Compile, prepare, and aggregate O&M data to include clarifying and updating the original sequences of operation to as-built conditions. Organize and present information in sufficient detail to clearly explain O&M requirements at the system, equipment, component, and subassembly level. Include an index preceding each submittal. Submit in accordance with this section and Section 01 33 00 SUBMITTAL PROCEDURES.

1.3.1 Package Quality

Documents must be fully legible. Operation and Maintenance data must be consistent with the manufacturer's standard brochures, schematics, printed instructions, general operating procedures, and safety precautions.

1.3.2 Package Content

Provide data package content in accordance with paragraph SCHEDULE OF OPERATION AND MAINTENANCE DATA PACKAGES. Comply with the data package requirements specified in the individual technical sections, including the content of the packages and addressing each product, component, and system designated for data package submission, except as follows. Use Data Package for commissioned items without a specified data package requirement in the individual technical sections. Provide a Data Package instead of Data Package 1 or 2, as specified in the individual technical section, for items that are commissioned.

1.3.3 Changes to Submittals

Provide manufacturer-originated changes or revisions to submitted data if a component of an item is so affected subsequent to acceptance of the O&M Data. Submit changes, additions, or revisions required by the Contracting Officer for final acceptance of submitted data within 30 calendar days of the notification of this change requirement.

1.3.4 Commissioning Authority Review and Approval

Submit the commissioned systems and equipment submittals to the Commissioning Authority (CxA) to review for completeness and applicability. Obtain validation from the CxA that the systems and equipment provided meet the requirements of the Contract documents and design intent, particularly as they relate to functionality, energy performance, water performance, maintainability, sustainability, system cost, indoor environmental quality, and local environmental impacts. The CxA communicates deficiencies to the Contracting Officer. Submit the O&M manuals to the Contracting Officer upon a successful review of the corrections, and with the CxA recommendation for approval and acceptance of these O&M manuals. This work is in addition to the normal review procedures for O&M data.

1.4 O&M DATABASE

Develop an editable, electronic spreadsheet based on the equipment in the Operation and Maintenance Manuals that contains the information required to start a preventive maintenance program. As a minimum, provide list of system equipment, location installed, warranty expiration date, manufacturer, model, and serial number.

1.5 OPERATION AND MAINTENANCE MANUAL FILE FORMAT

Assemble data packages into electronic Operation and Maintenance Manuals. Assemble each manual into a composite electronically indexed file using the most current version of Adobe Acrobat or similar software capable of producing PDF file format. Provide compact disks (CD) or data digital versatile disk (DVD) as appropriate, so that each one contains operation, maintenance and record files, project record documents, and training videos. Include a complete electronically linked operation and maintenance directory.

1.5.1 Organization

Bookmark Product and Drawing Information documents using the current version of CSI MasterFormat numbering system, and arrange submittals using the specification sections as a structure. Use CSI MasterFormat and UFGS numbers along with descriptive bookmarked titles that explain the content of the information that is being bookmarked.

1.5.2 CD or DVD Label and Disk Holder or Case

Provide the following information on the disk label and disk holder or case:

- a. Building Number
- b. Project Title
- c. Activity and Location
- d. Construction Contract Number
- e. Prepared For: (Contracting Agency)
- f. Prepared By: (Name, title, phone number and email address)
- g. Include the disk content on the disk label
- h. Date
- i. Virus scanning program used

1.6 TYPES OF INFORMATION REQUIRED IN O&M DATA PACKAGES

The following are a detailed description of the data package items listed in paragraph SCHEDULE OF OPERATION AND MAINTENANCE DATA PACKAGES.

1.6.1 Operating Instructions

Provide specific instructions, procedures, and illustrations for the following phases of operation for the installed model and features of each system:

1.6.1.1 Safety Precautions and Hazards

List personnel hazards and equipment or product safety precautions for operating conditions. Provide recommended safeguards for each identified hazard.

1.6.1.2 Operator Prestart

Provide procedures required to install, set up, and prepare each system for use.

1.6.1.3 Startup, Shutdown, and Post-Shutdown Procedures

Provide narrative description for Startup, Shutdown and Post-shutdown operating procedures including the control sequence for each procedure.

1.6.1.4 Normal Operations

Provide Control Diagrams with data to explain operation and control of systems and specific equipment. Provide narrative description of Normal Operating Procedures.

1.6.1.5 Emergency Operations

Provide Emergency Procedures for equipment malfunctions to permit a short period of continued operation or to shut down the equipment to prevent further damage to systems and equipment. Provide Emergency Shutdown Instructions for fire, explosion, spills, or other foreseeable contingencies. Provide guidance and procedures for emergency operation of utility systems including required valve positions, valve locations and zones or portions of systems controlled.

1.6.1.6 Operator Service Requirements

Provide instructions for services to be performed by the operator such as lubrication, adjustment, inspection, and recording gauge readings.

1.6.1.7 Environmental Conditions

Provide a list of Environmental Conditions (temperature, humidity, and other relevant data) that are best suited for the operation of each product, component or system. Describe conditions under which the item equipment should not be allowed to run.

1.6.1.8 Operating Log

Provide forms, sample logs, and instructions for maintaining necessary operating records.

1.6.1.9 Additional Requirements for HVAC Control Systems

Provide Data Package 5 and the following for control systems:

- a. Narrative description on how to perform and apply functions, features, modes, and other operations, including unoccupied operation, seasonal changeover, manual operation, and alarms. Include detailed technical manual for programming and customizing control loops and algorithms.
- b. Full as-built sequence of operations.
- c. Copies of checkout tests and calibrations performed by the Contractor (not Cx tests).
- d. Full points list. Provide a listing of rooms with the following information for each room:
 - (1) Floor
 - (2) Room number
 - (3) Room name
 - (4) Air handler unit ID
 - (5) Reference drawing number

- (6) Air terminal unit tag ID
- (7) Heating or cooling valve tag ID
- (8) Minimum cfm
- (9) Maximum cfm
- e. Full print out of all schedules and set points after testing and acceptance of the system.
- f. Full as-built print out of software program.
- g. Marking of system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations.

1.6.2 Preventive Maintenance

Provide the following information for preventive and scheduled maintenance to minimize repairs for the installed model and features of each system. Include potential environmental and indoor air quality impacts of recommended maintenance procedures and materials.

1.6.2.1 Lubrication Data

Include the following preventive maintenance lubrication data, in addition to instructions for lubrication required under paragraph OPERATOR SERVICE REQUIREMENTS:

- a. A table showing recommended lubricants for specific temperature ranges and applications.
- b. Charts with a schematic diagram of the equipment showing lubrication points, recommended types and grades of lubricants, and capacities.
- c. A Lubrication Schedule showing service interval frequency.

1.6.2.2 Preventive Maintenance Plan, Schedule, and Procedures

Provide manufacturer's schedule for routine preventive maintenance, inspections, condition monitoring (predictive tests) and adjustments required to ensure proper and economical operation and to minimize repairs. Provide instructions stating when the systems should be retested. Provide manufacturer's projection of preventive maintenance work-hours on a daily, weekly, monthly, and annual basis including craft requirements by type of craft. For periodic calibrations, provide manufacturer's specified frequency and procedures for each separate operation.

- a. Define the anticipated time required to perform each of each test (work-hours), test apparatus, number of personnel identified by responsibility, and a testing validation procedure permitting the record operation capability requirements within the schedule. Provide a remarks column for the testing validation procedure referencing operating limits of time, pressure, temperature, volume, voltage, current, acceleration, velocity, alignment, calibration, adjustments, cleaning, or special system notes. Delineate procedures for preventive maintenance, inspection, adjustment, lubrication and

cleaning necessary to minimize repairs.

- b. Repair requirements must inform operators how to check out, troubleshoot, repair, and replace components of the system. Include electrical and mechanical schematics and diagrams and diagnostic techniques necessary to enable operation and troubleshooting of the system after acceptance.

1.6.2.3 Cleaning Recommendations

Provide environmentally preferable cleaning recommendations in accordance with ASTM E1971.

1.6.3 Repair

Provide manufacturer's recommended procedures and instructions for correcting problems and making repairs for the installed model and features of each system. Include potential environmental and indoor air quality impacts of recommended maintenance procedures and materials.

1.6.3.1 Troubleshooting Guides and Diagnostic Techniques

Provide step-by-step procedures to promptly isolate the cause of typical malfunctions. Describe clearly why the checkout is performed and what conditions are to be sought. Identify tests or inspections and test equipment required to determine whether parts and equipment may be reused or require replacement.

1.6.3.2 Wiring Diagrams and Control Diagrams

Provide point-to-point drawings of wiring and control circuits including factory-field interfaces. Provide a complete and accurate depiction of the actual job specific wiring and control work. On diagrams, number electrical and electronic wiring and pneumatic control tubing and the terminals for each type, identically to actual installation configuration and numbering.

1.6.3.3 Repair Procedures

Provide instructions and a list of tools required to repair or restore the product or equipment to proper condition or operating standards.

1.6.3.4 Removal and Replacement Instructions

Provide step-by-step procedures and a list of required tools and supplies for removal, replacement, disassembly, and assembly of components, assemblies, subassemblies, accessories, and attachments. Provide tolerances, dimensions, settings and adjustments required. Use a combination of text and illustrations.

1.6.3.5 Spare Parts and Supply Lists

Provide lists of spare parts and supplies required for repair to ensure continued service or operation without unreasonable delays. Special consideration is required for facilities at remote locations. List spare parts and supplies that have a long lead-time to obtain.

1.6.3.6 Repair Work-Hours

Provide manufacturer's projection of repair work-hours including requirements by type of craft. Identify, and tabulate separately, repair that requires the equipment manufacturer to complete or to participate.

1.6.4 Real Property Equipment

Provide a list of installed equipment furnished under this contract. Include all information usually listed on manufacturer's name plate. In the "EQUIPMENT-IN-PLACE LIST" 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. Submit the final list 30 days after transfer of the completed facility.

Key the designations to the related area depicted on the contract drawings. 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

1.6.5 Appendices

Provide information required below and information not specified in the preceding paragraphs but pertinent to the maintenance or operation of the product or equipment. Include the following:

1.6.5.1 Product Submittal Data

Provide a copy of SD-03 Product Data submittals documented with the required approval.

1.6.5.2 Certificates

Provide a copy of SD-07 Certificates submittals documented with the required approval.

1.6.5.3 Manufacturer's Instructions

Provide a copy of SD-08 Manufacturer's Instructions submittals documented with the required approval.

1.6.5.4 O&M Submittal Data

Provide a copy of SD-10 Operation and Maintenance Data submittals documented with the required approval.

1.6.5.5 Parts Identification

Provide identification and coverage for the parts of each component,

assembly, subassembly, and accessory of the end items subject to replacement. Include special hardware requirements, such as requirement to use high-strength bolts and nuts. Identify parts by make, model, serial number, and source of supply to allow reordering without further identification. Provide clear and legible illustrations, drawings, and exploded views to enable easy identification of the items. When illustrations omit the part numbers and description, both the illustrations and separate listing must show the index, reference, or key number that will cross-reference the illustrated part to the listed part. Group the parts shown in the listings by components, assemblies, and subassemblies in accordance with the manufacturer's standard practice. Parts data may cover more than one model or series of equipment, components, assemblies, subassemblies, attachments, or accessories, such as typically shown in a master parts catalog.

1.6.5.6 Warranty Information

List and explain the various warranties and clearly identify the servicing and technical precautions prescribed by the manufacturers or contract documents in order to keep warranties in force. Include warranty information for primary components of the system. Provide copies of all warranties.

1.6.5.7 Extended Warranty Information

List all warranties for products, equipment, components, and sub-components whose duration exceeds one year. For each warranty listed, indicate the applicable specification section, duration, start date, end date, and the point of contact for warranty fulfillment. Also, list or reference the specific operation and maintenance procedures that must be performed to keep the warranty valid. Provide copies of all warranties.

1.6.5.8 Personnel Training Requirements

Provide information available from the manufacturers that is needed for use in training designated personnel to properly operate and maintain the equipment and systems.

1.6.5.9 Testing Equipment and Special Tool Information

Include information on test equipment required to perform specified tests and on special tools needed for the operation, maintenance, and repair of components. Provide final set points.

1.6.5.10 Testing and Performance Data

Include completed prefunctional checklists, functional performance test forms, and monitoring reports. Include recommended schedule for retesting and blank test forms. Provide final set points.

1.6.5.11 Field Test Reports and Manufacturer's Field Reports

Provide a copy of Field Test Reports (SD-06) and Manufacturer's Field Reports (SD-09) submittals documented with the required approval.

1.6.5.12 Contractor Information

Provide a list that includes the name, address, and telephone number of the General Contractor and each Subcontractor who installed the product or

equipment, or system. For each item, also provide the name address and telephone number of the manufacturer's representative and service organization that can provide replacements most convenient to the project site. Provide the name, address, and telephone number of the product, equipment, and system manufacturers.

1.7 SCHEDULE OF OPERATION AND MAINTENANCE DATA PACKAGES

Provide the O&M data packages specified in individual technical sections. The information required in each type of data package follows:

1.7.1 Data Package 1

- a. Safety precautions and hazards
- b. Cleaning recommendations
- c. Maintenance and repair procedures
- d. Warranty information
- e. Extended warranty information
- f. Contractor information
- g. Spare parts and supply list

1.7.2 Data Package 2

- a. Safety precautions and hazards
- b. Normal operations
- c. Environmental conditions
- d. Lubrication data
- e. Preventive maintenance plan, schedule, and procedures
- f. Cleaning recommendations
- g. Maintenance and repair procedures
- h. Removal and replacement instructions
- i. Spare parts and supply list
- j. Parts identification
- k. Warranty information
- l. Extended warranty information
- m. Contractor information

1.7.3 Data Package 3

- a. Safety precautions and hazards

- b. Operator prestart
- c. Startup, shutdown, and post-shutdown procedures
- d. Normal operations
- e. Emergency operations
- f. Environmental conditions
- g. Operating log
- h. Lubrication data
- i. Preventive maintenance plan, schedule, and procedures
- j. Cleaning recommendations
- k. Troubleshooting guides and diagnostic techniques
- l. Wiring diagrams and control diagrams
- m. Maintenance and repair procedures
- n. Removal and replacement instructions
- o. Spare parts and supply list
- p. Product submittal data
- q. O&M submittal data
- r. Parts identification
- s. Warranty information
- t. Extended warranty information
- u. Testing equipment and special tool information
- v. Testing and performance data
- w. Contractor information
- x. Field test reports

1.7.4 Data Package 4

- a. Safety precautions and hazards
- b. Operator prestart
- c. Startup, shutdown, and post-shutdown procedures
- d. Normal operations
- e. Emergency operations
- f. Operator service requirements

- g. Environmental conditions
- h. Operating log
- i. Lubrication data
- j. Preventive maintenance plan, schedule, and procedures
- k. Cleaning recommendations
- l. Troubleshooting guides and diagnostic techniques
- m. Wiring diagrams and control diagrams
- n. Repair procedures
- o. Removal and replacement instructions
- p. Spare parts and supply list
- q. Repair work-hours
- r. Product submittal data
- s. O&M submittal data
- t. Parts identification
- u. Warranty information
- v. Extended warranty information
- w. Personnel training requirements
- x. Testing equipment and special tool information
- y. Testing and performance data
- z. Contractor information
- aa. Field test reports

1.7.5 Data Package 5

- a. Safety precautions and hazards
- b. Operator prestart
- c. Start-up, shutdown, and post-shutdown procedures
- d. Normal operations
- e. Environmental conditions
- f. Preventive maintenance plan, schedule, and procedures
- g. Troubleshooting guides and diagnostic techniques

- h. Wiring and control diagrams
- i. Maintenance and repair procedures
- j. Removal and replacement instructions
- k. Spare parts and supply list
- l. Product submittal data
- m. Manufacturer's instructions
- n. O&M submittal data
- o. Parts identification
- p. Testing equipment and special tool information
- q. Warranty information
- r. Extended warranty information
- s. Testing and performance data
- t. Contractor information
- u. Field test reports
- v. Additional requirements for HVAC control systems

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 TRAINING

Prior to acceptance of the facility by the Contracting Officer for Beneficial Occupancy, provide comprehensive training for the systems and equipment specified in the technical specifications. The training must be targeted for the building maintenance personnel, and applicable building occupants. Instructors must be well-versed in the particular systems that they are presenting. Training must include classroom or field lectures based on the system operating requirements. The location of classroom training requires approval by the Contracting Officer.

3.1.1 Training Plan

Submit a written training plan to the Contracting Officer for approval at least 60 calendar days prior to the scheduled training. Training plan must be approved by the [Commissioning Authority \(CxA\)](#) prior to forwarding to the Contracting Officer. Also, coordinate the training schedule with the Contracting Officer and [CxA](#). Include within the plan the following elements:

- a. Equipment included in training
- b. Intended audience

- c. Location of training
- d. Dates of training
- e. Objectives
- f. Outline of the information to be presented and subjects covered including description
- g. Start and finish times and duration of training on each subject
- h. Methods (e.g. classroom lecture, video, site walk-through, actual operational demonstrations, written handouts)
- i. Instructor names and instructor qualifications for each subject
- j. List of texts and other materials to be furnished by the Contractor that are required to support training
- k. Description of proposed software to be used for video recording of training sessions.

3.1.2 Training Content

The core of this training must be based on manufacturer's recommendations and the operation and maintenance information. The CxA is responsible for overseeing and approving the content and adequacy of the training. Spend 95 percent of the instruction time during the presentation on the OPERATION AND MAINTENANCE DATA. Include the following for each system training presentation:

- a. Start-up, normal operation, shutdown, unoccupied operation, seasonal changeover, manual operation, controls set-up and programming, troubleshooting, and alarms.
- b. Relevant health and safety issues.
- c. Discussion of how the feature or system is environmentally responsive. Advise adjustments and optimizing methods for energy conservation.
- d. Design intent.
- e. Use of O&M Manual Files.
- f. Review of control drawings and schematics.
- g. Interactions with other systems.
- h. Special maintenance and replacement sources.
- i. Tenant interaction issues.

3.1.3 Training Outline

Provide the Operation and Maintenance Manual Files (Bookmarked PDF) and a written course outline listing the major and minor topics to be discussed by the instructor on each day of the course to each trainee in the

course. Provide the course outline 14 calendar days prior to the training.

3.1.4 Training Video Recording

Record classroom training session(s) on video. Provide to the Contracting Officer two copies of the training session(s) in DVD video recording format. Capture within the recording, in video and audio, the instructors' training presentations including question and answer periods with the attendees. The recording camera(s) must be attended by a person during the recording sessions to assure proper size of exhibits and projections during the recording are visible and readable when viewed as training.

3.1.5 Unresolved Questions from Attendees

If, at the end of the training course, there are questions from attendees that remain unresolved, the instructor must send the answers, in writing, to the Contracting Officer for transmittal to the attendees, and the training video must be modified to include the appropriate clarifications.

3.1.6 Validation of Training Completion

Ensure that each attendee at each training session signs a class roster daily to confirm Government participation in the training. At the completion of training, submit a signed validation letter that includes a sample record of training for reporting what systems were included in the training, who provided the training, when and where the training was performed, and copies of the signed class rosters. Provide two copies of the validation to the Contracting Officer, and one copy to the Operation and Maintenance Manual Preparer for inclusion into the Manual's documentation.

3.1.7 Quality Control Coordination

Coordinate this training with the CxA in accordance with Section 01 45 00.00 40 QUALITY CONTROL.

-- End of Section --

SECTION 02 41 00

DEMOLITION

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 OF SAFETY PROFESSIONALS (ASSP)

ASSP A10.6 (2006) Safety & Health Program
Requirements for Demolition Operations -
American National Standard for
Construction and Demolition Operations

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1 (2014) Safety -- Safety and Health
Requirements Manual

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

FAA AC 70/7460-1 (2016; Rev L; Change 2) Obstruction
Marking and Lighting

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 61 National Emission Standards for Hazardous
Air Pollutants

1.2 PROJECT DESCRIPTION

1.2.1 Definitions

1.2.1.1 Demolition

Demolition is the process of wrecking or taking out any load-supporting structural member of a facility together with any related handling and disposal operations.

1.2.1.2 Demolition Plan

Demolition Plan is the planned steps and processes for managing demolition activities and identifying the required sequencing activities and disposal mechanisms.

1.2.2 Demolition

Prepare a [Demolition Plan](#) and submit proposed demolition, and removal procedures for approval before work is started. Include in the plan procedures for careful removal and disposition of materials specified to be salvaged, coordination with other work in progress, a disconnection schedule of utility services, a detailed description of methods and

equipment to be used for each operation and of the sequence of operations. Identify components and materials to be salvaged for reuse or recycling with reference to paragraph Existing Facilities to be Removed. Append tracking forms for all removed materials indicating type, quantities, condition, destination, and end use. Coordinate with Waste Management Plan in accordance with Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL. Provide procedures for safe conduct of the work in accordance with EM 385-1-1. Plan shall be approved by Contracting Officer prior to work beginning.

1.2.3 General Requirements

Do not begin demolition until authorization is received from the Contracting Officer. The work of this section is to be performed in a manner that maximizes the value derived from the salvage and recycling of materials. Remove rubbish and debris from the project site; do not allow accumulations inside or outside the building. The work includes demolition, salvage of identified items and materials, and removal of resulting rubbish and debris. Remove rubbish and debris from Government property daily, unless otherwise directed. Store materials that cannot be removed daily in areas specified by the Contracting Officer. In the interest of occupational safety and health, perform the work in accordance with EM 385-1-1, Section 23, Demolition, and other applicable Sections.

1.3 ITEMS TO REMAIN IN PLACE

Take necessary precautions to avoid damage to existing items to remain in place, to be reused, or to remain the property of the Government. Repair or replace damaged items as approved by the Contracting Officer. Coordinate the work of this section with all other work indicated. Construct and maintain shoring, bracing, and supports as required. Ensure that structural elements are not overloaded. Increase structural supports or add new supports as may be required as a result of any cutting, removal, deconstruction, or demolition work performed under this contract. Do not overload structural elements or pavements to remain. Provide new supports and reinforcement for existing construction weakened by demolition, deconstruction, or removal work. Repairs, reinforcement, or structural replacement require approval by the Contracting Officer prior to performing such work.

1.3.1 Existing Construction Limits and Protection

Do not disturb existing construction beyond the extent indicated or necessary for installation of new construction. Provide protective measures to control accumulation and migration of dust and dirt in all work areas. Remove dust, dirt, and debris from work areas daily.

1.3.2 Weather Protection

For portions of the building to remain, protect building interior and materials and equipment from the weather at all times. Where removal of existing roofing is necessary to accomplish work, have materials and workmen ready to provide adequate and temporary covering of exposed areas.

1.3.3 Utility Service

Maintain existing utilities indicated to stay in service and protect against damage during demolition operations. Prior to start of work, utilities serving each area of alteration or removal will be shut off by

the Government and disconnected and sealed by the Contractor.

1.3.4 Facilities

Protect electrical and mechanical services and utilities. Where removal of existing utilities and pavement is specified or indicated, provide approved barricades, temporary covering of exposed areas, and temporary services or connections for electrical and mechanical utilities. 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, must remain standing without additional bracing, shoring, or lateral support until demolished or deconstructed, unless directed otherwise by the Contracting Officer. Ensure that no elements determined to be unstable are left unsupported and place and secure bracing, shoring, or lateral supports as may be required as a result of any cutting, removal, deconstruction, or demolition work performed under this contract.

1.4 BURNING

The use of burning at the project site for the disposal of refuse and debris will not be permitted. Where burning is permitted, adhere to federal, state, and local regulations.

1.5 AVAILABILITY OF WORK AREAS

Areas in which the work is to be accomplished will be required detailed and work area planning and phasing to safely and effectively facilitate continuous operation of the installation's Base Exchange and Commissary operations on the front side, inside, and back side (truck dock delivery areas) throughout the duration of the project. The contractor will need to coordinate routinely with the the Contracting Officers's Representative and designated facility management to control vehicle and pedestrian traffic(both indoor and outdoor and cordon off work areas in increments to allow retail operations to continue as much as possible. A detailed plan of work areas and restrictive safety barricading planned shall be submitted for reviewby the contracting officer's team 30 days prior to the first area barricade installation. The contractor shall submit an initial plan framework listing areas and approximate dates and durations projected for each area configuration within 15 days of contract award, for consideration by Base Exchange Management, Base Civil Engineer, Security Forces, and the Fire Marshall accordance with the following schedule:

Schedule	
Area	Date and estimated duration

Schedule	

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Demolition Plan; G

Existing Conditions

SD-07 Certificates

Notification; G

1.7 QUALITY ASSURANCE

Submit timely notification of demolition projects to Federal, State, regional, and local authorities in accordance with 40 CFR 61, Subpart M. Notify the Contracting Officer in writing 10 working days prior to the commencement of work in accordance with 40 CFR 61, Subpart M. Comply with federal, state, and local hauling and disposal regulations. In addition to the requirements of the "Contract Clauses," conform to the safety requirements contained in ASSP A10.6. Comply with the Environmental Protection Agency requirements specified. Use of explosives will not be permitted.

1.7.1 Dust and Debris Control

Prevent the spread of dust and debris to occupied portions of the building and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution.

1.8 PROTECTION

1.8.1 Traffic Control Signs

- a. Where pedestrian and driver safety is endangered in the area of

removal work, use traffic barricades with flashing lights. Anchor barricades in a manner to prevent displacement by wind. Notify the Contracting Officer prior to beginning such work.

Provide a minimum of 2 FAA type L-810 steady burning red obstruction lights on temporary structures (including cranes) over 100 feet, but less than 200 ft, above ground level. The use of LED based obstruction lights are not permitted. For temporary structures (including cranes) over 200 ft above ground level provide obstruction lighting in accordance with FAA AC 70/7460-1. Light construction and installation shall comply with FAA AC 70/7460-1. Lights shall be operational during periods of reduced visibility, darkness, and as directed by the Contracting Officer. Maintain the temporary services during the period of construction and remove only after permanent services have been installed and tested and are in operation.

1.8.2 Protection of Personnel

Before, during and after the demolition work continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the project 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.

1.9 FOREIGN OBJECT DAMAGE (FOD)

Aircraft and aircraft engines are subject to FOD from debris and waste material lying on airfield pavements. Remove all such materials that may appear on operational aircraft pavements due to the Contractor's operations. If necessary, the Contracting Officer may require the Contractor to install a temporary barricade at the Contractor's expense to control the spread of FOD potential debris. The barricade shall include a fence covered with a fabric designed to stop the spread of debris. Anchor the fence and fabric to prevent displacement by winds or jet/prop blasts. Remove barricade when no longer required.

1.10 RELOCATIONS

Perform the removal and reinstallation of relocated items as indicated with workmen skilled in the trades involved. Repair or replace items to be relocated which are damaged by the Contractor with new undamaged items as approved by the Contracting Officer.

1.11 EXISTING CONDITIONS

Before beginning any demolition or deconstruction work, survey the site and examine the drawings and specifications to determine the extent of the work. Record existing conditions in the presence of the Contracting Officer showing the condition of structures and other facilities adjacent to areas of alteration or removal. Photographs sized 4 inch will be acceptable as a record of existing conditions. Include in the record the elevation of the top of foundation walls, finish floor elevations, possible conflicting electrical conduits, plumbing lines, alarms systems, the location and extent of existing cracks and other damage and description of surface conditions that exist prior to before starting work. It is the Contractor's responsibility to verify and document all

required outages which will be required during the course of work, and to note these outages on the record document. Submit survey results.

PART 2 PRODUCTS

2.1 FILL MATERIAL

- a. Comply with excavating, backfilling, and compacting procedures for soils used as backfill material to fill basements, voids, depressions or excavations resulting from demolition or deconstruction of structures. *Fill material shall be waste products from demolition or deconstruction until all waste appropriate for this purpose is consumed.*
- b. *Fill and backfill material shall comply with Section 31 00 00 EARTHWORK.*

PART 3 EXECUTION

3.1 EXISTING FACILITIES TO BE REMOVED

Inspect and evaluate existing structures onsite for reuse. Existing construction scheduled to be removed for reuse shall be disassembled. Dismantled and removed materials are to be separated, set aside, and prepared as specified, and stored or delivered to a collection point for reuse, remanufacture, recycling, or other disposal, as specified. Materials shall be designated for reuse onsite whenever possible.

3.1.1 Structures

- a. Remove existing structures indicated to be removed *in their entirety*. Remove sidewalks, curbs, gutters and *pavements* as indicated.

3.1.2 Utilities and Related Equipment

3.1.2.1 General Requirements

Do not interrupt existing utilities serving occupied or used facilities, except when authorized in writing by the Contracting Officer. Do not interrupt existing utilities serving facilities occupied and used by the Government except when approved in writing and then only after temporary utility services have been approved and provided. Do not begin demolition or deconstruction work until all utility disconnections have been made. Shut off and cap utilities for future use, as indicated.

3.1.2.2 Disconnecting Existing Utilities

Remove existing utilities, as indicated and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by the Contracting Officer. When utility lines are encountered but are not indicated on the drawings, notify the Contracting Officer prior to further work in that area.

3.1.3 Fencing

Remove fencing, and transport to designated areas.

3.1.4 Paving and Slabs

Remove concrete and asphaltic concrete paving and slabs including

aggregate base as indicated. Provide neat sawcuts at limits of pavement removal as indicated. Pavement and slabs designated to be recycled and utilized in this project shall be moved, ground and stored as directed by the Contracting Officer. Pavement and slabs not to be used in this project shall be removed from the project site at Contractor's expense.

3.1.5 Patching

Where removals leave holes and damaged surfaces exposed in the finished work, patch and repair these holes and damaged surfaces to match adjacent finished surfaces, using on-site materials when available. Where new work is to be applied to existing surfaces, perform removals and patching in a manner to produce surfaces suitable for receiving new work. Finished surfaces of patched area shall be flush with the adjacent existing surface and shall match the existing adjacent surface as closely as possible as to texture and finish.

3.1.6 Mechanical Equipment and Fixtures

Disconnect mechanical hardware at the nearest connection to existing services to remain, unless otherwise noted. Disconnect mechanical equipment and fixtures at fittings. Remove service valves attached to the unit. Salvage each item of equipment and fixtures as a whole unit; listed, indexed, tagged, and stored. Salvage each unit with its normal operating auxiliary equipment. Transport salvaged equipment and fixtures, including motors and machines, to a designated storage area as directed by the Contracting Officer. Do not remove equipment until approved. Do not offer low-efficiency equipment for reuse.

3.1.6.1 Preparation for Storage

Remove water, dirt, dust, and foreign matter from units; tanks, piping and fixtures shall be drained; interiors, if previously used to store flammable, explosive, or other dangerous liquids, shall be steam cleaned. Seal openings with caps, plates, or plugs. Secure motors attached by flexible connections to the unit. Change lubricating systems with the proper oil or grease.

3.1.6.2 Piping

Disconnect piping at unions, flanges and valves, and fittings as required to reduce the pipe into straight lengths for practical storage. Store salvaged piping according to size and type. If the piping that remains can become pressurized due to upstream valve failure, end caps, blind flanges, or other types of plugs or fittings with a pressure gage and bleed valve shall be attached to the open end of the pipe to ensure positive leak control. Carefully dismantle piping that previously contained gas, gasoline, oil, or other dangerous fluids, with precautions taken to prevent injury to persons and property. Store piping outdoors until all fumes and residues are removed. Box prefabricated supports, hangers, plates, valves, and specialty items according to size and type. Wrap sprinkler heads individually in plastic bags before boxing. Classify piping not designated for salvage, or not reusable, as scrap metal.

3.1.6.3 Ducts

Classify removed duct work as scrap metal.

3.1.6.4 Fixtures, Motors and Machines

Remove and salvage fixtures, motors and machines associated with plumbing, heating, air conditioning, refrigeration, and other mechanical system installations. Salvage, box and store auxiliary units and accessories with the main motor and machines. Tag salvaged items for identification, storage, and protection from damage. Classify broken, damaged, or otherwise unserviceable units and not caused to be broken, damaged, or otherwise unserviceable as debris to be disposed of by the Contractor.

3.1.7 Electrical Equipment and Fixtures

Salvage motors, motor controllers, and operating and control equipment that are attached to the driven equipment. Salvage wiring systems and components. Box loose items and tag for identification. Disconnect primary, secondary, control, communication, and signal circuits at the point of attachment to their distribution system.

3.1.7.1 Fixtures

Remove and salvage electrical fixtures. Salvage unprotected glassware from the fixture and salvage separately. Salvage incandescent, mercury-vapor, and fluorescent lamps and fluorescent ballasts manufactured prior to 1978, boxed and tagged for identification, and protected from breakage.

3.1.7.2 Electrical Devices

Remove and salvage switches, switchgear, transformers, conductors including wire and nonmetallic sheathed and flexible armored cable, regulators, meters, instruments, plates, circuit breakers, panelboards, outlet boxes, and similar items. Box and tag these items for identification according to type and size.

3.1.7.3 Wiring Ducts or Troughs

Remove and salvage wiring ducts or troughs. Dismantle plug-in ducts and wiring troughs into unit lengths. Remove plug-in or disconnecting devices from the busway and store separately.

3.1.7.4 Conduit and Miscellaneous Items

Salvage conduit except where embedded in concrete or masonry. Consider corroded, bent, or damaged conduit as scrap metal. Sort straight and undamaged lengths of conduit according to size and type. Classify supports, knobs, tubes, cleats, and straps as debris to be removed and disposed.

3.1.8 Elevators and Hoists

Remove elevators, hoists, and similar conveying equipment and salvage as whole units, to the most practical extent. Remove and prepare items for salvage without damage to any of the various parts. Salvage and store rails for structural steel with the equipment as an integral part of the unit.

3.1.9 Items With Unique/Regulated Disposal Requirements

Remove and dispose of items with unique or regulated disposal requirements

in the manner dictated by law or in the most environmentally responsible manner.

3.2 CONCURRENT EARTH-MOVING OPERATIONS

Do not begin excavation, filling, and other earth-moving operations that are sequential to demolition or deconstruction work in areas occupied by structures to be demolished or deconstructed until all demolition and deconstruction in the area has been completed and debris removed. Fill holes, open basements and other hazardous openings.

3.3 DISPOSITION OF MATERIAL

3.3.1 Title to Materials

All materials and equipment removed and not reused or salvaged, shall become the property of the Contractor and shall be removed from Government property. Title to materials resulting from demolition and deconstruction, and materials and equipment to be removed, is vested in the Contractor upon approval by the Contracting Officer of the Contractor's demolition, deconstruction, and removal procedures, and authorization by the Contracting Officer to begin demolition and deconstruction. The Government will not be responsible for the condition or loss of, or damage to, such property after contract award. Showing for sale or selling materials and equipment on site is prohibited.

3.3.2 Reuse of Materials and Equipment

Remove and store materials and equipment listed in the Demolition Plan to be reused or relocated to prevent damage, and reinstall as the work progresses. Coordinate the re-use of materials and equipment with the re-use requirements in accordance with Section 01 74 19 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL. Capture re-use of materials in the diversion calculations for the project.

3.4 CLEANUP

Remove debris and rubbish from project site and similar excavations. Remove and transport the debris in a manner that prevents spillage on streets or adjacent areas. Apply local regulations regarding hauling and disposal.

3.5 DISPOSAL OF REMOVED MATERIALS

3.5.1 Regulation of Removed Materials

Dispose of debris, rubbish, scrap, and other nonsalvageable materials resulting from removal operations with all applicable federal, state and local regulations as contractually specified off the installation. Storage of removed materials on the project site is prohibited.

3.5.2 Burning on Government Property

Burning of materials removed from demolished and deconstructed structures will not be permitted on Government property.

3.5.3 Removal from Government Property

Transport waste materials removed from demolished and deconstructed

structures, except waste soil, from Government property for legal disposal. Dispose of waste soil as directed.

3.6 REUSE OF SALVAGED ITEMS

Recondition salvaged materials and equipment designated for reuse before installation. Replace items damaged during removal and salvage operations or restore them as necessary to usable condition.

-- End of Section --

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

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 CONCRETE INSTITUTE (ACI)

ACI 117	(2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary
ACI 121R	(2008) Guide for Concrete Construction Quality Systems in Conformance with ISO 9001
ACI 301	(2016) Specifications for Structural Concrete
ACI 302.1R	(2015) Guide for Concrete Floor and Slab Construction
ACI 304.2R	(2017) Guide to Placing Concrete by Pumping Methods
ACI 304R	(2000; R 2009) Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305.1	(2014) Specification for Hot Weather Concreting
ACI 305R	(2020) Guide to Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting
ACI 306R	(2016) Guide to Cold Weather Concreting
ACI 308.1	(2011) Specification for Curing Concrete
ACI 347R	(2014; Errata 1 2017) Guide to Formwork for Concrete
ACI SP-2	(2007; Abstract: 10th Edition) ACI Manual of Concrete Inspection
ACI SP-15	(2011) Field Reference Manual: Standard Specifications for Structural Concrete ACI 301-05 with Selected ACI References

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.4 (1995; R 2004) Basic Hardboard

ASTM INTERNATIONAL (ASTM)

ASTM A615/A615M (2022) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

ASTM A934/A934M (2022) Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars

ASTM A1064/A1064M (2022) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

ASTM C31/C31M (2022) Standard Practice for Making and Curing Concrete Test Specimens in the Field

ASTM C33/C33M (2018) Standard Specification for Concrete Aggregates

ASTM C39/C39M (2021) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

ASTM C42/C42M (2020) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

ASTM C78/C78M (2022) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

ASTM C94/C94M (2022a) Standard Specification for Ready-Mixed Concrete

ASTM C136/C136M (2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM C138/C138M (2017a) Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

ASTM C143/C143M (2020) Standard Test Method for Slump of Hydraulic-Cement Concrete

ASTM C150/C150M (2022) Standard Specification for Portland Cement

ASTM C172/C172M (2017) Standard Practice for Sampling Freshly Mixed Concrete

ASTM C173/C173M (2016) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

ASTM C231/C231M	(2022) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C311/C311M	(2022) Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete
ASTM C330/C330M	(2017a) Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C494/C494M	(2019; E 2022) Standard Specification for Chemical Admixtures for Concrete
ASTM C567/C567M	(2019) Determining Density of Structural Lightweight Concrete
ASTM C595/C595M	(2021) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2022) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C803/C803M	(2018) Standard Test Method for Penetration Resistance of Hardened Concrete
ASTM C873/C873M	(2015) Standard Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds
ASTM C900	(2015) Standard Test Method for Pullout Strength of Hardened Concrete
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C989/C989M	(2022) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1012/C1012M	(2018b) Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution
ASTM C1017/C1017M	(2013; E 2015) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1074	(2019) Standard Practice for Estimating Concrete Strength by the Maturity Method
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for

Testing Agency Evaluation

ASTM C1107/C1107M	(2020) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C1157/C1157M	(2020a) Standard Performance Specification for Hydraulic Cement
ASTM C1218/C1218M	(2020c) Standard Test Method for Water-Soluble Chloride in Mortar and Concrete
ASTM C1260	(2021) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1293	(2008; R 2015) Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction
ASTM C1567	(2022) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2022) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D5759	(2012; R 2020) Characterization of Coal Fly Ash and Clean Coal Combustion Fly Ash for Potential Uses
ASTM D6690	(2015) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM E96/E96M	(2022a; E 2023) Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials
ASTM E329	(2021) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection
ASTM E1155	(2020) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers
ASTM E1643	(2018a) Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs

ASTM E1745 (2017) Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI 10MSP (2018) Manual of Standard Practice

CRSI RB4.1 (2016) Supports for Reinforcement Used in Concrete

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST PS 1 (2009) DOC Voluntary Product Standard PS 1-07, Structural Plywood

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 104 (1980) Method of Calculation of the Fineness Modulus of Aggregate

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED NC (2013) Leadership in Energy and Environmental Design(tm) New Construction Rating System

1.2 DEFINITIONS

- a. "Cementitious material" as used herein must include all portland cement, pozzolan, fly ash, and slag cement.
- b. "Exposed to public view" means situated so that it can be seen from eye level from a public location after completion of the building. A public location is accessible to persons not responsible for operation or maintenance of the building.
- c. "Chemical admixtures" are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes.
- d. "Supplementary cementing materials" (SCM) include coal fly ash, slag cement, natural or calcined pozzolans, and ultra-fine coal ash when used in such proportions to replace the portland cement that result in improvement to sustainability and durability and reduced cost.
- e. "Design strength" (f'c) is the specified compressive strength of concrete at time(s) specified in this section to meet structural design criteria.
- f. "Mass Concrete" is any concrete system that approaches a maximum temperature of 158 degrees F within the first 72 hours of placement. In addition, it includes all concrete elements with a section thickness of 3 feet or more regardless of temperature.
- g. "Mixture proportioning" is the process of designing concrete mixture proportions to enable it to meet the strength, service life and constructability requirements of the project while minimizing the initial and life-cycle cost.

- h. "Mixture proportions" are the masses or volumes of individual ingredients used to make a unit measure (cubic meter or cubic yard) of concrete.
- i. "Pozzolan" is a siliceous or siliceous and aluminous material, which in itself possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.
- j. "Workability (or consistence)" is the ability of a fresh (plastic) concrete mix to fill the form/mould properly with the desired work (vibration) and without reducing the concrete's quality. Workability depends on water content, chemical admixtures, aggregate (shape and size distribution), cementitious content and age (level of hydration).

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Concrete Curing Plan

Quality Control Plan; G

Quality Control Personnel Certifications; G

Quality Control Organizational Chart

Laboratory Accreditation; G

Form Removal Schedule; G

Maturity Method Data

SD-02 Shop Drawings

Formwork

Reinforcing Steel; G

SD-03 Product Data

Joint Sealants; (LEED NC)

Joint Filler; (LEED NC)

Formwork Materials

Cementitious Materials; (LEED NC)

Vapor Retarder

Concrete Curing Materials

Reinforcement; (LEED NC)

Sealers

Admixtures

Biodegradable Form Release Agent

Pumping Concrete

Finishing Plan

Nonshrink Grout

SD-05 Design Data

Concrete Mix Design; G

Formwork Calculations

SD-06 Test Reports

Concrete Mix Design; G

Fly Ash

Slag Cement

Aggregates

Tolerance Report

Compressive Strength Tests; G

Unit Weight of Structural Concrete

Air Content

Slump Tests

Water

SD-07 Certificates

Reinforcing Bars

VOC Content for Form Release Agents, Curing Compounds, and
Concrete Penetrating Sealers

Safety Data Sheets

Field Testing Technician and Testing Agency

SD-08 Manufacturer's Instructions

Sealers

Joint Sealants; (LEED NC)

Curing Compound

1.4 MODIFICATION OF REFERENCES

Accomplish work in accordance with ACI publications except as modified herein. Consider the advisory or recommended provisions to be mandatory. Interpret reference to the "Building Official," the "Structural Engineer," and the "Architect/Engineer" to mean the Contracting Officer.

1.5 DELIVERY, STORAGE, AND HANDLING

Follow ACI 301, ACI 304R and ASTM A934/A934M requirements and recommendations. Do not deliver concrete until vapor retarder, forms, reinforcement, embedded items, and chamfer strips are in place and ready for concrete placement. Do not store concrete curing compounds or sealers with materials that have a high capacity to adsorb volatile organic compound (VOC) emissions. Do not store concrete curing compounds or sealers in occupied spaces.

1.5.1 Reinforcement

Store reinforcement of different sizes and shapes in separate piles or racks raised above the ground to avoid excessive rusting. Protect from contaminants such as grease, oil, and dirt. Ensure bar sizes can be accurately identified after bundles are broken and tags removed.

1.6 QUALITY ASSURANCE

1.6.1 Design Data

1.6.1.1 Formwork Calculations

ACI 347R. Include design calculations indicating arrangement of forms, sizes and grades of supports (lumber), panels, and related components. Furnish drawings and calculations of shoring and re-shoring methods proposed for floor and roof slabs, spandrel beams, and other horizontal concrete members. Calculations must indicate concrete pressure with both live and dead loads, along with material types.

1.6.1.2 Concrete Mix Design

Sixty days minimum prior to concrete placement, submit a mix design for each strength and type of concrete. Submit a complete list of materials including type; brand; source and amount of cement, supplementary cementitious materials, and admixtures; and applicable reference specifications. Submit mill test and all other test for cement, supplementary cementitious materials, aggregates, and admixtures. Provide documentation of maximum nominal aggregate size, gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Provide mix proportion data using at least three different water-cementitious material ratios for each type of mixture, which produce a range of strength encompassing those required for each type of concrete required. If source material changes, resubmit mix proportion data using revised source material. Provide only materials that have been proven by trial mix studies to meet the requirements of this specification, unless otherwise approved in writing by the

Contracting Officer. Indicate clearly in the submittal where each mix design is used when more than one mix design is submitted. Resubmit data on concrete components if the qualities or source of components changes. Required average strength can be documented by field experience if field strength test data are available and represent a single group of at least 10 consecutive strength tests for one mixture, using materials and conditions similar to those expected for work, and encompassing a period of not less than 45 days. The average of field strength tests shall equal or exceed fcr'. Changes in materials, conditions, and proportions within the test record shall not have been more closely restricted than those for the proposed work. Test records shall not be more than 24 months old. Obtain mix design approval from the contracting officer prior to concrete placement.

1.6.2 Shop Drawings

1.6.2.1 Formwork

Drawings showing details of formwork including, but not limited to; joints, supports, studding and shoring, and sequence of form and shoring removal. Indicate placement schedule, construction, location and method of forming control joints. Include locations of inserts, conduit, sleeves and other embedded items. Reproductions of contract drawings are unacceptable. Submit [form removal schedule](#) indicating element and minimum length of time for form removal.

Design, fabricate, erect, support, brace, and maintain formwork so that it is able to support, without failure, all vertical and lateral loads that may reasonably be anticipated to be applied to the formwork.

1.6.2.2 Reinforcing Steel

Indicate bending diagrams, assembly diagrams, splicing and laps of bars, shapes, dimensions, and details of bar reinforcing, accessories, and concrete cover. Do not scale dimensions from structural drawings to determine lengths of reinforcing bars. Reproductions of contract drawings are unacceptable.

1.6.3 Control Submittals

1.6.3.1 Concrete Curing Plan

Submit proposed materials, methods and duration for curing concrete elements in accordance with [ACI 308.1](#).

1.6.3.2 Pumping Concrete

Submit proposed materials and methods for pumping concrete. Submittal must include mix designs, pumping equipment including type of pump and size and material for pipe, and maximum length and height concrete is to be pumped.

1.6.3.3 Finishing Plan

Submit proposed material and procedures to be used in obtaining the finish for the floors. Include qualification of person to be used for obtaining floor tolerance measurement, description of measuring equipment to be used, and a sketch showing lines and locations the measuring equipment will follow.

1.6.3.4 VOC Content for form release agents, curing compounds, and concrete penetrating sealers

Submit certification for the form release agent, curing compounds, and concrete penetrating sealers that indicate the VOC content of each product.

1.6.3.5 Safety Data Sheets

Submit Safety Data Sheets (SDS) for all materials that are regulated for hazardous health effects. SDS must be readily accessible during each work shift to employees when they are at the construction site.

1.6.4 Test Reports

1.6.4.1 Fly Ash

Submit test results in accordance with [ASTM C618](#) for fly. Submit test results performed within 6 months of submittal date.

1.6.4.2 Slag Cement

Submit test results in accordance with [ASTM C989/C989M](#) for slag cement. Submit test results performed within 6 months of submittal date.

1.6.4.3 Aggregates

Submit test results in accordance with [ASTM C33/C33M](#), or [ASTM C330/C330M](#) for lightweight aggregate, and [ASTM C1293](#) or [ASTM C1567](#) as required in the paragraph titled ALKALI-AGGREGATE REACTION.

1.6.5 Quality Control Plan

Develop and submit for approval a concrete quality control program in accordance with the guidelines of [ACI 121R](#) and as specified herein. The plan must include approved laboratories. Provide direct oversight for the concrete qualification program inclusive of associated sampling and testing. All quality control reports must be provided to the Contracting Officer, Quality Manager and Concrete Supplier. Maintain a copy of [ACI SP-15](#) and [CRSI 10MSP](#) at project site.

1.6.6 Quality Control Personnel Certifications

The Contractor must submit for approval the responsibilities of the various quality control personnel, including the names and qualifications of the individuals in those positions and a [quality control organizational chart](#) defining the quality control hierarchy and the responsibility of the various positions. Quality control personnel must be employed by the Contractor.

Submit American Concrete Institute certification for the following:

- a. CQC personnel responsible for inspection of concrete operations.
- b. Lead Foreman or Journeyman of the Concrete Placing, Finishing, and Curing Crews.
- c. Field Testing Technicians: ACI Concrete Field Testing Technician, Grade I.

1.6.6.1 Quality Manager Qualifications

The quality manager must hold a current license as a professional engineer in a U.S. state or territory with experience on at least five similar projects. Evidence of extraordinary proven experience may be considered by the Contracting Officer as sufficient to act as the Quality Manager.

1.6.6.2 Field Testing Technician and Testing Agency

Submit data on qualifications of proposed testing agency and technicians for approval by the Contracting Officer prior to performing testing on concrete.

- a. Work on concrete under this contract must be performed by an ACI Concrete Field Testing Technician Grade 1 qualified in accordance with **ACI SP-2** or equivalent. Equivalent certification programs must include requirements for written and performance examinations as stipulated in **ACI SP-2**.
- b. Testing agencies that perform testing services on reinforcing steel must meet the requirements of **ASTM E329**.
- c. Testing agencies that perform testing services on concrete materials must meet the requirements of **ASTM C1077**.

1.6.7 Laboratory Qualifications for Concrete Qualification Testing

The concrete testing laboratory must have the necessary equipment and experience to accomplish required testing. The laboratory must meet the requirements of **ASTM C1077** and be Cement and Concrete Reference Laboratory (CCRL) inspected.

1.6.8 Laboratory Accreditation

Laboratory and testing facilities must be provided by and at the expense of the Contractor. The laboratories performing the tests must be accredited in accordance with **ASTM C1077**, including **ASTM C78/C78M** and **ASTM C1260**. The accreditation must be current and must include the required test methods, as specified. Furthermore, the testing must comply with the following requirements:

- a. Aggregate Testing and Mix Proportioning: Aggregate testing and mixture proportioning studies must be performed by an accredited laboratory and under the direction of a registered professional engineer in a U.S. state or territory competent in concrete materials who is competent in concrete materials and must sign all reports and designs.
- b. Acceptance Testing: Furnish all materials, labor, and facilities required for molding, curing, testing, and protecting test specimens at the site and in the laboratory. Furnish and maintain boxes or other facilities suitable for storing and curing the specimens at the site while in the mold within the temperature range stipulated by **ASTM C31/C31M**.
- c. Contractor Quality Control: All sampling and testing must be performed by an approved, onsite, independent, accredited laboratory.

1.7 ENVIRONMENTAL REQUIREMENTS

Provide space ventilation according to material manufacturer recommendations, at a minimum, during and following installation of concrete curing compound and sealer. Maintain one of the following ventilation conditions during the curing period or for 72 hours after installation:

- a. Supply 100 percent outside air 24 hours a day.
- b. Supply airflow at a rate of 6 air changes per hour, when outside temperatures are between 55 degrees F and 84 degrees F and humidity is between 30 percent and 60 percent.
- c. Supply airflow at a rate of 1.5 air changes per hour, when outside air conditions are not within the range stipulated above.

1.7.1 Submittals for Environmental Performance

- a. Provide data indication the percentage of post-industrial pozzolan (fly ash, slag cement) cement substitution as a percentage of the full product composite by weight.
- b. Provide data indicating the percentage of post-industrial and post-consumer recycled content aggregate.
- c. Provide product data indicating the percentage of post-consumer recycled steel content in each type of steel reinforcement as a percentage of the full product composite by weight.
- d. Provide product data stating the location where all products were manufactured
- e. For projects using FSC certified formwork, provide chain-of-custody documentation for all certified wood products.
- f. For projects using reusable formwork, provide data showing how formwork is reused.
- g. Provide SDS product information data showing that form release agents meet any environmental performance goals such as using vegetable and soy based products.
- h. Provide SDS product information data showing that concrete adhesives meet any environmental performance goals including low emitting, low volatile organic compound products.

PART 2 PRODUCTS

2.1 FORMWORK MATERIALS

- a. Form-facing material in contact with concrete must be lumber, plywood, and metal. Submit product information on proposed form-facing materials if different from that specified herein.
- b. Design formwork, shores, reshores, and backshores to support loads transmitted to them and to comply with applicable building code requirements.

- c. Design formwork to withstand pressure resulting from placement and vibration of concrete and to maintain specified tolerances.
- d. Provide temporary openings in formwork if needed to facilitate cleaning and inspection.
- e. Design formwork joints to inhibit leakage of mortar.
- f. Limit deflection of facing materials for concrete surfaces exposed to view to 1/240 of center-to-center spacing of facing supports.
- h. Submit product information on proposed form-facing materials if different from that specified herein.
- i. Submit shop drawings for formwork, shoring, reshoring, and backshoring. Shop drawings must be signed and sealed by a licensed design engineer.
- j. Submit design calculations for formwork, shoring, reshoring, and backshoring. Design calculations must be signed and sealed by a licensed design engineer.

2.1.1 Wood Forms

Use lumber as specified in Section 06 10 00 ROUGH CARPENTRY and as follows. Provide lumber that is square edged or tongue-and-groove boards, free of raised grain, knotholes, or other surface defects. Provide plywood that complies with NIST PS 1, B-B concrete form panels or better or AHA A135.4, hardboard for smooth form lining.

2.1.1.1 Concrete Form Plywood (Standard Rough)

Provide plywood that conforms to NIST PS 1, B-B, concrete form, not less than 5/8-inch thick.

2.1.1.2 Overlaid Concrete Form Plywood (Standard Smooth)

Provide plywood that conforms to NIST PS 1, B-B, high density form overlay, not less than 5/8-inch thick.

2.1.2 Carton Forms

Moisture resistant treated paper faces, biodegradable, structurally sufficient to support weight of wet concrete until initial set.

2.1.3 Steel Forms

Provide steel form surfaces that do not contain irregularities, dents, or sags.

2.2 FORMWORK ACCESSORIES

- a. Use commercially manufactured formwork accessories, including ties and hangers.
- b. Form ties and accessories must not reduce the effective cover of the reinforcement.

2.2.1 Form Ties

- a. Use form ties with ends or end fasteners that can be removed without damage to concrete.
- b. The breakback distance for ferrous ties must be at least 2 in. for Surface Finish-2.0 or Surface Finish-3.0, as defined in ACI 301.
- c. If the breakback distance is less than 3/4 in., use coated or corrosion-resistant ties.
- d. Submit manufacturer's data sheet on form ties.

2.2.2 Biodegradable Form Release Agent

- a. Provide form release agent that is colorless, biodegradable, and water-based, with a zero VOC content.
- b. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.
- c. Provide form release agent that reduces formwork moisture absorption, and does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene. Submit documentation indicating type of biobased material in product and biobased content. Indicate relative dollar value of biobased content products to total dollar value of products included in project.
- d. Submit manufacturer's product data on formwork release agent for use on each form-facing material.

2.2.3 Chamfer Materials

Use lumber materials with dimensions of 3/4 x 3/4 in.

2.2.4 Construction and movement joints

- a. Submit details and locations of construction joints in accordance with the requirements herein.
- b. Locate construction joints within middle one-third of spans of slabs, beams, and girders. If a beam intersects a girder within the middle one-third of girder span, the distance between the construction joint in the girder and the edge of the beam must be at least twice the width of the larger member.
- c. For members with post-tensioning tendons, locate construction joints where tendons pass through centroid of concrete section.
- d. Locate construction joints in walls and columns at underside of slabs, beams, or girders and at tops of footings or slabs.
- e. Make construction joints perpendicular to main reinforcement.
- f. Provide movement joints where indicated in Contract Documents or in accepted alternate locations.
- g. Submit location and detail of movement joints if different from those

indicated in Contract Documents.

- h. Submit manufacturer's data sheet on expansion joint materials.

2.2.5 Other Embedded items

Use sleeves, inserts, anchors, and other embedded items of material and design indicated in Contract Documents.

2.3 CONCRETE MATERIALS

2.3.1 Cementitious Materials

2.3.1.1 Portland Cement

- a. Unless otherwise specified, provide cement that conforms to [ASTM C150/C150M](#) Type II.
- b. Use one brand and type of cement for formed concrete having exposed-to-view finished surfaces.
- c. For portland cement manufactured in a kiln fueled by hazardous waste, maintain a record of source for each batch. Supplier must certify that no hazardous waste is used in the fuel mix or raw materials. Supplier must certify that the hazardous waste is neutralized by the manufacturing process and that no additional pollutants are discharged.
- d. Submit information along with evidence demonstrating compliance with referenced standards. Submittals must include types of cementitious materials, manufacturing locations, shipping locations, and certificates showing compliance.
- e. Cementitious materials must be stored and kept dry and free from contaminants.

2.3.1.2 Blended Cements

- a. Blended cements must conform to [ASTM C595/C595M](#) Type IL or [ASTM C1157/C1157M](#) Type MS.
- b. Slag cement added to the Type IS blend must meet [ASTM C989/C989M](#).

2.3.1.3 Fly Ash

- a. [ASTM C618](#), Class F, except that the maximum allowable loss on ignition must not exceed 3 percent.
- b. If fly ash is used it shall range from [20 to 25](#) percent by weight of cementitious material, provided the fly ash does not reduce the amount of cement in the concrete mix below the minimum requirements of local building codes. Where the use of fly ash cannot meet the minimum level, it shall not be used. Report the chemical analysis of the fly ash in accordance with [ASTM C311/C311M](#). Evaluate and classify fly ash in accordance with [ASTM D5759](#).

2.3.1.4 Slag Cement

[ASTM C989/C989M](#), Grade 100 120.

2.3.2 Water

- a. Water or ice must comply with the requirements of [ASTM C1602/C1602M](#).
- b. Minimize the amount of water in the mix. Improve workability by adjusting the grading of the aggregate and using admixture rather than by adding water.
- c. Water must be potable; free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances deleterious to concrete.
- d. Protect mixing water and ice from contamination during storage and delivery.
- e. Submit test report showing water complies with [ASTM C1602/C1602M](#).
- f. When nonpotable source is proposed for use, submit documentation on effects of water on strength and setting time in compliance with [ASTM C1602/C1602M](#).

2.3.3 Aggregate

2.3.3.1 Normal-Weight Aggregate

- a. Aggregates must conform to [ASTM C33/C33M](#).
- b. Aggregates used in concrete must be obtained from the same sources and have the same size range as aggregates used in concrete represented by submitted field test records or used in trial mixtures.
- c. Store and handle aggregate in a manner that will avoid segregation and prevents contamination by other materials or other sizes of aggregates. Store aggregates in locations that will permit them to drain freely. Do not use aggregates that contain frozen lumps.
- d. Submit types, pit or quarry locations, producers' names, aggregate supplier statement of compliance with [ASTM C33/C33M](#), and [ASTM C1293](#) expansion data not more than 18 months old.

2.3.4 Admixtures

- a. Chemical admixtures must conform to [ASTM C494/C494M](#).
- b. Air-entraining admixtures must conform to [ASTM C260/C260M](#).
- c. Chemical admixtures for use in producing flowing concrete must conform to [ASTM C1017/C1017M](#).
- d. Do not use calcium chloride admixtures.
- e. Admixtures used in concrete must be the same as those used in the concrete represented by submitted field test records or used in trial mixtures.
- f. Protect stored admixtures against contamination, evaporation, or damage.
- g. To ensure uniform distribution of constituents, provide agitating

equipment for admixtures used in the form of suspensions or unstable solutions. Protect liquid admixtures from freezing and from temperature changes that would adversely affect their characteristics.

- h. Submit types, brand names, producers' names, manufacturer's technical data sheets, and certificates showing compliance with standards required herein.

2.4 MISCELLANEOUS MATERIALS

2.4.1 Concrete Curing Materials

Provide concrete curing material in accordance with **ACI 301** Section 5 and **ACI 308.1** Section 2. Submit product data for concrete curing compounds. Submit manufactures instructions for placement of curing compound.

2.4.2 Nonshrink Grout

Nonshrink grout in accordance with **ASTM C1107/C1107M**.

2.4.3 Floor Finish Materials

2.4.3.1 Sealers

- a. Use concrete penetrating sealers with a low (maximum 100 grams/liter, less water and less exempt compounds) VOC content. Submit manufactures instructions for placement of sealers.

2.4.4 Expansion/Contraction Joint Filler

ASTM D1752 Type III. Material must be 1/2 inch thick.

2.4.5 Joint Sealants

Submit manufacturer's product data, indicating VOC content.

2.4.5.1 Horizontal Surfaces, 3 Percent Slope, Maximum

ASTM D6690 or **ASTM C920**, Type M, Class 25, Use T.

2.4.5.2 Vertical Surfaces Greater Than 3 Percent Slope

ASTM C920, Type M, Grade NS, Class 25, Use T.

2.4.6 Vapor Retarder

ASTM E1745 Class C A polyethylene sheeting, minimum 10 mil thickness or other equivalent material with a maximum permeance rating of 0.04 perms per **ASTM E96/E96M**.

Consider plastic vapor retarders and adhesives with a high recycled content, low toxicity low VOC (Volatile Organic Compounds) levels.

2.5 CONCRETE MIX DESIGN

2.5.1 Properties and Requirements

- a. Use materials and material combinations listed in this section and the contract documents.

- b. Cementitious material content must be adequate for concrete to satisfy the specified requirements for strength, w/cm, durability, and finishability described in this section and the contract documents.

The minimum cementitious material content for concrete used in floors must meet the following requirements:

Nominal maximum size of aggregate, in.	Minimum cementitious material content, pounds per cubic yard
1-1/2	470
1	520
3/4	540
3/8	610

- c. Selected target slump must meet the requirements this section, the contract documents, and must not exceed 9 in. Concrete must not show visible signs of segregation.
- d. The target slump must be enforced for the duration of the project. Determine the slump by ASTM C143/C143M. Slump tolerances must meet the requirements of ACI 117.
- e. The nominal maximum size of coarse aggregate for a mixture must not exceed three-fourths of the minimum clear spacing between reinforcement, one-fifth of the narrowest dimension between sides of forms, or one-third of the thickness of slabs or toppings.
- f. Concrete must be air entrained for members assigned to Exposure Class F1, F2, or F3. The total air content must be in accordance with the requirements of the paragraph titled DURABILITY.
- g. Measure air content at the point of delivery in accordance with ASTM C173/C173M or ASTM C231/C231M.
- h. Concrete for slabs to receive a hard-troweled finish must not contain an air-entraining admixture or have a total air content greater than 3 percent.
- i. Concrete properties and requirements for each portion of the structure are specified in the table below. Refer to the paragraph titled DURABILITY for more details on exposure categories and their requirements.

	Minimum $f'c$ psi	Exposure Categories^	Miscellaneous Requirements
Footings	4000 at 28 days	S0 ; C0 ; ; F0	Slump: 3 - 5 in. Nominal maximum aggregate size must be 1 in. 0.44 max W/C
Columns and walls	4000 at 28 days	S0 ; C0 ; ; F0	Slump: 3 - 5 in. Nominal maximum aggregate size must be 1 in. 0.44 max W/C
Beams and elevated slabs	4000 at 28 days	S0 ; C0 ; ; F0	Slump: 3 - 5 in. Nominal maximum aggregate size must be 1 in. 0.44 max W/C
Slabs-on-ground	4000 at 28 days	S0 ; C0 ;; ; F0	Slump: 3 - 5 in. Nominal maximum aggregate size must be 1 in. 0.44 max W/C
Concrete Toppings	4000 at 28 days	S0 ; C0 ; ; F0	Slump: 3 - 5 in. Nominal maximum aggregate size must be 3/8 in. 0.44 max W/C

2.5.2 Durability

2.5.2.1 Alkali-Aggregate Reaction

Do not use any aggregate susceptible to alkali-carbonate reaction (ACR). Use one of the three options below for qualifying concrete mixtures to reduce the potential of alkali-silica reaction (ASR):

- For each aggregate used in concrete, the expansion result determined in accordance with **ASTM C1293** must not exceed 0.04 percent at one year.
- For each aggregate used in concrete, the expansion result of the aggregate and cementitious materials combination determined in accordance with **ASTM C1567** must not exceed 0.10 percent at an age of 16 days.

2.5.2.2 Freezing and Thawing Resistance

- Provide concrete meeting the following requirements based on exposure class assigned to members for freezing-and-thawing exposure in Contract Documents:

Exposure class	Maximum w/cm^*	Minimum $f'c$, psi	Air content	Additional Requirements
F0	N/A	2500	N/A	
F1	0.55	3500	Depends on aggregate size	N/A
F2	0.45	4500	Depends on aggregate size	See limits on maximum cementitious material by mass
F3	0.40	5000	Depends on aggregate size	See limits on maximum cementitious material by mass
F3 plain concrete	0.45	4500	Depends on aggregate size	See limits on maximum cementitious material by mass

*The maximum w/cm limits do not apply to lightweight concrete.

- Concrete must be air entrained for members assigned to Exposure Class F1, F2, or F3. The total air content must meet the requirements of the following table:

Nominal maximum aggregate size, in.	Total air content, percent*^	
	Exposure Class F2 and F3	Exposure Class F1
3/8	7.5	6.0
1/2	7.0	5.5
3/4	6.0	5.0
1	6.0	4.5
1-1/2	5.5	4.5
2	5.0	4.0
3	5.5	3.5

*Tolerance on air content as delivered must be plus/minus 1.5 percent.

^For f'c greater than 5000 psi, reducing air content by 1.0 percentage point is acceptable.

- c. Submit documentation verifying compliance with specified requirements.

2.5.2.3 Corrosion and Chloride Content

- a. Provide concrete meeting the requirements of the following table based on the exposure class assigned to members requiring protection against reinforcement corrosion in Contract Documents.
- b. Submit documentation verifying compliance with specified requirements.
- c. Water-soluble chloride ion content contributed from constituents including water, aggregates, cementitious materials, and admixtures must be determined for the concrete mixture by **ASTM C1218/C1218M** at age between 28 and 42 days.
- d. The maximum water-soluble chloride ion (Cl-) content in concrete, percent by mass of cement is as follows:

Exposure class	Maximum w/cm*	Minimum f'c, psi	Maximum water-soluble chloride ion (Cl-) content in concrete, percent by mass of cement
Reinforced concrete			
C0	N/A	2500	1.00
C1	N/A	2500	0.30
C2	0.4	5000	0.15
Prestressed concrete			

Exposure class	Maximum w/cm*	Minimum f'c, psi	Maximum water-soluble chloride ion (CL-) content in concrete, percent by mass of cement
C0	N/A	2500	0.06
C1	N/A	2500	0.06
C2	0.4	5000	0.06

*The maximum w/cm limits do not apply to lightweight concrete.

2.5.2.4 Sulfate Resistance

- a. Provide concrete meeting the requirements of the following table based on the exposure class assigned to members for sulfate exposure.

Exposure class	Maximum w/cm	Minimum f'c, psi	Required cementitious materials-types			Calcium chloride admixture
			ASTM C150/C150M	ASTM C595/C595M	ASTM C1157/C1157M	
S0	N/A	2500	N/A	N/A	N/A	No restrictions
S1	0.50	4000	II [^]	Types with (MS) designation	MS	No restrictions
S2	0.45	4500	V [^]	Types with (HS) designation	HS	Not permitted
S3	0.45	4500	V + pozzolan or slag cement ^{**}	Types with (HS) designation plus pozzolan or slag cement ^{**}	HS + pozzolan or slag cement ^{**}	Not permitted
S3	0.40	5000	V ^{***}	Types with (HS) designation	HS	Not permitted

* For seawater exposure, other types of portland cements with tricalcium aluminate (C3A) contents up to 10 percent are acceptable if the w/cm does not exceed 0.40.

** The amount of the specific source of the pozzolan or slag cement to be used shall be at least the amount determined by test or service record to improve sulfate resistance when used in concrete containing Type V cement. Alternatively, the amount of the specific source of the pozzolan or slag used shall not be less than the amount tested in accordance with ASTM C1012/C1012M and meeting the requirements maximum expansion requirements listed herein.

*** If Type V cement is used as the sole cementitious material, the optional sulfate requirement of 0.040 percent maximum expansion in

ASTM C150/C150M shall be required.

^ Other available types of cement, such as Type III or Type I, are acceptable in exposure classes S1 or S2 if the C3A contents are less than 8 or 5 percent, respectively.

- b. The maximum w/cm limits for sulfate exposure do not apply to lightweight concrete.
- c. Alternative combinations of cementitious materials of those listed in this paragraph are acceptable if they meet the maximum expansion requirements listed in the following table:

Exposure class	Maximum expansion when tested using ASTM C1012/C1012M		
	At 6 months	At 12 months	At 18 months
S1	0.10 percent	N/A	N/A
S2	0.05 percent	0.10 percent^	N/A
S3	N/A	N/A	0.10 percent

^The 12-month expansion limit applies only when the measured expansion exceeds the 6-month maximum expansion limit.

2.5.2.5 Concrete Temperature

The temperature of concrete as delivered must not exceed 95°F.

2.5.2.6 Concrete permeability

- a. Provide concrete meeting the requirements of the following table based on exposure class assigned to members requiring low permeability in the Contract Documents.

Exposure class	Maximum w/cm*	Minimum f'c, psi	Additional minimum requirements
W0	N/A	2500	None
W1	0.5	4000	None

*The maximum w/cm limits do not apply to lightweight concrete.

- b. Submit documentation verifying compliance with specified requirements.

2.5.3 Trial Mixtures

Trial mixtures must be in accordance to ACI 301.

2.5.4 Ready-Mix Concrete

Provide concrete that meets the requirements of ASTM C94/C94M.

Ready-mixed concrete manufacturer must provide duplicate delivery tickets with each load of concrete delivered. Provide delivery tickets with the following information in addition to that required by [ASTM C94/C94M](#):

- a. Type and brand cement
- b. Cement and supplementary cementitious materials content in [94-pound](#) bags per cubic [yard](#) of concrete
- c. Maximum size of aggregate
- d. Amount and brand name of admixtures
- e. Total water content expressed by water cementitious material ratio

2.6 [REINFORCEMENT](#)

- a. Bend reinforcement cold. Fabricate reinforcement in accordance with fabricating tolerances of [ACI 117](#).
- b. Submit manufacturer's certified test report for reinforcement.
- c. Submit placing drawings showing fabrication dimensions and placement locations of reinforcement and reinforcement supports. Placing drawings must indicate locations of splices, lengths of lap splices, and details of mechanical and welded splices.
- d. Submit request with locations and details of splices not indicated in Contract Documents.
- e. Submit request to place column dowels without using templates.
- f. Submit request for field cutting, including location and type of bar to be cut and reason field cutting is required.

2.6.1 [Reinforcing Bars](#)

- a. Reinforcing bars must be deformed, except spirals, load-transfer dowels, and welded wire reinforcement, which may be plain.
- b. [ASTM A615/A615M](#) with the bars marked S, Grade [60](#).
- c. Submit mill certificates for reinforcing bars.

2.6.2 [Welded wire reinforcement](#)

- a. Use welded wire reinforcement specified in Contract Documents and conforming to one or more of the specifications given herein.
- b. Plain welded wire reinforcement must conform to [ASTM A1064/A1064M](#), with welded intersections spaced no greater than [12 in.](#) apart in direction of principal reinforcement.
- c. Deformed welded wire reinforcement must conform to [ASTM A1064/A1064M](#), with welded intersections spaced no greater than [16 in.](#) apart in direction of principal reinforcement.

2.6.3 Reinforcing Bar Supports

- a. Provide reinforcement support types within structure as required by Contract Documents. Reinforcement supports must conform to **CRSI RB4.1**. Submit description of reinforcement supports and materials for fastening coated reinforcement if not in conformance with **CRSI RB4.1**.
- b. Legs of supports in contact with formwork must be hot-dip galvanized, or plastic coated after fabrication, or stainless-steel bar supports.

PART 3 EXECUTION

3.1 EXAMINATION

- a. Do not begin installation until substrates have been properly constructed; verify that substrates are level.
- b. If substrate preparation is the responsibility of another installer, notify Contracting Officer of unsatisfactory preparation before processing.
- c. Check field dimensions before beginning installation. If dimensions vary too much from design dimensions for proper installation, notify Contracting Officer and wait for instructions before beginning installation.

3.2 PREPARATION

Determine quantity of concrete needed and minimize the production of excess concrete. Designate locations or uses for potential excess concrete before the concrete is poured.

3.2.1 General

- a. Surfaces against which concrete is to be placed must be free of debris, loose material, standing water, snow, ice, and other deleterious substances before start of concrete placing.
- b. Remove standing water without washing over freshly deposited concrete. Divert flow of water through side drains provided for such purpose.

3.2.2 Subgrade Under Foundations and Footings

- a. When subgrade material is semi-porous and dry, sprinkle subgrade surface with water as required to eliminate suction at the time concrete is deposited, or seal subgrade surface by covering surface with specified vapor retarder.
- b. When subgrade material is porous, seal subgrade surface by covering surface with specified vapor retarder.

3.2.3 Subgrade Under Slabs on Ground

- a. Before construction of slabs on ground, have underground work on pipes and conduits completed and approved.
- b. Previously constructed subgrade or fill must be cleaned of foreign materials

- c. Finish surface of capillary water barrier under interior slabs on ground must not show deviation in excess of **1/4 inch** when tested with a **10-foot** straightedge parallel with and at right angles to building lines.
- d. Finished surface of subgrade or fill under exterior slabs on ground must not be more than **0.02-foot** above or **0.10-foot** below elevation indicated.

3.2.4 Edge Forms and Screed Strips for Slabs

- a. Set edge forms or bulkheads and intermediate screed strips for slabs to obtain indicated elevations and contours in finished slab surface and must be strong enough to support vibrating bridge screeds or roller pipe screeds if nature of specified slab finish requires use of such equipment.
- b. Align concrete surface to elevation of screed strips by use of strike-off templates or approved compacting-type screeds.

3.2.5 Reinforcement and Other Embedded Items

- a. Secure reinforcement, joint materials, and other embedded materials in position, inspected, and approved before start of concrete placing.
- b. When concrete is placed, reinforcement must be free of materials deleterious to bond. Reinforcement with rust, mill scale, or a combination of both will be considered satisfactory, provided minimum nominal dimensions, nominal weight, and minimum average height of deformations of a hand-wire-brushed test specimen are not less than applicable ASTM specification requirements.

3.3 FORMS

- a. Provide forms, shoring, and scaffolding for concrete placement. Set forms mortar-tight and true to line and grade.
- b. Chamfer above grade exposed joints, edges, and external corners of concrete **0.75 inch**. Place chamfer strips in corners of formwork to produce beveled edges on permanently exposed surfaces.
- c. Provide formwork with clean-out openings to permit inspection and removal of debris.
- d. Inspect formwork and remove foreign material before concrete is placed.
- e. At construction joints, lap form-facing materials over the concrete of previous placement. Ensure formwork is placed against hardened concrete so offsets at construction joints conform to specified tolerances.
- f. Provide positive means of adjustment (such as wedges or jacks) of shores and struts. Do not make adjustments in formwork after concrete has reached initial setting. Brace formwork to resist lateral deflection and lateral instability.
- g. Fasten form wedges in place after final adjustment of forms and before concrete placement.

- h. Provide anchoring and bracing to control upward and lateral movement of formwork system.
- i. Construct formwork for openings to facilitate removal and to produce opening dimensions as specified and within tolerances.
- j. Provide runways for moving equipment. Support runways directly on formwork or structural members. Do not support runways on reinforcement. Loading applied by runways must not exceed capacity of formwork or structural members.
- k. Position and support expansion joint materials, waterstops, and other embedded items to prevent displacement. Fill voids in sleeves, inserts, and anchor slots temporarily with removable material to prevent concrete entry into voids.
- l. Clean surfaces of formwork and embedded materials of mortar, grout, and foreign materials before concrete placement.

3.3.1 Coating

- a. Cover formwork surfaces with an acceptable material that inhibits bond with concrete.
- b. If formwork release agent is used, apply to formwork surfaces in accordance with manufacturer's recommendations before placing reinforcement. Remove excess release agent on formwork prior to concrete placement.
- c. Do not allow formwork release agent to contact reinforcement or hardened concrete against which fresh concrete is to be placed.

3.3.2 Reshoring

- a. Do not allow structural members to be loaded with combined dead and construction loads in excess of loads indicated in the accepted procedure.
- b. Install and remove reshores or backshores in accordance with accepted procedure.
- c. For floors supporting shores under newly placed concrete, either leave original supporting shores in place, or install reshores or backshores. Shoring system and supporting slabs must resist anticipated loads. Locate reshores and backshores directly under a shore position or as indicated on formwork shop drawings.
- d. In multistory buildings, place reshoring or backshoring over a sufficient number of stories to distribute weight of newly placed concrete, forms, and construction live loads.

3.3.3 Reuse

- a. Reuse forms providing the structural integrity of concrete and the aesthetics of exposed concrete are not compromised.
- b. Wood forms must not be clogged with paste and must be capable of absorbing high water-cementitious material ratio paste.

- c. Remove leaked mortar from formwork joints before reuse.

3.3.4 Forms for Standard Rough Form Finish

Provide formwork in accordance with **ACI 301** Section 5 with a surface finish, SF-1.0, for formed surfaces that are to be concealed by other construction.

3.3.5 Forms for Standard Smooth Form Finish

Provide formwork in accordance with **ACI 301** Section 5 with a surface finish, SF-3.0, for formed surfaces that are exposed to view. Do not provide mockup of concrete surface appearance and texture.

3.3.6 Form Ties

- a. For post-tensioned structures, do not remove formwork supports until stressing records have been accepted by the Contracting Officer.
- b. After ends or end fasteners of form ties have been removed, repair tie holes in accordance with **ACI 301** Section 5 requirements.

3.3.7 Forms for Concrete Pan Joist Construction

Pan-form units for one-way or two-way concrete joist and slab construction must be factory-fabricated units of the approximate section indicated. Units must consist of steel or molded fiberglass concrete form pans. Closure units must be furnished as required.

3.3.8 Tolerances for Form Construction

- a. Construct formwork so concrete surfaces conform to tolerances in **ACI 117**.
- b. Position and secure sleeves, inserts, anchors, and other embedded items such that embedded items are positioned within **ACI 117** tolerances.
- c. To maintain specified elevation and thickness within tolerances, install formwork to compensate for deflection and anticipated settlement in formwork during concrete placement. Set formwork and intermediate screed strips for slabs to produce designated elevation, camber, and contour of finished surface before formwork removal. If specified finish requires use of vibrating screeds or roller pipe screeds, ensure that edge forms and screed strips are strong enough to support such equipment.

3.3.9 Removal of Forms and Supports

- a. If vertical formed surfaces require finishing, remove forms as soon as removal operations will not damage concrete.
- b. Remove top forms on sloping surfaces of concrete as soon as removal will not allow concrete to sag. Perform repairs and finishing operations required. If forms are removed before end of specified curing period, provide curing and protection.
- c. Do not damage concrete during removal of vertical formwork for columns, walls, and sides of beams. Perform needed repair and

finishing operations required on vertical surfaces. If forms are removed before end of specified curing period, provide curing and protection.

- d. Form-facing material and horizontal facing support members may be removed before in-place concrete reaches specified compressive strength if shores and other supports are designed to allow facing removal without deflection of supported slab or member.

3.3.10 Strength of Concrete Required for Removal of Formwork

If removal of formwork, reshoring, or backshoring is based on concrete reaching a specified in-place strength, mold and field-cure cylinders in accordance with [ASTM C31/C31M](#). Test cylinders in accordance with [ASTM C39/C39M](#). Alternatively, use one or more of the methods listed herein to evaluate in-place concrete strength for formwork removal.

- a. Tests of cast-in-place cylinders in accordance with [ASTM C873/C873M](#). This option is limited to slabs with concrete depths from 5 to 12 in.
- b. Penetration resistance in accordance with [ASTM C803/C803M](#).
- c. Pullout strength in accordance with [ASTM C900](#).
- d. Maturity method in accordance with [ASTM C1074](#). Submit [maturity method data](#) using project materials and concrete mix proportions used on the project to demonstrate the correlation between maturity and compressive strength of laboratory cured test specimens to the Contracting Officer.

3.4 PLACING REINFORCEMENT AND MISCELLANEOUS MATERIALS

- a. Unless otherwise specified, placing reinforcement and miscellaneous materials must be in accordance to [ACI 301](#). Provide bars, welded wire reinforcement, wire ties, supports, and other devices necessary to install and secure reinforcement.
- b. Reinforcement must not have rust, scale, oil, grease, clay, or foreign substances that would reduce the bond. Rusting of reinforcement is a basis of rejection if the effective cross-sectional area or the nominal weight per unit length has been reduced. Remove loose rust prior to placing steel. Tack welding is prohibited.
- c. Nonprestressed cast-in-place concrete members must have concrete cover for reinforcement given in the following table:

Concrete Exposure	Member	Reinforcement	Specified cover, in.
Cast against and permanently in contact with ground	All	All	3

Concrete Exposure	Member	Reinforcement	Specified cover, in.
Exposed to weather or in contact with ground	All	No. 6 through No. 18 bars	2
		No. 5 bar, W31 or D31 wire, and smaller	1-1/2
Not exposed to weather or in contact with ground	Slabs, joists, and walls	No. 14 and No. 18 bars	1-1/2
		No. 11 bar and smaller	3/4
	Beams, columns, pedestals, and tension ties	Primary reinforcement, stirrups, ties, spirals, and hoops	1-1/2

- d. Cast-in-place prestressed concrete members must have concrete cover for reinforcement, ducts, and end fittings given in the following table:

Concrete	Member	Reinforcement	Specified
Cast against and permanently in contact with ground	All	All	3
Exposed to weather or in contact with ground	Slabs, joists, and walls	All	1
	All other	All	1-1/2
Not exposed to weather or in contact with ground	Slabs, joists, and walls	All	3/4
		Primary reinforcement	1-1/2
	Beams, columns, and tension ties	Stirrups, ties, spirals, and hoops	1

- e. Precast nonprestressed or prestressed concrete members manufactured under plant conditions must have concrete cover for reinforcement, ducts, and end fittings given in the following table:

Concrete Exposure	Member	Reinforcement	Specified cover, in.
Exposed to weather or in contact with ground	Walls	No. 14 and No. 18 bars; tendons larger than 1-1/2 in. diameter	1-1/2
		No. 11 bars and smaller; W31 and D31 wire, and smaller; tendons and strands 1-1/2 in.	3/4
	All other	No. 14 and No. 18 bars; tendons larger than 1-1/2 in.	2
		No. 6 through No. 11 bars; tendons and strands larger than 5/8 in. diameter through 1-1/2 in.	1-1/2
		No. 5 bar, W31 or D31 wire, and smaller; tendons and strands 5/8 in. diameter and smaller	1-1/4

Concrete Exposure	Member	Reinforcement	Specified cover, in.
Not exposed to weather or in contact with ground	Slabs, joists, and walls	No. 14 and No. 18 bars; tendons larger than 1-1/2 in. diameter	1-1/4
		Tendons and strands 1-1/2 in. diameter and smaller	3/4
		No. 11 bar, W31 or D31	5/8
	Beams, columns, pedestals, and tension ties	Primary reinforcement	Greater of bar diameter and 5/8 and need not exceed 1-1/2
		Stirrups, ties, spirals, and hoops	3/8

3.4.1 General

Provide details of reinforcement that are in accordance with the Contract Documents.

3.4.2 Vapor Retarder and Vapor Barrier

- a. Install in accordance with **ASTM E1643**. Provide beneath the on-grade concrete floor slab. Use the greatest widths and lengths practicable to eliminate joints wherever possible. Lap joints a minimum of 12 inches and tape.
- b. Remove torn, punctured, or damaged vapor retarder material and provide with new vapor retarder prior to placing concrete. Concrete placement must not damage vapor retarder. Place vapor barrier 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, a thin layer of approximately 1/2 inch of fine graded material should be rolled or compacted over the fill before installation of the vapor barrier to reduce the possibility of puncture. Control concrete placement so as to prevent damage to the vapor barrier.

3.4.3 Reinforcement Supports

Provide reinforcement support in accordance with **CRSI RB4.1** and **ACI 301** Section 3 requirements. Supports for coated or galvanized bars must also

be coated with electrically compatible material for a distance of at least 2 inches beyond the point of contact with the bars.

3.4.4 Splicing

As indicated in the Contract Documents. For splices not indicated follow ACI 301. Do not splice at points of maximum stress. Overlap welded wire reinforcement the spacing of the cross wires, plus 2 inches.

3.4.5 Future Bonding

Plug exposed, threaded, mechanical reinforcement bar connectors with a greased bolt. Provide bolt threads that match the connector. Countersink the connector in the concrete. Caulk the depression after the bolt is installed.

3.4.6 Setting Miscellaneous Material

Place and secure anchors and bolts, pipe sleeves, conduits, and other such items in position before concrete placement and support against displacement. Plumb anchor bolts and check location and elevation. Temporarily fill voids in sleeves with readily removable material to prevent the entry of concrete.

3.4.7 Fabrication

Shop fabricate reinforcing bars to conform to shapes and dimensions indicated for reinforcement, and as follows:

- a. Provide fabrication tolerances that are in accordance with ACI 117.
- b. Provide hooks and bends that are in accordance with the Contract Documents.

Reinforcement must be bent cold to shapes as indicated. Bending must be done in the shop. Rebending of a reinforcing bar that has been bent incorrectly is not be permitted. Bending must be in accordance with standard approved practice and by approved machine methods.

Deliver reinforcing bars bundled, tagged, and marked. Tags must be metal with bar size, length, mark, and other information pressed in by machine. Marks must correspond with those used on the placing drawings.

Do not use reinforcement that has any of the following defects:

- a. Bar lengths, depths, and bends beyond specified fabrication tolerances
- b. Bends or kinks not indicated on drawings or approved shop drawings
- c. Bars with reduced cross-section due to rusting or other cause

Replace defective reinforcement with new reinforcement having required shape, form, and cross-section area.

3.4.8 Placing Reinforcement

Place reinforcement in accordance with ACI 301.

For slabs on grade (over earth or over capillary water barrier) and for

footing reinforcement, support bars or welded wire reinforcement on precast concrete blocks, spaced at intervals required by size of reinforcement, to keep reinforcement the minimum height specified above the underside of slab or footing.

For slabs other than on grade, supports for which any portion is less than 1 inch from concrete surfaces that are exposed to view or to be painted must be of precast concrete units, plastic-coated steel, or stainless steel protected bar supports. Precast concrete units must be wedge shaped, not larger than 3-1/2 by 3-1/2 inches, and of thickness equal to that indicated for concrete protection of reinforcement. Provide precast units that have cast-in galvanized tie wire hooked for anchorage and blend with concrete surfaces after finishing is completed.

Provide reinforcement that is supported and secured together to prevent displacement by construction loads or by placing of wet concrete, and as follows:

- a. Provide supports for reinforcing bars that are sufficient in number and have sufficient strength to carry the reinforcement they support, and in accordance with ACI 301 and CRSI 10MSP. Do not use supports to support runways for concrete conveying equipment and similar construction loads.
- b. Equip supports on ground and similar surfaces with sand-plates.
- c. Support welded wire reinforcement as required for reinforcing bars.
- d. Secure reinforcements to supports by means of tie wire. Wire must be black, soft iron wire, not less than 16 gage.
- e. Reinforcement must be accurately placed, securely tied at intersections, and held in position during placing of concrete by spacers, chairs, or other approved supports. Point wire-tie ends away from the form. Unless otherwise indicated, numbers, type, and spacing of supports must conform to the Contract Documents.
- f. Bending of reinforcing bars partially embedded in concrete is permitted only as specified in the Contract Documents.

3.4.9 Spacing of Reinforcing Bars

- a. Spacing must be as indicated in the Contract Documents.
- b. Reinforcing bars may be relocated to avoid interference with other reinforcement, or with conduit, pipe, or other embedded items. If any reinforcing bar is moved a distance exceeding one bar diameter or specified placing tolerance, resulting rearrangement of reinforcement is subject to preapproval by the Contracting Officer.

3.4.10 Concrete Protection for Reinforcement

Additional concrete protection must be in accordance with the Contract Documents.

3.5 BATCHING, MEASURING, MIXING, AND TRANSPORTING CONCRETE

In accordance with ASTM C94/C94M, ACI 301, ACI 302.1R and ACI 304R, except as modified herein. Batching equipment must be such that the concrete

ingredients are consistently measured within the following tolerances: 1 percent for cement and water, 2 percent for aggregate, and 3 percent for admixtures. Furnish mandatory batch ticket information for each load of ready mix concrete.

3.5.1 Measuring

Make measurements at intervals as specified in paragraphs SAMPLING and TESTING.

3.5.2 Mixing

- a. Mix concrete in accordance with **ASTM C94/C94M**, **ACI 301** and **ACI 304R**.
- b. Machine mix concrete. Begin mixing within 30 minutes after the cement has been added to the aggregates. Place concrete within 90 minutes of either addition of mixing water to cement and aggregates or addition of cement to aggregates if the concrete temperature is less than **84 degrees F**.
- c. Place concrete within 60 minutes if the concrete temperature is greater than **84 degrees F** except as follows: if set retarding admixture is used and slump requirements can be met, limit for placing concrete may remain at 90 minutes. Additional water may be added, provided that both the specified maximum slump and submitted water-cementitious material ratio are not exceeded and the required concrete strength is still met. When additional water is added, an additional 30 revolutions of the mixer at mixing speed is required.
- d. If the entrained air content falls below the specified limit, add a sufficient quantity of admixture, within the manufacturer's recommended dosage, to bring the entrained air content within the specified limits. Dissolve admixtures in the mixing water and mix in the drum to uniformly distribute the admixture throughout the batch. Do not reconstitute concrete that has begun to solidify.
- e. When fibers are used, add fibers together with the aggregates and never as the first component in the mixer. Fibers must be dispensed into the mixing system using appropriate dispensing equipment and procedure as recommended by the manufacturer.

3.5.3 Transporting

Transport concrete from the mixer to the forms as rapidly as practicable. Prevent segregation or loss of ingredients. Clean transporting equipment thoroughly before each batch. Do not use aluminum pipe or chutes. Remove concrete which has segregated in transporting and dispose of as directed.

3.6 PLACING CONCRETE

Place concrete in accordance with **ACI 301** Section 5. Concrete shall be placed within 15 minutes of discharge into non-agitating equipment.

3.6.1 Footing Placement

Concrete for footings may be placed in excavations without forms upon inspection and approval by the Contracting Officer. Excavation width must be a minimum of **4 inches** greater than indicated.

3.6.2 Pumping

ACI 304R and ACI 304.2R. Pumping must not result in separation or loss of materials nor cause interruptions sufficient to permit loss of plasticity between successive increments. Loss of slump in pumping equipment must not exceed 2 inches at discharge/placement. Do not convey concrete through pipe made of aluminum or aluminum alloy. Avoid rapid changes in pipe sizes. Limit maximum size of coarse aggregate to 33 percent of the diameter of the pipe. Limit maximum size of well-rounded aggregate to 40 percent of the pipe diameter. Take samples for testing at both the point of delivery to the pump and at the discharge end.

3.6.3 Cold Weather

Cold weather concrete must meet the requirements of ACI 306.1 unless otherwise specified. Do not allow concrete temperature to decrease below 50 degrees F. Obtain approval prior to placing concrete when the ambient temperature is below 40 degrees F or when concrete is likely to be subjected to freezing temperatures within 24 hours. Cover concrete and provide sufficient heat to maintain 50 degrees F minimum adjacent to both the formwork and the structure while curing. Limit the rate of cooling to 37 degrees F in any one hour and 50 degrees F per 24 hours after heat application.

3.6.4 Hot Weather

Hot weather concrete must meet the requirements of ACI 305.1 unless otherwise specified. Maintain required concrete temperature using Figure 4.2 in ACI 305R to prevent the evaporation rate from exceeding 0.2 pound of water per square foot of exposed concrete per hour. Cool ingredients before mixing or use other suitable means to control concrete temperature and prevent rapid drying of newly placed concrete. Shade the fresh concrete as soon as possible after placing. Start curing when the surface of the fresh concrete is sufficiently hard to permit curing without damage. Provide water hoses, pipes, spraying equipment, and water hauling equipment, where job site is remote to water source, to maintain a moist concrete surface throughout the curing period. Provide burlap cover or other suitable, permeable material with fog spray or continuous wetting of the concrete when weather conditions prevent the use of either liquid membrane curing compound or impervious sheets. For vertical surfaces, protect forms from direct sunlight and add water to top of structure once concrete is set.

3.6.5 Bonding

Surfaces of set concrete at joints, must be roughened and cleaned of laitance, coatings, loose particles, and foreign matter. Roughen surfaces in a manner that exposes the aggregate uniformly and does not leave laitance, loosened particles of aggregate, nor damaged concrete at the surface.

Obtain bonding of fresh concrete that has set as follows:

- a. At joints between footings and walls or columns, between walls or columns and the beams or slabs they support, and elsewhere unless otherwise specified; roughened and cleaned surface of set concrete must be dampened, but not saturated, immediately prior to placing of fresh concrete.

- b. At joints in exposed-to-view work; at vertical joints in walls; at joints near midpoint of span in girders, beams, supported slabs, other structural members; in work designed to contain liquids; the roughened and cleaned surface of set concrete must be dampened but not saturated and covered with a cement grout coating.
- c. Provide cement grout that consists of equal parts of portland cement and fine aggregate by weight with not more than 6 gallons of water per sack of cement. Apply cement grout with a stiff broom or brush to a minimum thickness of 1/16 inch. Deposit fresh concrete before cement grout has attained its initial set.

3.7 WASTE MANAGEMENT

Provide as specified in the Waste Management Plan and as follows.

3.7.1 Mixing Equipment

Before concrete pours, designate Contractor-owned site meeting environmental standards for cleaning out concrete mixing trucks. Minimize water used to wash equipment.

3.7.2 Reinforcing Steel

Collect reinforcing steel and place in designated area for recycling.

3.7.3 Other Waste

Identify concrete manufacturer's or supplier's policy for collection or return of construction waste, unused material, deconstruction waste, and/or packaging material. Return excess cement to supplier.

3.8 SURFACE FINISHES EXCEPT FLOOR, SLAB, AND PAVEMENT FINISHES

3.8.1 Defects

Repair surface defects in accordance with ACI 301 Section 5.

3.8.2 Not Against Forms (Top of Walls)

Surfaces not otherwise specified must be finished with wood floats to even surfaces. Finish must match adjacent finishes.

3.8.3 Formed Surfaces

3.8.3.1 Tolerances

Tolerances in accordance with ACI 117 and as indicated.

3.8.3.2 As-Cast Rough Form

Provide for surfaces not exposed to public view a surface finish SF-1.0. Patch holes and defects in accordance with ACI 301.

3.8.3.3 Standard Smooth Finish

Provide for surfaces exposed to public view a surface finish SF-3.0. Patch holes and defects in accordance with ACI 301.

3.9 FLOOR, SLAB, AND PAVEMENT FINISHES AND MISCELLANEOUS CONSTRUCTION

In accordance with **ACI 301** and **ACI 302.1R**, unless otherwise specified. Slope floors uniformly to drains where drains are provided. Where straightedge measurements are specified, Contractor must provide straightedge.

3.9.1 Finish

Place, consolidate, and immediately strike off concrete to obtain proper contour, grade, and elevation before bleedwater appears. Permit concrete to attain a set sufficient for floating and supporting the weight of the finisher and equipment. If bleedwater is present prior to floating the surface, drag the excess water off or remove by absorption with porous materials. Do not use dry cement to absorb bleedwater. Grate tampers ("jitterbugs") shall not be used.

3.9.1.1 Scratched

Use for surfaces intended to receive bonded applied cementitious applications. Finish concrete in accordance with **ACI 301** Section 5 for a scratched finish.

3.9.1.2 Floated

Use for surfaces to receive roofing, and exterior slabs where not otherwise specified. Finish concrete in accordance with **ACI 301** Section 5 for a floated finish.

3.9.1.3 Steel Troweled

Use for floors intended for equipment pads. Finish concrete in accordance with **ACI 301** Section 5 for a steel troweled finish.

3.9.1.4 Broomed

Use on surfaces of mechanical room, exterior walks, platforms, patios, and ramps, unless otherwise indicated. Finish concrete in accordance with **ACI 301** Section 5 for a broomed finish.

3.9.1.5 Concrete Toppings Placement

The following requirements apply to the placement of toppings of concrete on base slabs that are either freshly placed and still plastic, or on hardened base slabs.

- a. Placing on a Fresh Base: Screed and bull float the base slab. As soon as the water sheen has disappeared, lightly rake the surface of the base slab with a stiff bristle broom to produce a bonding surface for the topping. Immediately spread the topping mixture evenly over the roughened base before final set takes place. Give the topping the finish specified herein.
- b. Bonding to a Hardened Base: When the topping is to be bonded to a floated or troweled hardened base, roughen the base by scarifying, grit-blasting, scabbling, planing, flame cleaning, or acid-etching to lightly expose aggregate and provide a bonding surface. Remove dirt, laitance, and loose aggregate by means of a stiff wire broom. Keep the clean base wet for a period of 12 hours preceding the application

of the topping. Remove excess water and apply a 1:1:1/2 cement-sand-water grout, and brush into the surface of the base slab. Do not allow the cement grout to dry, and spread it only short distances ahead of the topping placement. Do not allow the temperature differential between the completed base and the topping mixture to exceed 41 degrees F at the time of placing. Place the topping and finish as specified herein.

3.9.2 Flat Floor Finishes

ACI 302.1R. Construct in accordance with one of the methods recommended in Table 10.15.3a, "Slab-on-ground flatness/levelness construction guide" or Table 10.15.3b, "Suspended slab flatness/levelness construction guide" appropriate for the type of construction. ACI 117 for tolerance tested by ASTM E1155.

a. Specified Conventional Value:

Floor Flatness (Ff) 20 minimum
Floor Levelness (FL) 15 minimum

3.9.2.1 Measurement of Floor Tolerances

Test slab within 24 hours of the final troweling. Provide tests to Contracting Officer within 12 hours after collecting the data. Floor flatness inspector is required to provide a tolerance report which must include:

- a. Key plan showing location of data collected.
- b. Results required by ASTM E1155.

3.9.2.2 Remedies for Out of Tolerance Work

Contractor is required to repair and retest any floors not meeting specified tolerances. Prior to repair, Contractor must submit and receive approval for the proposed repair, including product data from any materials proposed. Repairs must not result in damage to structural integrity of the floor. For floors exposed to public view, repairs must prevent any uneven or unusual coloring of the surface.

3.10 JOINTS

3.10.1 Construction Joints

Make and locate joints not indicated so as not to impair strength and appearance of the structure, as approved. Joints must be perpendicular to main reinforcement. Reinforcement must be continued and developed across construction joints. Locate construction joints as follows:

3.10.1.1 Construction Joints for Constructability Purposes

- a. In walls, at top of footing; at top of slabs on ground; at top and bottom of door and window openings or where required to conform to architectural details; and at underside of deepest beam or girder framing into wall.
- b. In columns or piers, at top of footing; at top of slabs on ground; and at underside of deepest beam or girder framing into column or pier.

- c. Near midpoint of spans for supported slabs, beams, and girders unless a beam intersects a girder at the center, in which case construction joints in girder must offset a distance equal to twice the width of the beam. Make transfer of shear through construction joint by use of inclined reinforcement.

Provide keyways at least 1-1/2-inches deep in construction joints in walls and slabs and between walls and footings; approved bulkheads may be used for slabs.

3.10.2 Isolation Joints in Slabs on Ground

- a. Provide joints at points of contact between slabs on ground and vertical surfaces, such as column pedestals, foundation walls, grade beams, and elsewhere as indicated.
- b. Fill joints with premolded joint filler strips 1/2 inch thick, extending full slab depth. Install filler strips at proper level below finish floor elevation with a slightly tapered, dress-and-oiled wood strip temporarily secured to top of filler strip to form a groove not less than 3/4 inch in depth where joint is sealed with sealing compound and not less than 1/4 inch in depth where joint sealing is not required. Remove wood strip after concrete has set. Contractor must clean groove of foreign matter and loose particles after surface has dried.

3.10.3 Sealing Joints in Slabs on Ground

- a. Contraction and control joints which are to receive finish flooring material must be sealed with joint sealing compound after concrete curing period. Slightly underfill groove with joint sealing compound to prevent extrusion of compound. Remove excess material as soon after sealing as possible.
- b. Sealed groove must be left ready to receive filling material that is provided as part of finish floor covering work.

3.11 CONCRETE TOPPING

3.11.1 Standard Topping

Provide topping for treads and platforms of metal steel stairs and elsewhere as indicated.

3.11.1.1 Preparations Prior to Placing

- a. When topping is placed on a metal surface, such as metal pans for steel stairs, remove dirt, loose material, oil, grease, asphalt, paint, and other contaminants from metal surface.

3.11.1.2 Placing

Spread standard topping mixture evenly on previously prepared base slab or metal surface, brought to correct level with a straightedge, and struck off. Topping must be consolidated, floated, checked for trueness of surface, and refloated as specified for float finish.

3.11.1.3 Finishing

Give finishes standard topping surfaces as indicated.

3.12 CURING AND PROTECTION

Curing and protection in accordance with **ACI 301** Section 5, unless otherwise specified. Begin curing immediately following form removal. Avoid damage to concrete from vibration created by blasting, pile driving, movement of equipment in the vicinity, disturbance of formwork or protruding reinforcement, and any other activity resulting in ground vibrations. Protect concrete from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks, and oil stains. Do not allow concrete to dry out from time of placement until the expiration of the specified curing period. Do not use membrane-forming compound on surfaces where appearance would be objectionable, on any surface to be painted, where coverings are to be bonded to the concrete, or on concrete to which other concrete is to be bonded. If forms are removed prior to the expiration of the curing period, provide another curing procedure specified herein for the remaining portion of the curing period. Provide moist curing for those areas receiving liquid chemical sealer, hardener, or epoxy coating. Allow curing compound/sealer installations to cure prior to the installation of materials that adsorb VOCs.

3.12.1 Curing Periods

ACI 301 Section 5, except 10 days for retaining walls, pavement or chimneys. Begin curing immediately after placement. Protect concrete from premature drying, excessively hot temperatures, and mechanical injury; and maintain minimal moisture loss at a relatively constant temperature for the period necessary for hydration of the cement and hardening of the concrete. The materials and methods of curing are subject to approval by the Contracting Officer.

3.12.2 Curing Formed Surfaces

Accomplish curing of formed surfaces, including undersurfaces of girders, beams, supported slabs, and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed before end of curing period, accomplish final curing of formed surfaces by any of the curing methods specified above, as applicable.

3.12.3 Curing Unformed Surfaces

- a. Accomplish initial curing of unformed surfaces, such as monolithic slabs, floor topping, and other flat surfaces, by membrane curing.
- b. Accomplish final curing of unformed surfaces by any of curing methods specified, as applicable.

3.12.4 Temperature of Concrete During Curing

When temperature of atmosphere is **41 degrees F** and below, maintain temperature of concrete at not less than **55 degrees F** throughout concrete curing period or **45 degrees F** when the curing period is measured by maturity. When necessary, make arrangements before start of concrete placing for heating, covering, insulation, or housing as required to maintain specified temperature and moisture conditions for concrete during

curing period.

When the temperature of atmosphere is 80 degrees F and above or during other climatic conditions which cause too rapid drying of concrete, make arrangements before start of concrete placing for installation of wind breaks, of shading, and for fog spraying, wet sprinkling, or moisture-retaining covering of light color as required to protect concrete during curing period.

Changes in temperature of concrete must be uniform and not exceed 37 degrees F in any one hour nor 80 degrees F in any 24-hour period.

3.12.5 Protection from Mechanical Injury

During curing period, protect concrete from damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration and from damage caused by rain or running water.

3.12.6 Protection After Curing

Protect finished concrete surfaces from damage by construction operations.

3.13 FIELD QUALITY CONTROL

3.13.1 Aggregate Testing

3.13.1.1 Fine Aggregate

At least once during each shift when the concrete plant is operating, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM C136/C136M and COE CRD-C 104 for the fine aggregate or for each fine aggregate if it is batched in more than one size or classification. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits. When the amount passing on any sieve is outside the specification limits, the fine aggregate shall be immediately resampled and retested. If there is another failure on any sieve, the fact shall be immediately reported to the Contracting Officer, concreting shall be stopped, and immediate steps taken to correct the grading.

3.13.1.2 Coarse Aggregate

At least once during each shift in which the concrete plant is operating, there shall be a sieve analysis in accordance with ASTM C136/C136M for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor shall be responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control coarser than the specification limits for samples taken other than as delivered to the mixer to allow for degradation during handling. When the amount passing any sieve is outside the specification limits, the coarse aggregate shall be immediately resampled and retested. If the second sample fails on any sieve, that fact shall be reported to the Contracting Officer. Where two consecutive averages of 5 tests are outside specification limits, the operation shall be considered out of

control and reported to the Contracting Officer. Concreting shall be stopped and immediate steps shall be taken to correct the grading.

3.13.2 Concrete Sampling

ASTM C172/C172M. Collect samples of fresh concrete to perform tests specified. **ASTM C31/C31M** for making test specimens.

3.13.3 Concrete Testing

3.13.3.1 Slump Tests

ASTM C143/C143M. Take concrete samples during concrete placement/discharge. The maximum slump may be increased as specified with the addition of an approved admixture provided that the water-cementitious material ratio is not exceeded. Perform tests at commencement of concrete placement, when test cylinders are made, and for each batch (minimum) or every **20 cubic yards** (maximum) of concrete.

3.13.3.2 Temperature Tests

Test the concrete delivered and the concrete in the forms. Perform tests in hot or cold weather conditions (**below 50 degrees F and above 80 degrees F**) for each batch (minimum) or every **20 cubic yards** (maximum) of concrete, until the specified temperature is obtained, and whenever test cylinders and slump tests are made.

3.13.3.3 Compressive Strength Tests

ASTM C39/C39M. Make six **4 inch by 8 inch** test cylinders for each set of tests in accordance with **ASTM C31/C31M**, **ASTM C172/C172M** and applicable requirements of **ACI 305R** and **ACI 306R**. Take precautions to prevent evaporation and loss of water from the specimen. Test two cylinders at 7 days, two cylinders at 28 days, and hold two cylinder in reserve. Take samples for strength tests of each mix design of concrete placed each day not less than once a day, nor less than once for each **100 cubic yards** of concrete for the first **500 cubic yards**, then every **500 cubic yards** thereafter, nor less than once for each **5400 square feet** of surface area for slabs or walls. For the entire project, take no less than five sets of samples and perform strength tests for each mix design of concrete placed. Each strength test result must be the average of two cylinders from the same concrete sample tested at 28 days. Concrete compressive tests must meet the requirements of this section, the Contract Document, and **ACI 301**. Retest locations represented by erratic core strengths. Where retest does not meet concrete compressive strength requirements submit a mitigation or remediation plan for review and approval by the contracting officer. Repair core holes with nonshrink grout. Match color and finish of adjacent concrete.

3.13.3.4 Air Content

ASTM C173/C173M or **ASTM C231/C231M** for normal weight concrete. Test air-entrained concrete for air content at the same frequency as specified for slump tests.

3.13.3.5 Unit Weight of Structural Concrete

ASTM C567/C567M and **ASTM C138/C138M**. Determine unit weight of lightweight and normal weight concrete. Perform test for every **20 cubic yards** maximum.

3.13.3.6 Strength of Concrete Structure

The strength of the concrete structure will be considered to be deficient if any of the following conditions are identified:

- a. Failure to meet compressive strength tests as evaluated.
- b. Reinforcement not conforming to requirements specified.
- c. Concrete which differs from required dimensions or location in such a manner as to reduce strength.
- d. Concrete curing and protection of concrete against extremes of temperature during curing, not conforming to requirements specified.
- e. Concrete subjected to damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration.
- f. Poor workmanship likely to result in deficient strength.

Where the strength of the concrete structure is considered deficient submit a mitigation or remediation plan for review and approval by the contracting officer.

3.13.3.7 Non-Conforming Materials

Factors that indicate that there are non-conforming materials include (but not limited to) excessive compressive strength, inadequate compressive strength, excessive slump, excessive voids and honeycombing, concrete delivery records that indicate excessive time between mixing and placement, or excessive water was added to the mixture during delivery and placement. Any of these indicators alone are sufficient reason for the Contracting Officer to request additional sampling and testing.

Investigations into non-conforming materials must be conducted at the Contractor's expense. The Contractor must be responsible for the investigation and must make written recommendations to adequately mitigate or remediate the non-conforming material. The Contracting Officer may accept, accept with reduced payment, require mitigation, or require removal and replacement of non-conforming material at no additional cost to the Government.

3.13.3.8 Testing Concrete Structure for Strength

When there is evidence that strength of concrete structure in place does not meet specification requirements or there are non-conforming materials, make cores drilled from hardened concrete for compressive strength determination in accordance with [ASTM C42/C42M](#), and as follows:

- a. Take at least three representative cores from each member or area of concrete-in-place that is considered potentially deficient. Location of cores will be determined by the Contracting Officer.
- b. Test cores after moisture conditioning in accordance with [ASTM C42/C42M](#) if concrete they represent is more than superficially wet under service.
- c. Air dry cores, ([60 to 80 degrees F](#) with relative humidity less than 60

percent) for 7 days before test and test dry if concrete they represent is dry under service conditions.

- d. Strength of cores from each member or area are considered satisfactory if their average is equal to or greater than 85 percent of the 28-day design compressive strength of the class of concrete.

Fill core holes solid with patching mortar and finished to match adjacent concrete surfaces.

Correct concrete work that is found inadequate by core tests in a manner approved by the Contracting Officer.

3.14 REPAIR, REHABILITATION AND REMOVAL

Before the Contracting Officer accepts the structure the Contractor must inspect the structure for cracks, damage and substandard concrete placements that may adversely affect the service life of the structure. A report documenting these defects must be prepared which includes recommendations for repair, removal or remediation must be submitted to the Contracting Officer for approval before any corrective work is accomplished.

3.14.1 Crack Repair

Prior to final acceptance, all cracks in excess of 0.02 inches wide must be documented and repaired. The proposed method and materials to repair the cracks must be submitted to the Contracting Officer for approval. The proposal must address the amount of movement expected in the crack due to temperature changes and loading.

3.14.2 Repair of Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed voids or deleterious materials. Concrete surfaces with weak surfaces less than 1/4 inch thick must be diamond ground to remove the weak surface. Surfaces containing weak surfaces greater than 1/4 inch thick must be removed and replaced or mitigated in a manner acceptable to the Contracting Officer.

3.14.3 Failure of Quality Assurance Test Results

Proposed mitigation efforts by the Contractor must be approved by the Contracting Officer prior to proceeding.

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SECTION 04 20 00

UNIT MASONRY

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 CONCRETE INSTITUTE (ACI)

ACI 216.1 (2014) Code Requirements for Determining
Fire Resistance of Concrete and Masonry
Construction Assemblies

ACI SP-66 (2004) ACI Detailing Manual

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M (2016a) Standard Specification for Zinc
Coating (Hot-Dip) on Iron and Steel
Hardware

ASTM A167 (2011) Standard Specification for
Stainless and Heat-Resisting
Chromium-Nickel Steel Plate, Sheet, and
Strip

ASTM A185/A185M (2007) Standard Specification for Steel
Welded Wire Reinforcement, Plain, for
Concrete

ASTM A615/A615M (2020) Standard Specification for Deformed
and Plain Carbon-Steel Bars for Concrete
Reinforcement

ASTM A641/A641M (2019) Standard Specification for
Zinc-Coated (Galvanized) Carbon Steel Wire

ASTM A653/A653M (2020) Standard Specification for Steel
Sheet, Zinc-Coated (Galvanized) or
Zinc-Iron Alloy-Coated (Galvannealed) by
the Hot-Dip Process

ASTM A951/A951M (2011) Standard Specification for Steel
Wire for Masonry Joint Reinforcement

ASTM A996/A996M (2016) Standard Specification for
Rail-Steel and Axle-Steel Deformed Bars
for Concrete Reinforcement

ASTM A1008/A1008M (2021a) Standard Specification for Steel,
Sheet, Cold-Rolled, Carbon, Structural,
High-Strength Low-Alloy, High-Strength

Low-Alloy with Improved Formability,
Solution Hardened, and Bake Hardenable

ASTM A1064/A1064M

(2017) Standard Specification for
Carbon-Steel Wire and Welded Wire
Reinforcement, Plain and Deformed, for
Concrete

ASTM B370

(2012; R 2019) Standard Specification for
Copper Sheet and Strip for Building
Construction

ASTM C90

(2021) Standard Specification for
Loadbearing Concrete Masonry Units

ASTM C129

(2017) Standard Specification for
Nonloadbearing Concrete Masonry Units

ASTM C207

(2018) Standard Specification for Hydrated
Lime for Masonry Purposes

ASTM C270

(2019a; E 2019) Standard Specification for
Mortar for Unit Masonry

ASTM C476

(2020) Standard Specification for Grout
for Masonry

ASTM C494/C494M

(2019) Standard Specification for Chemical
Admixtures for Concrete

ASTM C641

(2017) Standard Test Method for Iron
Staining Materials in Lightweight Concrete
Aggregates

ASTM C1019

(2019) Standard Test Method for Sampling
and Testing Grout

ASTM C1384

(2012a) Standard Specification for
Admixtures for Masonry Mortars

ASTM D2000

(2018) Standard Classification System for
Rubber Products in Automotive Applications

ASTM D2287

(2019) Nonrigid Vinyl Chloride Polymer and
Copolymer Molding and Extrusion Compounds

THE MASONRY SOCIETY (TMS)

TMS MSJC

(2016) Masonry Standard Joint Committee's
(MSJC) Book - Building Code Requirements
and Specification for Masonry Structures,
Containing TMS 402/ACI 530/ASCE 5, TMS
602/ACI 530.1/ASCE 6, and Companion
Commentaries

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S"
classification. Submittals not having a "G" or "S" classification are for

information only. Submit the following in accordance with Section
01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Reinforcement Detail Drawings; G

SD-03 Product Data

Hot Weather Procedures; G

Cold Weather Procedures; G

Cement; G

Cementitious Materials; G

Insulation; G

SD-05 Design Data

Masonry Compressive Strength; G

Fire-Rated Concrete Masonry Units

SD-06 Test Reports

Fire-Rated Concrete Masonry Units

SD-07 Certificates

Concrete Masonry Units (CMU)

Admixtures for Masonry Mortar

Admixtures for Grout

Anchors, Ties, and Bar Positioners

Joint Reinforcement

Insulation

SD-08 Manufacturer's Instructions

Admixtures for Masonry Mortar

Admixtures for Grout

SD-10 Operation and Maintenance Data

Take-Back Program

1.3 QUALITY ASSURANCE

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver, store, handle, and protect material to avoid chipping, breakage, and contact with soil or contaminating material. Store and prepare

materials in already disturbed areas to minimize project site disturbance and size of project site.

1.4.1 Masonry Units

Cover and protect masonry units from precipitation. Conform to handling and storage requirements of **TMS MSJC**.

- a. Pack glazed brick, glazed structural clay tile, and prefaced concrete masonry units in the manufacturer's standard paper cartons, trays, or shrink wrapped pallets with a divider between each unit. Do not stack pallets. Do not remove units from cartons until cartons are placed on scaffolds or in the location where units are to be laid.
- b. Mark prefabricated lintels 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

Store steel reinforcing bars, coated anchors, ties, and joint reinforcement above the ground. Maintain steel reinforcing bars and uncoated ties free of loose mill scale and loose rust.

1.4.3 Cementitious Materials, Sand and Aggregates

Deliver cementitious and other packaged materials in unopened containers, plainly marked and labeled with manufacturers' names and brands. Store cementitious material in dry, weathertight enclosures or completely cover. Handle cementitious materials in a manner that will prevent the inclusion of foreign materials and damage by water or dampness. Store sand and aggregates in a manner to prevent contamination and segregation.

1.5 PROJECT/SITE CONDITIONS

Conform to **TMS MSJC** for hot and cold weather masonry erection.

1.5.1 Hot Weather Procedures

When ambient air temperature exceeds **100 degrees F**, or exceeds **90 degrees F** and the wind velocity is greater than **8 mph**, comply with **TMS MSJC** Article 1.8 D for: preparation prior to conducting masonry work; construction while masonry work is in progress; and protection for newly completed masonry.

1.5.2 Cold Weather Procedures

When ambient temperature is below **40 degrees F**, comply with **TMS MSJC** Article 1.8 C for: preparation prior to conducting masonry work; construction while masonry work is in progress; and protection for newly completed masonry.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Design - Specified Compressive Strength of Masonry

The specified compressive strength of masonry, f'_m , is as indicated for each type of masonry.

2.1.2 Performance - Verify Masonry Compressive Strength

Verify specified compressive strength of masonry using the "Unit Strength Method" of TMS MSJC. Submit calculations and certifications of unit and mortar strength.

Verify specified compressive strength of masonry using the "Prism Test Method" of TMS MSJC when the "Unit Strength Method" cannot be used. Submit test results.

2.2 MANUFACTURED UNITS

2.2.1 General Requirements

Do not change the source of materials, which will affect the appearance of the finished work, after the work has started except with Contracting Officer's approval. Submit test reports from an approved independent laboratory. Certify test reports on a previously tested material as the same materials as that proposed for use in this project. Submit certificates of compliance stating that the materials meet the specified requirements.

2.2.2 Concrete Units

2.2.2.1 Aggregates

Test lightweight aggregates, and blends of lightweight and heavier aggregates in proportions used in producing the units, for stain-producing iron compounds in accordance with ASTM C641, visual classification method. Do not incorporate aggregates for which the iron stain deposited on the filter paper exceeds the "light stain" classification.

Use industrial waste by-products (air-cooled slag, cinders, or bottom ash), ground waste glass and concrete, granulated slag, and expanded slag in aggregates.

2.2.2.2 Concrete Masonry Units (CMU)

2.2.2.2.1 Cement

Use only cement that has a low alkali content and is of one brand.

2.2.2.2.2 Size

Provide units with specified dimension of as indicated on drawings 7 5/8 inches high, and 15 5/8 inches long.

2.2.2.2.3 Surfaces

Provide units with exposed surfaces that are smooth and of uniform texture.

2.2.2.2.4 Weather Exposure

Provide concrete masonry units with water-repellant admixture added during manufacture where units will be exposed to weather.

2.2.2.2.5 Unit Types

- a. Hollow Load-Bearing Units: **ASTM C90**, lightweight. Provide load-bearing units for exterior walls, foundation walls, load-bearing walls, and shear walls.
- b. Hollow Non-Load-Bearing Units: **ASTM C129**, lightweight. Load-bearing units may be provided in lieu of non-load-bearing units.

2.2.2.2.6 Jamb Units

Provide jamb units 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.

2.2.2.3 Patterned, Decorative Screen Units

Provide patterned, decorative screen units that conform to **ASTM C129**. Provide units that have uniform through-the-wall pattern, color, and texture.

2.2.2.4 Fire-Rated Concrete Masonry Units

For indicated fire-rated construction, provide concrete masonry units 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 by linear interpolation based on the percent by dry-rodded volume of each aggregate used in manufacturing the units.

TABLE I FIRE-RATED CONCRETE MASONRY UNITS							
Aggregate Type	Minimum Equivalent Thickness for Fire-Resistance Rating, inch						
	1/2 hour	3/4 hour	1 hour	1-1/2 hour	2 hours	3 hours	4 hours
Calcareous or siliceous gravel (other than limestone)	2.0	2.4	2.8	3.6	4.2	5.3	6.2
Limestone, cinders, or air-cooled slag	1.9	2.3	2.7	3.4	4.0	5.0	5.9
Expanded clay, expanded shale, or expanded slate	1.8	2.2	2.6	3.3	3.6	4.4	5.1
Expanded slag or pumice	1.5	1.9	2.1	2.7	3.2	4.0	4.7

Determine equivalent thickness in accordance with **ACI 216.1**. Where walls are to receive plaster or be faced with brick, or otherwise form an assembly; include the thickness of plaster or brick or other material in the assembly in determining the equivalent thickness. Submit calculation results.

2.3 EQUIPMENT

2.3.1 Vibrators

Maintain at least one spare vibrator on site at all times.

2.3.2 Grout Pumps

Pumping through aluminum tubes is not permitted.

2.4 MATERIALS

2.4.1 Mortar Materials

2.4.1.1 Cementitious Materials

Provide cementitious materials that conform to those permitted by [ASTM C270](#).

2.4.1.2 Hydrated Lime and Alternates

Provide lime that conforms to one of the materials permitted by [ASTM C207](#) for use in combination with portland cement, hydraulic cement, and blended hydraulic cement. Do not use lime in combination with masonry cement or mortar cement.

2.4.1.3 Admixtures for Masonry Mortar

In cold weather, use a non-chloride based accelerating admixture that conforms to [ASTM C1384](#), unless Type III portland cement is used in the mortar.

In showers and kitchens, use mortar that contains a water-repellent admixture that conforms to [ASTM C1384](#). Provide a water-repellent admixture, conforming to [ASTM C1384](#) and of the same brand and manufacturer as the block's integral water-repellent, in the mortar used to place concrete masonry units that have an integral water-repellent admixture.

2.4.1.4 Aggregate and Water

Provide aggregate (sand) and water that conform to materials permitted by [ASTM C270](#).

2.4.2 Grout and Ready-Mix Grout Materials

2.4.2.1 Cementitious Materials for Grout

Provide cementitious materials that conform to those permitted by [ASTM C476](#).

2.4.2.2 Admixtures for Grout

Water-reducing admixtures that conform to [ASTM C494/C494M](#) Type F or G and viscosity-modifying admixtures that conform to [ASTM C494/C494M](#) Type S are permitted for use in grout. Other admixtures require approval by the Contracting Officer.

In cold weather, a non-chloride based accelerating admixture may be used subject to approval by the Contracting Officer; use accelerating admixture that is non-corrosive and conforms to [ASTM C494/C494M](#), Type C.

2.4.2.3 Aggregate and Water

Provide fine and coarse aggregates and water that conform to materials permitted by [ASTM C476](#).

2.5 MORTAR AND GROUT MIXES

2.5.1 Mortar Mix

- a. Provide mortar Type S unless specified otherwise herein. Do not use masonry cement in the mortar. Do not use air-entrainment in the mortar.
- b. Use [ASTM C270](#) Type S cement-lime mortar or mortar cement mortar for seismic-force-resisting elements indicated.
- c. Provide mortar that conforms to [ASTM C270](#). Use Type S mortar for foundation walls, basement walls, and in piers.
- d. Provide Type S mortar for non-load-bearing, non-shear-wall interior masonry.
- e. For field-batched mortar, measure component materials by volume. Use measuring boxes for materials that do not come in packages, such as sand, for consistent batching. [Do not use shovels as a measuring device](#). Mix cementitious materials and aggregates between 3 and 5 minutes in a mechanical batch mixer with a sufficient amount of water to produce a workable consistency. Do not hand mix mortar unless approved by the Contracting Officer. Maintain workability of mortar by remixing or retempering. Discard mortar that has begun to stiffen or is not used within 2-1/2 hours after initial mixing.
- f. For preblended mortar, follow manufacturer's mixing instructions.

2.5.2 Grout and Ready Mix Grout Mix

Use grout that conforms to [ASTM C476](#), fine. Use conventional grout with a slump between [8 and 11 inches](#). Use self-consolidating grout with slump flow of [24 to 30 inches](#) and a visual stability index (VSI) not greater than 1. Provide minimum grout strength of [2000 psi](#) in 28 days, as tested in accordance with [ASTM C1019](#). Do not change proportions and do not use materials with different physical or chemical characteristics in grout for the work unless additional evidence is furnished that grout meets the specified requirements. Use ready-mixed grout that conforms to [ASTM C476](#).

2.6 ACCESSORIES

2.6.1 Grout Barriers

Grout barriers for vertical cores that consist of fine mesh wire, fiberglass, or expanded metal.

2.6.2 [Anchors, Ties, and Bar Positioners](#)

2.6.2.1 General

- a. Fabricate anchors and ties without drips or crimps. Size anchors and ties to provide a minimum of [5/8 inch](#) mortar cover from each face of masonry.

- b. Fabricate steel wire anchors and ties shall from wire conforming to [ASTM A1064/A1064M](#) and hot-dip galvanize in accordance with [ASTM A153/A153M](#).
- c. Fabricate joint reinforcement in conformance with [ASTM A951/A951M](#). Hot dip galvanize joint reinforcement in exterior walls and in interior walls exposed to moist environment in conformance with [ASTM A153/A153M](#). Galvanize joint reinforcement in other interior walls in conformance with [ASTM A641/A641M](#); coordinate with paragraph JOINT REINFORCEMENT below.
- d. Fabricate sheet metal anchors and ties in conformance with [ASTM A1008/A1008M](#). Hot dip galvanize sheet metal anchors and ties in exterior walls and in interior walls exposed to moist environment in compliance with [ASTM A153/A153M](#) Class B. Galvanize sheet metal anchors and ties in other interior walls in compliance with [ASTM A653/A653M](#), Coating Designation G60.
- e. Submit two anchors, ties and bar positioners of each type used, as samples.

2.6.2.2 Wire Mesh Anchors

Provide wire mesh anchors of [1/4 inch](#) mesh galvanized hardware cloth, conforming to [ASTM A185/A185M](#), with length not less than [12 inches](#), at intersections of interior non-bearing masonry walls.

2.6.2.3 Wall Ties for Multi-Wythe Masonry Construction

Provide rectangular-shaped wall ties, fabricated of hot-dipped galvanized [W1.7](#) diameter steel wire. Provide rectangular wall ties no less than [4 inches](#) wide.

Provide adjustable type wall ties, if approved for use, that consist of two essentially U-shaped elements fabricated of minimum [W2.8](#) diameter steel wire or pintle type ties that are inserted to eyes of horizontal joint reinforcement, hot-dip galvanized. Provide adjustable ties with double pintle legs and allows a maximum offset of [1-1/4 inch](#) between each element of the tie and maximum distance between connecting parts no more than [1/16 inch](#). Form the pintle and eye elements shall be formed so that both can be in the same plane. Wall ties may also be of a continuous type conforming to paragraph JOINT REINFORCEMENT.

2.6.2.4 Dovetail Anchors

Provide dovetail anchors of [3/16 inch](#) diameter steel wire, triangular shaped, and attached to a [12 gauge](#) or heavier steel dovetail section. Use these anchors to connect the exterior masonry wythe as it passes over the face of concrete columns, beams, or walls. Fill cells immediately above and below these anchors unless solid units are used. Furnish dovetail slots, which are specified to be installed by others, in accordance with Section [03 30 00](#) CAST-IN-PLACE CONCRETE.

2.6.2.5 Adjustable Anchors

2.6.2.5.1 Anchorage to Structural Steel

Provide hot-dip galvanized adjustable anchors for connecting masonry walls to the structural steel frame as detailed on the drawings. Provide

zinc-rich paint for touching up paint after welding galvanized anchors to structural steel.

2.6.2.5.2 Anchorage of Veneer to Light Gauge Steel or Concrete Backing

Use one of the following types of adjustable anchors to connect veneer to light gauge steel or concrete backing:

- a. sheet metal at least $7/8$ inch wide, 0.06 inch thick, and with corrugations having a wavelength of 0.3 to 0.5 inch and an amplitude of 0.06 to 0.10 inch or bent, notched or punched to provide equivalent performance;
- b. wire anchors of minimum size $W1.7$ with ends bent to form a minimum 2 inches extension and without drips;
- c. or wire pintle anchors used in conjunction with joint reinforcement.

Do not exceed $1/16$ inch clearance between connecting parts of the tie. Assemble adjustable anchors to prevent disengagement. Provide pintle anchors with one or more pintle legs of wire size $W2.8$ and an offset not exceeding $1-1/4$ inch.

2.6.2.6 Veneer Anchor Screws

Provide screws for attachment of veneer anchors to cold-formed steel framing members of size as required by design to provide the needed pullout load capacity but not less than No. 12. Provide length of screws such that the screws penetrate the holding member by not less than $5/8$ inch.

2.6.2.7 Bar Positioners

Factory-fabricate bar positioners, used to prevent displacement of reinforcing bars during the course of construction, from 9 gauge steel wire or equivalent, and hot-dip galvanized. Bar positioners must be suitable for intended use and be corrosion resistant steel. Bar positioners not fully contained within the wythe must be hot-dip galvanized.

2.6.3 Joint Reinforcement

Factory fabricate joint reinforcement in conformance with $ASTM A951/A951M$, welded construction. Provide ladder type joint reinforcement, having one longitudinal wire in the mortar bed of each face shell for hollow units and one wire for solid units and with all wires a minimum of 9 gauge. Size joint reinforcement to provide a minimum of $5/8$ inch cover from each face. Space crosswires not more than 16 inches. Provide joint reinforcement for straight runs in flat sections not less than 10 feet long. Provide joint reinforcement with factory formed corners and intersections. If approved for use, joint reinforcement may be furnished with adjustable wall tie features. Submit one piece of each type used, including corner and wall intersection pieces, showing at least two cross wires.

2.6.4 Reinforcing Steel Bars

Reinforcing steel bars and rods shall conform to $ASTM A615/A615M$ or

ASTM A996/A996M, Grade 60.

2.6.5 Concrete Masonry Control Joint Keys

Provide control joint keys of a factory fabricated solid section of natural or synthetic rubber (or combination thereof) conforming to ASTM D2000 M2AA-805 with a minimum durometer hardness of 80 or polyvinyl chloride conforming to ASTM D2287 Type PVC 654-4 with a minimum durometer hardness of 85. Form the control joint key with a solid shear section not less than 5/8 inch thick and 3/8 inch thick flanges, with a tolerance of plus or minus 1/16 inch, to fit neatly, but without forcing, in masonry unit jamb sash grooves.

2.6.6 Through Wall Flashing and Weeps

2.6.6.1 General

Provide coated copper, copper or stainless steel sheet, self-adhesive rubberized sheet, or reinforced membrane sheet flashing except that flashing indicated to terminate in reglets shall be metal or coated-metal flashing and except that the material shall be one which is not adversely affected by dampproofing material.

2.6.6.2 Coated-Copper Flashing

Provide 7 ounce, electrolytic copper sheet, uniformly coated on both sides with acidproof, alkaliproof, asphalt impregnated kraft paper or polyethylene sheets.

2.6.6.3 Copper or Stainless Steel Flashing

Provide copper sheet, complying with ASTM B370, minimum 16 ounce weight; or stainless steel, ASTM A167, Type 304 or 316, 0.015 inch thick, No. 2D finish. Where indicated, provide with factory-fabricated deformations that mechanically bond flashing against horizontal movement in all directions, where deformations consist of dimples, diagonal corrugations, or a combination of dimples and transverse corrugations.

2.6.6.4 Reinforced Membrane Flashing

Provide polyester film core with a reinforcing fiberglass scrim bonded to one side. Provide membrane that is impervious to moisture, flexible, is not affected by caustic alkalis, and after being exposed for not less than 1/2 hour to a temperature of 32 degrees F, shows no cracking when, at that temperature, it is bent 180 degrees over a 1/16 inch diameter mandrel and then bent at the same point over the same size mandrel in the opposite direction 360 degrees.

2.6.6.5 Rubberized Flashing

Provide self-adhesive rubberized asphalt sheet flashing consisting of 32-mil thick pliable and highly adhesive rubberized asphalt compound bonded completely and integrally to 8-mil thick, high density, cross-laminated polyethylene film to produce an overall thickness of 40 mils. Provide rubberized, asphalt-based mastic and surface conditioner that are each approved by flashing manufacturer for use with flashing material.

2.6.6.6 Weep Ventilators

Provide weep ventilators that are prefabricated from stainless steel or plastic. Provide inserts with grill or louver-type openings designed to allow the passage of moisture from cavities and to prevent the entrance of insects, and with a rectangular closure strip to prevent mortar droppings from clogging the opening. Provide ventilators with compressible flanges to fit in a standard $\frac{3}{8}$ inch wide mortar joint and with height equal to the nominal height of the unit.

2.6.6.7 Single-Wythe Exterior Wall CMU Flashing System

In single-wythe exterior CMU walls, provide a system of CMU cell flashing pans and interlocking CMU web covers made from UV-resistant, high-density polyethylene. For exterior CMU walls, provide a flashing/weep system in open cores that do not receive grout. Cell flashing pans are to have integral weep spouts built into mortar bed joints that extend into the cell to prevent clogging with mortar.

2.6.6.8 Metal Drip Edge

Provide stainless steel drip edge, 15-mil thick, hemmed edges, with down-turned drip at the outside edge and upturned dam at the inside edge for use with membrane flashings.

2.6.7 RIGID BOARD-TYPE INSULATION

Provide rigid board-type insulation as specified in Section 07 21 13 BOARD AND BLOCK INSULATION.

PART 3 EXECUTION

3.1 EXAMINATION

Prior to start of work, verify the applicable conditions as set forth in TMS MSJC, inspection.

3.2 PREPARATION

3.2.1 Stains

Protect exposed surfaces from mortar and other stains. When mortar joints are tooled, remove mortar from exposed surfaces with fiber brushes and wooden paddles. Protect base of walls from splash stains by covering adjacent ground with sand, sawdust, or polyethylene.

3.2.2 Loads

Do not apply uniform loads for at least 12 hours or concentrated loads for at least 72 hours after masonry is constructed. Provide temporary bracing as required.

3.2.3 Concrete Surfaces

Where masonry is to be placed, clean concrete of laitance, dust, dirt, oil, organic matter, or other foreign materials and slightly roughen to provide a surface texture with a depth of at least $\frac{1}{8}$ inch. Sandblast, if necessary, to remove laitance from pores and to expose the aggregate.

3.2.4 Shelf Angles

Adjust shelf angles as required to keep the masonry level and at the proper elevation.

3.3 ERECTION

3.3.1 General

- a. Coordinate masonry work with the work of other trades to accommodate built-in items and to avoid cutting and patching. Lay masonry units to match existing bond pattern. Lay facing courses level with back-up courses, unless the use of adjustable ties has been approved in which case the tolerances is plus or minus 1/2 inch. Adjust each unit to its final position while mortar is still soft and has plastic consistency.
- b. Remove and clean units that have been disturbed after the mortar has stiffened, and relay with fresh mortar. Keep air spaces, cavities, chases, expansion joints, and spaces to be grouted free from mortar and other debris. Select units to be used in exposed masonry surfaces from those having the least amount of chipped edges or other imperfections detracting from the appearance of the finished work.
- c. When necessary to temporarily discontinue the work, step (rack) back the masonry for joining when work resumes. Toothing may be used only when specifically approved by the Contracting Officer. Before resuming work, remove loose mortar and thoroughly clean the exposed joint. Cover the top of walls subjected to rain or snow with nonstaining waterproof covering or membrane when work is not in process. Extend the covering a minimum of 610 mm 2 feet down on each side of the wall and hold securely in place.
- d. Ensure that units being laid and surfaces to receive units are free of water film and frost. Lay solid units in a nonfurrowed full bed of mortar. Bevel mortar for veneer wythes and slope down toward the cavity side. Shove units into place so that the vertical joints are tight. Completely fill vertical joints between solid units with mortar, except where indicated at control, expansion, and isolation joints. Place hollow units so that mortar extends to the depth of the face shell at heads and beds, unless otherwise indicated. Mortar will be permitted to protrude up to 1/2 inch into the space or cells to be grouted. Provide means to prevent mortar from dropping into the space below or clean grout spaces prior to grouting.
- e. In multi-wythe construction with collar joints no more than 3/4 inch wide, bring up the inner wythe not more than 16 inches ahead of the outer wythe. Fill collar joints with mortar during the laying of the facing wythe, and filling shall not lag the laying of the facing wythe by back-buttering each unit as it is laid.

3.3.1.1 Jointing

Tool mortar joints when the mortar is thumbprint hard. Tool horizontal joints after tooling vertical joints. Brush mortar joints to remove loose and excess mortar.

3.3.1.1.1 Tooled Joints

Tool mortar joints in exposed exterior and interior masonry surfaces concave, using a jointer that is slightly larger than the joint width so that complete contact is made along the edges of the unit. Perform tooling so that the mortar is compressed and the joint surface is sealed. Use a jointer of sufficient length to obtain a straight and true mortar joint. No exterior joints are to be left un-tooled.

3.3.1.1.2 Flush Joints

Flush cut mortar joints in concealed masonry surfaces and joints at electrical outlet boxes in wet areas. Finish flush cut joints by cutting off the mortar flush with the face of the wall. Point joints in unparged masonry walls below grade tight. For architectural units, such as fluted units, completely fill both the head and bed joints and flush cut.

3.3.1.1.3 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 **3/8 inch**. On the exterior side of exterior frames, joints between frames and abutting masonry walls shall be raked to a depth of **3/8 inch**.

3.3.1.1.4 Joint Widths

- a. Construct brick masonry with mortar joint widths equal to the difference between the specified and nominal dimensions of the unit, within tolerances permitted by **TMS MSJC**.
- b. Provide **3/8 inch** wide mortar joints in concrete masonry, except for prefaced concrete masonry units.
- c. Provide **3/8 inch** wide mortar joints on unfaced side of prefaced concrete masonry units and not less than **3/16 inch** nor more than **1/4 inch** wide on prefaced side.
- d. Maintain mortar joint widths within tolerances permitted by **TMS MSJC**

3.3.1.2 Cutting and Fitting

Use full units of the proper size wherever possible, in lieu of cut units. Locate cut units where they would have the least impact on the architectural aesthetic goals of the facility. Perform cutting and fitting, including that required to accommodate the work of others, by masonry mechanics using power masonry saws. Concrete masonry units may be wet or dry cut. Before being placed in the work, dry wet-cut units to the same surface-dry appearance as uncut units being laid in the wall. Provide cut edges that are clean, true and sharp.

- a. Carefully make openings in the masonry 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. Provide reinforced masonry lintels above openings over **12 inches** wide for pipes, ducts, cable trays, and other wall penetrations, unless steel sleeves are used.
- b. Do not reduce masonry units in size by more than one-third in height and one-half in length. Do not locate cut products at ends of walls,

corners, and other openings.

3.3.1.3 Unfinished Work

Rack back unfinished work for joining with new work. Tooothing may be resorted to only when specifically approved by the Contracting Officer. Remove loose mortar and thoroughly clean the exposed joints before laying new work.

3.3.1.4 Control Joints

Provide control joints in concrete masonry as **required**. Construct by raking out mortar within the head joint in accordance with the details shown on the Drawings. Form a continuous vertical joint at control joint locations, including through bond beams, by utilizing half blocks in alternating courses on each side of the joint. Interrupt the control joint key in courses containing continuous bond beam reinforcement. Interrupt the horizontal reinforcement and grout in bond beams at the control joint except in bond beams at the floor and roof diaphragms.

Where mortar was placed in the joint, rake both faces of the control joints to a depth of **3/4 inch**. Install backer rod and sealant on both faces in accordance with Section **07 92 00 JOINT SEALANTS**.

3.3.2 Partitions

- a. Construct partitions continuous from floor to underside of floor or roof deck where **required in existing construction and if shown**. Fill openings in firewalls around joists and other structural members **if required by demolition activities and 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 **4 inches** above the ceiling level. Construct an isolation joint in the intersection between partitions and structural or exterior walls.
- b. Tie interior partitions having **4 inch** nominal thickness units to intersecting partitions of **4 inch** units, **5 inches** into partitions of **6 inch** units, and **7 inches** into partitions of **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. Tie interior partitions over **4 inches** thick together with joint reinforcement. Provide joint reinforcement with prefabricated pieces at corners and intersections of partitions.
- c. Double-Faced Bases or Partitions: Construct double-faced clay unit bases and partitions of two-unit construction. Bond units by overlapping from opposite faces of the wall, **2 inches** for **6 inch** thick partitions and **4 inches** for **8 inch** thick or greater. A single wythe prefaced concrete masonry base or partition may be made with double faced units.

3.3.3 Anchored Veneer Construction

- a. Construct exterior masonry wythes to the thickness **if required to match existing**. **Match** minimum air space behind the masonry veneer. Provide means to ensure that the cavity space and flashings are kept clean of mortar droppings and other loose debris. Maintain chases and raked-out joints free from mortar and debris **as required**.

- b. Place masonry in running bond pattern.
- c. For veneer over stud framing, do not install veneer until the exterior sheathing, moisture barrier, veneer anchors and flashing have been installed on the backing. Take extreme care to avoid damage to the moisture barrier and flashing during construction of the masonry veneer. Repair or replace portions of the moisture barrier and flashing that are damaged prior to completion of the veneer. Provide a continuous cavity **if required to match existing** as indicated.
- d. For veneer with a masonry backup wythe, lay up both the inner and the outer wythes together except when adjustable joint reinforcement assemblies are approved for use. When both wythes are not brought up together, install through-wall flashings with the exterior wythe, securing the top edge of the flashing with a termination bar and sealant, or protect flashings that are installed with the interior wythe from damage until they are fully enclosed in the wall.
- e. Provide anchors (ties) to connect the veneer to its backing in sufficient quantity to comply with the following requirements: maximum wall area per anchor {tie) of _____, and maximum vertical spacing of **16 inches**, and maximum horizontal spacing of **32 inches**. Provide additional anchors around openings larger than **16 inch** in either direction. Space anchors around perimeter of opening at a maximum of **24 inches** on center. Place anchors within **12 inches** of openings. Anchors with drips are not permitted.
- f. With hollow units, embed anchors in mortar or grout and extend into the veneer a minimum of **1-1/2 inch**, with at least **5/8 inch** mortar or grout cover to outside face.

3.3.4 Composite Walls

Tie masonry wythes together with joint reinforcement or with unit wall ties. Embed wall ties at least **1-1/2 inch** into mortar of solid units and at least **1/2 inch** into the mortar of the outer face shell of hollow units. Provide at least one tie every **2.67 square feet** for wire size **W1.7** and at least one tie every **4.50 square feet** for wire size **W2.8**. Space ties at a maximum of **36 inches** horizontally and **24 inches** vertically. Do not cross expansion joints or control joints with ties. Fill collar joints between masonry facing and masonry backup solidly with grout.

3.3.5 Reinforced, Single Wythe Concrete Masonry Units Walls

3.3.5.1 Concrete Masonry Unit Placement

- a. Fully bed units used to form piers, pilasters, columns, starting courses on footings, solid foundation walls, lintels, and beams, and where cells are to be filled with grout in mortar under both face shells and webs. Provide mortar beds under both face shells for other units. Mortar head joints for a distance in from the face of the unit not less than the thickness of the face shell.
- b. Solidly grout foundation walls below grade.
- c. Stiffen double walls 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 each wall

within the double wall. Adequately reinforce walls and partitions for support of wall-hung plumbing fixtures when chair carriers are not specified.

3.3.5.2 Preparation for Reinforcement

Lay units in such a manner as to preserve the unobstructed vertical continuity of cores to be grouted. Remove mortar protrusions extending **1/2 inch** or more into cells before placing grout. Position reinforcing bars accurately as indicated before placing grout. Where vertical reinforcement occurs, fill cores solid with grout in accordance with paragraph PLACING GROUT in this Section.

3.3.6 Cavity Walls (Multi-Wythe Noncomposite Walls)

Provide a continuous cavity **if required to match existing**. Bevel mortar beds away from cavity to prevent projection into cavity when bricks are shoved in place. Keep cavities clear and clean of mortar droppings. At the bottom of cavity walls, in the course immediately above the through-wall flashing, temporarily omit one brick every **4 feet**. Clean mortar droppings and debris out of the cavity through the temporary openings at least once each day masonry is laid, and more often when required to keep the cavities clean. Fill in the openings with bricks and mortar after the wall is complete and the cavity has been inspected and found clean.

Securely tie the two wythes together with horizontal joint reinforcement, or provide ties to connect the masonry wythes in sufficient quantity to comply with the following requirements: maximum wall area per tie of **16 inches**, and maximum vertical spacing of **8 inches**, and maximum horizontal spacing of **16 inches**. Provide additional ties around openings larger than **16 inches** in either direction. Space ties around perimeter of opening at a maximum of **3 feet** on center. Place ties within **12 inches** of openings. Ties with drips are not permitted.

3.3.7 ANCHORAGE

3.3.7.1 Anchorage to Concrete

Anchorage of masonry to the face of concrete columns, beams, or walls shall be with dovetail anchors spaced not over **16 inches** on centers vertically and **24 inches** on center horizontally.

3.3.7.2 Anchorage to Structural Steel

Masonry shall be anchored to vertical structural steel framing with adjustable steel wire anchors spaced not over **16 inches** on centers vertically, and if applicable, not over **24 inches** on centers horizontally.

3.3.7.3 Anchorage at Intersecting Walls

Provide wire mesh anchors at maximum **16 inches** spacing at intersections of interior non-bearing masonry walls.

Anchor structural masonry walls with strap anchors of minimum size **1/4 inch x 1-1/2 inch x 28 inches** including **2 inch** 90 degree bends at each end to form U or Z shape at maximum spacing **48 inches**, grouted into the wall, unless the drawings indicate a movement joint at the intersection.

3.3.8 Lintels

3.3.8.1 Masonry Lintels

Construct masonry lintels 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. Extend lintel reinforcement beyond each side of masonry opening 40 bar diameters or 24 inches, whichever is greater. Support reinforcing bars in place prior to grouting and locate 1/2 inch above the bottom inside surface of the lintel unit.

3.3.8.2 Precast Concrete and Steel Lintels

Provide precast concrete and steel lintels as shown on the Drawings. Set lintels in a full bed of mortar with faces plumb and true. Provide steel and precast lintels with a minimum bearing length of 8 inches unless otherwise indicated. In partially grouted masonry, provide fully grouted units under the full lintel bearing length, unless otherwise indicated.

3.4 INSTALLATION

3.4.1 Bar Reinforcement Installation

3.4.1.1 Preparation

Submit detail drawings showing bar splice locations. Identify bent bars on a bending diagram and reference and locate such bars on the drawings. Show wall dimensions, bar clearances, and wall openings. Utilize bending details that conform to the requirements of ACI SP-66. 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, resubmit the approved shop drawings with the additional openings shown along with the proposed changes. Clearly highlight location of these additional openings. Provide wall elevation drawings with minimum scale of 1/4 inch per foot. Submit 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; lintels; and wall openings.

Clean reinforcement of loose, flaky rust, scale, grease, mortar, grout, and other coatings that might destroy or reduce its bond prior to placing grout. Do not use bars with kinks or bends not shown on the approved shop drawings. Place reinforcement prior to grouting. Unless otherwise indicated, extend vertical wall reinforcement to within 2 inches of tops of walls.

3.4.1.2 Positioning Bars

- a. Accurately place vertical bars within the cells at the positions indicated on the drawings. A minimum clearance of 1/2 inch shall be maintained between the bars and masonry units. Provide minimum clearance between parallel bars of 1/2 inch between the bars and masonry units for coarse grout and a minimum clearance of 1/4 inch between the bars and masonry units for fine grout. Provide minimum clearance between parallel bars of 1 inch or one diameter of the reinforcement, whichever is greater. Vertical reinforcement 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 or by other means to prevent displacement beyond permitted tolerances. As masonry work progresses, secure vertical reinforcement to prevent displacement beyond allowable tolerances.

- b. Wire column and pilaster lateral ties in position around the vertical reinforcing bars. Place lateral ties in contact with the vertical reinforcement and do not place in horizontal mortar bed joints.
- c. Position horizontal reinforcing bars as indicated. Stagger splices in adjacent horizontal bars, unless otherwise indicated.
- d. Form splices by lapping bars as indicated. Do not cut, bend or eliminate reinforcing bars. Foundation dowel bars may be field-bent when permitted by TMS MSJC.

3.4.1.3 Splices of Bar Reinforcement

Lap splice reinforcing bars as indicated. When used, provide welded or mechanical connections that develop at least 125 percent of the specified yield strength of the reinforcement.

3.4.2 Placing Grout

3.4.2.1 General

Fill cells containing reinforcing bars with grout. Solidly 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. Solidly grout cells under lintel bearings on each side of openings for full height of openings. Solidly grout walls below grade, lintels, and bond beams. Units other than open end units may require grouting each course to preclude voids in the units.

Discard site-mixed grout that is not placed within 1-1/2 hours after water is first added to the batch or when the specified slump is not met without adding water after initial mixing. Discard ready-mixed grout that does not meet the specified slump without adding water other than water that was added at the time of initial discharge. Allow sufficient time between grout lifts to preclude displacement or cracking of face shells of masonry units. Provide a grout shear key between lifts when grouting is delayed and the lower lift loses plasticity. If blowouts, flowouts, misalignment, or cracking of face shells should occur during construction, tear down the wall and rebuild.

3.4.2.2 Vertical Grout Barriers for Multi-Wythe Composite Walls

In multi-wythe composite walls, provide grout barriers in the collar joint not more than 30 feet apart, or as required, to limit the horizontal flow of grout for each pour.

3.4.2.3 Horizontal Grout Barriers

Embed horizontal grout barriers in mortar below cells of hollow units receiving grout.

3.4.2.4 Grout Holes and Cleanouts

3.4.2.4.1 Grout Holes

Provide grouting holes in slabs, spandrel beams, and other in-place overhead construction. Locate holes over vertical reinforcing bars or as required to facilitate grout fill in bond beams. Provide additional openings spaced not more than **16 inches** on centers where grouting of hollow unit masonry is indicated. Form such openings not less than **4 inches** in diameter or **3 by 4 inches** in horizontal dimensions. Upon completion of grouting operations, plug and finish grouting holes to match surrounding surfaces.

3.4.2.4.2 Cleanouts for Hollow Unit Masonry Construction

For hollow masonry units, provide cleanout holes at the bottom of every grout pour in cores containing vertical reinforcement when the height of the grout pour exceeds **5 feet 4 inches**. Where all cells are to be grouted, construct cleanout courses using bond beam units in an inverted position to permit cleaning of all cells. Provide cleanout holes at a maximum spacing of **32 inches** where all cells are to be filled with grout.

Establish a new series of cleanouts if grouting operations are stopped for more than 4 hours. Provide cleanouts not less than **3 by 3 inch** by cutting openings in one face shell. Manufacturer's standard cutout units may be used at the Contractor's option. Do not cleanout holes until masonry work, reinforcement, and final cleaning of the grout spaces have been completed and inspected. For walls which will be exposed to view, close cleanout holes in an approved manner to match surrounding masonry.

3.4.2.4.3 Cleanouts for Multi-Wythe Composite Masonry Construction

Provide cleanouts for construction of walls that incorporate a grout filled cavity between solid masonry wythes, provide cleanouts at the bottom of every pour by omitting every other masonry unit from one wythe. Establish a new series of cleanouts if grouting operations are stopped for more than 4 hours. Do not plug cleanout holes until masonry work, reinforcement, and final cleaning of the grout spaces have been completed and inspected. For walls which will be exposed to view, close cleanout holes in an approved manner to match surrounding masonry.

3.4.2.5 Grout Placement

A grout pour is the total height of masonry to be grouted prior to erection of additional masonry. A grout lift is an increment of grout placement within a grout pour. A grout pour is filled by one or more lifts of grout.

- a. Lay masonry to the top of a pour permitted by **TMS MSJC** Table 7, based on the size of the grout space and the type of grout. Prior to grouting, remove masonry protrusions that extend **1/2 inch** or more into cells or spaces to be grouted. Provide grout holes and cleanouts in accordance with paragraph GROUT HOLES AND CLEANOUTS above when the grout pour height exceeds **5 feet 4 inches**. Hold reinforcement, bolts, and embedded connections rigidly in position before grouting is started. Do not prewet concrete masonry units.
- b. Place grout using a hand bucket, concrete hopper, or grout pump to fill the grout space without segregation of aggregate. Operate grout

pumps to produce a continuous stream of grout without air pockets, segregation, or contamination.

- c. If the masonry has cured at least 4 hours, grout slump is maintained between **10 to 11 inches**, and no intermediate reinforced bond beams are placed between the top and bottom of the pour height, place conventional grout in lifts not exceeding **12 feet 8 inches**. For the same curing and slump conditions but with intermediate bond beams, limit conventional grout lift to the bottom of the lowest bond beam that is more than **5 feet 4 inches** above the bottom of the lift, but do not exceed **12 feet 8 inches**. If masonry has not cured at least 4 hours or grout slump is not maintained between **10 to 11 inches**, place conventional grout in lifts not exceeding **5 feet 4 inches**.
- d. Consolidate conventional grout lift and reconsolidate after initial settlement before placing next lift. For grout pours that are **12 inches** or less in height, consolidate and reconsolidate grout by mechanical vibration or puddling. For grout pours that are greater than **12 inches** in height, consolidate and reconsolidate grout by mechanical vibration. Apply vibrators at uniformly spaced points not further apart than the visible effectiveness of the machine. Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation. If previous lift is not permitted to set, dip vibrator into previous lift. Do not insert vibrators into lower lifts that are in a semi-solidified state. If lower lift sets prior to placement of subsequent lift, form a grout key by terminating grout a minimum of **1-1/2 inch** below a mortar joint. Vibrate each vertical cell containing reinforcement in partially grouted masonry. Do not form grout keys within beams.
- e. If the masonry has cured 4 hours, place self-consolidating grout (SCG) in lifts not exceeding the pour height. If masonry has not cured for at least 4 hours, place SCG in lifts not exceeding **5 feet 4 inches**. Do not mechanically consolidate self-consolidating grout. Place self-consolidating grout in accordance with manufacturer's recommendations.
- f. Upon completion of each day's grouting, remove waste materials and debris from the equipment, and dispose of outside the masonry.

3.4.3 Joint Reinforcement Installation

Install joint reinforcement at **16 inches** on center unless otherwise indicated. Lap joint reinforcement not less than **6 inches**. Install prefabricated sections at corners and wall intersections. Place the longitudinal wires of joint reinforcement in mortar beds to provide not less than **5/8 inch** cover to either face of the unit.

3.4.4 Bond Beams

Reinforce and grout bond beams as indicated and as described in paragraphs above. Install grout barriers under bond beam units to retain the grout as required, unless wall is fully grouted or solid bottom units are used. For high lift grouting in partially grouted masonry, provide grout retaining material on the top of bond beams to prevent upward flow of grout. Ensure that reinforcement is continuous, including around corners, except through control joints or expansion joints, unless otherwise indicated.

3.4.5 Flashing and Weeps

- a. Install through-wall flashing at obstructions in the cavity and where indicated on Drawings. Ensure continuity of the flashing at laps and inside and outside corners by splicing in a manner approved by the flashing manufacturer. Ensure that the top edge of the flashing is sealed by turning the flashing $\frac{1}{2}$ inch into the mortar bed joint of backup masonry or attaching a termination bar and applying compatible sealant at the top edge of the termination bar or lapping a minimum of 6 inches under the weather resistive barrier or securing the sheet metal flashing into a reglet cast into the concrete backup. Terminate the horizontal leg of the flashing by extending the sheet metal $\frac{1}{2}$ inch beyond the outside face of masonry and turning downward with a hemmed drip or terminating the fabric flashing $\frac{1}{2}$ inch short of the outside face of masonry and adhering the flashing to a sheet metal drip edge or extending the fabric flashing beyond the outside face of masonry and, when construction is complete, cutting the flashing flush with the face of masonry. Provide sealant below the drip edge of through-wall flashing.
- b. Wherever through-wall flashing occurs, provide weep holes to drain flashing to exterior at acceptable locations as indicated. Provide weeps of open head joints or weep ventilators. Locate weeps not more than 24 inches on centers in mortar joints of the exterior wythe directly on the horizontal leg of through-wall flashing over foundations, bond beams, and any other horizontal interruptions of the cavity. Place weep holes perfectly horizontal or slightly canted downward to encourage water drainage outward and not inward. Other methods may be used for providing weeps when spacing is reduced to 16 inches on center and approved by the Contracting Officer. Maintain weeps free of mortar and other obstructions.
- c. Install single-wythe CMU flashing system in bed joints of CMU walls where CMU cells are open. Install CMU cell pans with upturned edges located below face shells and webs of CMUs above and with weep spouts aligned with face of wall on the exterior side. Install CMU web covers so that they cover upturned edges of CMU cell pans at CMU webs and extend from face shell to face shell.

3.5 APPLICATION

3.5.1 Insulation

Insulate cavity walls (multi-wythe noncomposite masonry walls), if required to match existing, by installing board-type insulation on the cavity side of the inner wythe. Apply board type insulation directly to the masonry or thru-wall flashing with adhesive. Neatly fit insulation between obstructions without impaling insulation on ties or anchors. Apply insulation in parallel courses with vertical joints breaking midway over the course below and in moderate contact with adjoining units without forcing. Cut to fit neatly against adjoining surfaces. Tape or seal the joints between the boards.

3.5.2 Interface with Other Products

3.5.2.1 Built-In Items

Fill spaces around built-in items with mortar. Point openings around flush-mount electrical outlet boxes in wet locations with mortar. Embed

anchors, ties, wall plugs, accessories, flashing, pipe sleeves and other items required to be built-in as the masonry work progresses. Fully embed anchors, ties and joint reinforcement in the mortar. Fill cells receiving anchor bolts and cells of the first course below bearing plates with grout, unless otherwise indicated.

3.5.2.2 Door and Window Frame Joints

On the exposed interior and exterior sides of exterior frames, rake joints between frames and abutting masonry walls to a depth of $\frac{3}{8}$ inch.

3.5.2.3 Bearing Plates

Set bearing plates for beams, joists, joist girders and similar structural members to the proper line and elevation with damp-pack bedding mortar, except where non-shrink grout is indicated. Provide bedding mortar and non-shrink grout as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5.3 Tolerances

Lay masonry plumb, true to line, with courses level within the tolerances of TMS MSJC, Article 3.3 F.

3.6 POINTING AND CLEANING

After mortar joints have attained their initial set, but prior to hardening, completely remove mortar and grout daubs and splashings from masonry-unit surfaces that will be exposed or painted. Before completion of the work, rake out defects in joints of masonry to be exposed or painted, fill with mortar, and tool to match existing joints. Immediately after grout work is completed, remove scum and stains that have percolated through the masonry work using a low pressure stream of water and a stiff bristled brush. Do not clean masonry surfaces, other than removing excess surface mortar, until mortar in joints has hardened. Leave masonry surfaces clean, free of mortar daubs, dirt, stain, and discoloration, including scum from cleaning operations, and with tight mortar joints throughout. Do not use metal tools and metal brushes for cleaning.

3.6.1 Dry-Brushing Concrete Masonry

Dry brush exposed concrete masonry surfaces at the end of each day's work and after any required pointing, using stiff-fiber bristled brushes.

3.7 CLOSE-OUT TAKE-BACK PROGRAM

Collect information from manufacturer for take-back program options. Set aside masonry units, full and partial to be returned to manufacturer for recycling into new product. When such a service is not available, seek local recyclers to reclaim the materials. Submit documentation that includes contact information, summary of procedures, and the limitations and conditions applicable to the project. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.

3.8 PROTECTION

Protect facing materials against staining. Cover top of walls with nonstaining waterproof covering or membrane to protect from moisture intrusion when work is not in progress. Continue covering the top of the unfinished walls until the wall is waterproofed with a complete roof or

parapet system. Extend covering a minimum of 2 feet down on each side of the wall and hold securely in place. Before starting or resuming work, clean top surface of masonry in place of loose mortar and foreign material.

-- End of Section --

SECTION 05 05 20

POST-INSTALLED CONCRETE AND MASONRY ANCHORS

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 CONCRETE INSTITUTE (ACI)

- ACI 355.2 (2007) Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary
- ACI 355.4 (2011) Qualification of Post-Installed Adhesive Anchors in Concrete (ACI 355.4) and Commentary

ASTM INTERNATIONAL (ASTM)

- ASTM A36/A36M (2019) Standard Specification for Carbon Structural Steel
- ASTM A153/A153M (2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- ASTM A193/A193M (2022a) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
- ASTM A615/A615M (2022) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- ASTM E488/E488M (2022) Standard Test Methods for Strength of Anchors in Concrete Elements
- ASTM F1554 (2020) Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

INTERNATIONAL CODE COUNCIL (ICC)

- ICC IBC (2021) International Building Code

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

- ISO/IEC 17011 (2017) Paper - Conformity assessment - Requirements for accreditation bodies accrediting conformity assessment bodies

ISO/IEC 17025

(2017) Paper - General requirements for
the competence of testing and calibration
laboratories

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1

(2014) Safety -- Safety and Health
Requirements Manual

1.2 APPLICABILITY

This guide specification covers the requirements for all anchors that are post-installed into hardened concrete, concrete masonry, or brick. This guide specification does not cover through bolts, powder or pneumatic actuated nails, or cast in anchors. Refer to Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS for requirements of through bolts, powder or pneumatic actuated nails, or cast in anchors.

1.3 DEFINITIONS

1.3.1 Anchor

"Anchor" includes steel elements post-installed into hardened concrete, concrete masonry, or brick and used to transmit applied loads.

1.3.2 Periodic Special Inspections

"Periodic Special Inspection" as used herein means that, as a minimum, the Post-Installed Anchor Special Inspector must perform inspections in accordance with this specification.

1.3.3 Continuous Special Inspections

"Continuous Special Inspection" as used herein means that the Post-Installed Anchor Special Inspector observes the drilling and cleaning of holes, the injection of adhesive into the holes, and the insertion of anchors into the holes. When applicable for the type of installation, or as indicated in the project drawings, "Continuous Special Inspection" also includes observation of measures to secure the anchor during the adhesive curing period.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Installer Qualifications; G

Post-Installed Anchor Special Inspector Qualifications; G

SD-03 Product Data

Mechanical Anchors in Concrete; G

Adhesive Anchor System in Concrete; G

Mechanical and Adhesive Anchors in Masonry; G

Non-Shrink, Non-Metallic Grout; G

SD-06 Test Reports

Post-Installed Anchor Special Inspections Report; G

SD-07 Certificates

Post-Installed Anchor Certification; G

SD-08 Manufacturer's Instructions

Manufacturer's Printed Installation Instructions; G

Non-Shrink, Non-Metallic Grout; G

Manufacturer's Safety Data Sheets

1.5 QUALITY ASSURANCE

Perform all work in accordance with [EM 385-1-1](#) and all manufacturer's instructions and recommendations. To protect personnel from overexposure to toxic materials, conform to the applicable [manufacturer's Safety Data Sheets](#) (SDS) or local regulation. Submit the SDS for epoxies and other potentially hazardous materials.

1.5.1 Qualifications

The submittals must identify individuals who will be working on this contract and their relevant experience and training. Do not make changes in approved personnel without prior approval of the Contracting Officer.

1.5.1.1 Installer Qualifications

Each worker engaged in the installation of post-installed anchors must have satisfactorily completed an applicable certification program or equivalent instruction program through the manufacturer or manufacturer's representative for all anchoring products they will install. A manufacturer's representative must train all installers per the installation instructions as listed in the ICC-ES Evaluation Report for the anchor being installed. Training must consist of a review and performance test of the complete installation process, including but not limited to:

- a. Hole drilling procedure
- b. Hole preparation & cleaning technique
- c. Adhesive injection technique & dispenser training / maintenance
- d. Anchor/threaded rod preparation and installation
- e. Rebar dowel preparation and installation

Submit certification for each worker showing that they have completed the above training within three years prior to onsite work. Certification must include organization or manufacturer's name, instructor's name and qualifications, trainee's name, list of instruction received, date of instruction, and confirmation of successful performance tests.

1.5.1.2 Post-Installed Anchor Special Inspector Qualifications

The Contractor must retain the services of a third party Special Inspector independent of the installing contractor and manufacturer. The individual(s) who perform special inspections for post-installed anchors must meet all Installer Qualification requirements and have a minimum of 1 year of experience as a Special Inspector on previous projects involving similar scope of work. Submit resumes, pertinent information, past experience, and training.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Packing, Shipping, Handling, and Unloading

Deliver products to job site in manufacturer's or distributor's original packaging undamaged, complete with installation instructions. Inspect materials delivered to site for damage. Unload and store with minimal handling.

1.6.2 Storage

Protect, store, and handle materials in accordance with manufacturer's recommendations to prevent damage or deterioration. Do not allow chemical materials to freeze. Remove materials that have not been stored in accordance with the manufacturer's recommendations, including expired materials, from the job site.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Post-Installed Anchors

Provide anchors of the type, effective embedment, and diameter indicated on contract drawings. Minimum spacing and concrete edge distances must be as shown on contract drawings. Design values listed must be as tested according to [ASTM E488/E488M](#) for the substrate type, substrate moisture condition, concrete aggregate type (normal weight or lightweight concrete), and concrete/masonry strength. Minimum ultimate strength tension and shear values must be as indicated on contract drawings. If more than one type of anchor is to be used on a project, clearly indicate on the submittal where each type of anchor will be used.

2.1.1.1 Post-Installed Anchor Certification

Submit product information with recommended design values and physical characteristics for each type anchor shown on the drawings.

Provide certified test reports showing compliance with specified performance characteristics and physical properties. Anchors must have one of the following certifications:

- a. ICC-ES Evaluation Report indicating conformance with current applicable ICC ES Acceptance Criteria
- b. Third party Evaluation Report in conformance with **ACI 355.2** or **ACI 355.4**, as applicable. Third party must be accredited under **ISO/IEC 17025** by a recognized accreditation body conforming to the requirements of **ISO/IEC 17011** in accordance with **ACI 355.4**.

2.1.1.2 Manufacturer's Printed Installation Instructions

Submit manufacturer's instructions for each anchor type shown on the drawings.

2.1.1.3 Mechanical Anchors in Concrete

Anchors must have been tested and qualified for performance in cracked and uncracked concrete in accordance with **ACI 355.2**.

Anchors must be galvanized in accordance with **ASTM A153/A153M** or stainless steel in accordance with **ASTM A193/A193M** unless otherwise indicated.

2.1.1.4 Adhesive Anchor System in Concrete

Use an adhesive to bond steel anchors to concrete. The adhesive must be a moisture insensitive, structural adhesive. Anchors must have been tested and qualified for performance in cracked and uncracked concrete, horizontal and overhead applications, and long term creep in accordance with **ACI 355.4**.

Threaded rod anchors must meet the requirements of **ASTM F1554** Grade 36 **ASTM A36/A36M**. Threaded rods must be galvanized in accordance with **ASTM A153/A153M** or stainless steel in accordance with **ASTM A193/A193M** unless otherwise indicated. Reinforcing bars must meet the requirements of **ASTM A615/A615M** Grade 60.

Adhesive anchors must have the below characteristic bond strengths for uncracked and cracked concrete in **4000 psi** concrete with maximum short term temperatures of **130 degrees F** and maximum long term temperatures of **110 degrees F**:

ANCHOR	Tau,uncr (characteristic bond strength, uncracked concrete)	Tau,cr (characteristic bond strength, cracked concrete)
	(psi)	(psi)
3/4" diameter threaded rod	2130	1250
1" diameter threaded rod	1960	1240

2.1.1.5 Mechanical and Adhesive Anchors in Masonry

Anchors must have been tested and qualified, by a third party, specifically for performance in hollow concrete masonry/filled concrete masonry to match the project's actual base material.

Adhesives must be moisture insensitive, low creep, structural adhesive. Threaded rods must meet the requirements of **ASTM F1554** Grade 36 **ASTM A36/A36M**.

Anchors must be galvanized in accordance with [ASTM A153/A153M](#) or stainless steel in accordance with [ASTM A193/A193M](#) unless otherwise indicated.

2.2 EQUIPMENT

Assemble at the site of the work, sufficient equipment that is dependable, appropriate and adequate to accomplish the work specified. Maintain the equipment in good working condition.

PART 3 EXECUTION

3.1 ANCHORING AND REINFORCING

Install anchors in accordance with the spacing and edge clearances indicated on the drawings. Anchor capacity is also highly dependent on proper installation. Follow all manufacturer and Evaluation Report installation instructions.

3.1.1 Drilling and Installing Mechanical Anchors

Drill holes for anchors using drilling equipment and bits suitable for the intended purpose, in accordance with Manufacturer's published installation instructions. Diameter of holes must be as recommended by the anchor manufacturer. Unless otherwise shown on the Drawings, all holes must be drilled perpendicular to the concrete surface. Deviations more than [6 degrees](#) from perpendicular are not acceptable. Unless otherwise specified, do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength. Mechanical anchors must not be installed in concrete that is less than 7 days old.

Clean holes, install anchors and set anchors in place in accordance with the manufacturer's recommendations. Protect threads and anchor from damage during anchor installation. Ensure proper embedment and placement in accordance with contract documents and all other work. Aim wedges away from any concrete edges that are less than [9 inches](#) from centerline of hole.

Tighten nuts against smooth washers to the manufacturer's recommended torque, using a calibrated torque wrench. Following attainment of 10 percent of the specified torque, 100 percent of the specified torque must be reached within 7 or less complete turns of the nut. If the specified torque is not achieved within the required number of turns, the anchor must be removed and replaced unless otherwise directed by the Engineer of Record.

3.1.2 Drilling and Installing Adhesive Anchors

Drill holes for anchors using drilling equipment and bits suitable for the intended purpose, in accordance with Manufacturer's Printed Installation Instructions and Evaluation Report installation instructions. Diameter of holes must be as recommended by the anchor manufacturer. Unless otherwise shown on the drawings, all holes must be drilled perpendicular to the concrete surface. Deviations more than 10 degrees from perpendicular are not acceptable. Unless otherwise specified, do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength. Adhesive anchors must not be installed in concrete that is less than 21 days old.

Clean holes, place grout, and install anchors in accordance with anchor manufacturer's recommendations. Remove excess adhesive after the anchor has been set in place. Remove spills on adjacent surfaces. Protect threads and anchor from damage during anchor installation. Ensure proper embedment and placement in accordance with contract documents and all other work. Do not disturb or load anchors before manufacturer specified cure time has elapsed.

Adhesives must be stored at temperatures prescribed by the manufacturer and must not be used beyond the expiration date.

3.1.3 Unused or Repairs to Drilled Holes

Any holes made for anchors that are not used must be filled with **non-shrink, non metallic grout** suitable for the orientation and size of hole and have a minimum compressive strength of **4000 psi**. Repair must completely fill hole and be flush with existing concrete or masonry. Place in accordance with manufacturer's recommended instructions. Final anchor positions must not be within **1 inch** of repair patches.

3.2 EMBEDDED ITEMS

Existing reinforcing bars or other embedded items in the structure may conflict with specified anchor locations. Existing reinforcing and embedded items must not be damaged during installation of post-installed anchors.

The contractor must review the project **and** as-built drawings and must use Radar detection systems (such as Hilti Ferrosan), X-Ray, or other appropriate means to accurately locate the position of reinforcing bars and embedded items at the locations of the anchors in the field.

Create a template at each anchor connection location prior to fabricating holes in connection plates. Template must be made by locating existing reinforcing with an approved reinforcement detection system.

3.3 TESTS AND INSPECTIONS

3.3.1 Mechanical Anchors

For mechanical anchors, periodic special inspections are required. Inspections must be in accordance with **ICC IBC** and the Evaluation Report.

Mechanical Anchors must be inspected during installation, to verify anchor type, anchor dimensions, base material type, drill bit, hole dimensions, hole cleaning procedures, anchor spacing, edge distances, base material thickness, base material age, effective embedment, tightening torque, adherence to the manufacturer's printed installation instructions, and any additional items recommended in the Evaluation Report.

3.3.2 Adhesive Anchors

For adhesive anchors, periodic special inspection are required as a minimum. Where adhesive anchors are used to resist sustained tension in horizontal or upwardly inclined orientations, or where the findings of the Evaluation Report for the adhesive anchor product require it, continuous special inspection is needed. Inspections must be in accordance with **ICC IBC** and the Evaluation Report.

Adhesive anchors must be inspected during installation, to verify anchor type, anchor dimensions, base material type, base material age, drill bit, hole dimensions, hole cleaning procedures, anchor spacing, edge distances, base material thickness, effective embedment, tightening torque, adhesive mixing, filling of the hole with adhesive, adherence to the manufacturer's printed installation instructions, and any additional items recommended in the Evaluation Report.

3.3.3 Action Required from Failed Tests/Inspections

Immediately report failed anchor locations and test results to the Contracting Officer. Anchors that fail to meet installation requirements must be regarded as malfunctioning. Do not re-use holes unless specifically allowed by manufacturer's published instructions and approved by the Post-Installed Anchor Special Inspector.

Fill unused anchor holes and patch failed anchor locations in accordance with this specification. Prior to performing the repair, the Contractor must submit to the Contracting Officer for approval, the proposed fill and patch materials.

Additional tests, repairs, delays, or modification of work to accommodate failed tests will be at no cost to the Government.

3.3.4 Post-Installed Anchor Special Inspections Report

Report the results of all inspections weekly. Submit report as an electronic PDF file to the Contracting Officer for review by the Engineer of Record. The report must include the following:

- a. Exact locations of the inspected and tested work
- b. Inspector's name
- c. Date of inspection
- d. Summary of work completed during the inspection period
- e. Test results
- f. Statement by the Special Inspector that clearly identifies the tested anchors as being acceptable or rejected.
- g. Statement by the Special Inspector confirming that the materials and installation procedures conform with the approved contract documents and the manufacturer's published installation instructions.

3.4 DUST CONTROL

Control dust resulting from demolition to prevent the spread of dust and avoid creation of a nuisance in the surrounding area. Do not use water when it will result in, or create, hazardous or objectionable conditions such as ice, flooding, or pollution.

-- End of Section --

SECTION 05 05 23.16

STRUCTURAL WELDING

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 INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360 (2016) Specification for Structural Steel Buildings

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4 (2012) Standard Symbols for Welding, Brazing and Nondestructive Examination

AWS D1.1/D1.1M (2015; Errata 1 2015; Errata 2 2016) Structural Welding Code - Steel

AWS D1.3/D1.3M (2018) Structural Welding Code - Sheet Steel

AWS D1.4/D1.4M (2011) Structural Welding Code - Reinforcing Steel

AWS D1.8/D1.8M (2016) Structural Welding Code—Seismic Supplement

JAPANESE ARCHITECTURAL STANDARD SPECIFICATIONS (JASS)

JASS 6 (2015) Structural Steelwork Specification for Building Construction

JAPANESE INDUSTRIAL STANDARDS (JIS)

JIS Z 2305 (2013) Non-destructive Testing - Qualification and Certification of Personnel

JIS Z 2320 (2007) Non-destructive Testing - Magnetic Particle Testing

JIS Z 2343 (2001) Non-destructive Testing - Penetrant Testing

JIS Z 3021 (2016) Welding and Allied Processes - Symbolic Representation

JIS Z 3400 (2013) Quality Requirements for Fusion Welding of Metallic Materials

JIS Z 3420	(2003) Specification and Approval of Welding Procedures for Metallic Materials - General Rules
JIS Z 3801	(2018) Standard Qualification Test and Acceptance Requirements for Manual Welding Technique
JIS Z 3841	(2018) Test Method and Criteria in Semi-Automatic Welding Technology Certification
JIS Z 3881	(2014) Standard Qualification Procedure for Gas Pressure Welding Technique of Steel Bars for Concrete Reinforcement
MINISTRY OF LAND, INFRASTRUCTURE, TRANSPORT AND TOURISM, GOVERNMENT OF JAPAN (MLIT)	
MLIT-SS Chapter 7	(2019) Public Building Construction Standard Specifications - Ch.7 Steel Frame Work
JAPAN WELDING ENGINEERING SOCIETY (JWES)	
WES 9009	(2007) Safety and Health in Welding, Thermal Cutting, and Allied Processes Parts 1 through 6

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Welding Quality Assurance Plan; G

SD-03 Product Data

Welding Procedure Qualifications; G

Welder, Welding Operator, and Tacker Qualification

Previous Qualifications

Pre-Qualified Procedures; G

Welding Electrodes and Rods

SD-06 Test Reports

Nondestructive Testing

Weld Inspection Log

SD-07 Certificates

Certified Welding Inspector

Nondestructive Testing Personnel

1.3 QUALITY ASSURANCE

Except for pre-qualified (in accordance with JASS 6 and JIS Z 3420) and previously qualified procedures, each Contractor performing welding must record in detail and qualify the welding procedure specification for any welding procedure followed in the fabrication of weldments. Conform welding procedure qualifications to AWS D1.1/D1.1M or JASS 6 and JIS Z 3420 and to the specifications in this section. Submit for approval copies of the welding procedure specification and the procedure qualification records for each type of welding being performed. Submission of the welder, welding operator, or tackler qualification test records is also required. Approval of any procedure, however, does not relieve the Contractor of the sole responsibility for producing a finished structure meeting all the specified requirements. Submit this information on the forms in Annex M of AWS D1.1/D1.1M or in accordance with JIS Z 3420. Individually identify and clearly reference on the detail drawings and erection drawings all welding procedure specifications, or suitably key them to the contract drawings. In case of conflict between this specification and AWS D1.1/D1.1M or JASS 6 and JIS Z 3420, this specification governs.

1.3.1 General Requirements

Fabricate work in MLIT Certified Fabrication Plant. Erect work by MLIT Certified Erector.

a. For Structural Projects, provide documentation of the following:

- (1) Component Thickness 1/8 inch and greater: Qualification documents (WPS, PQR, and WPQ) in accordance with JASS 6 and JIS Z 3420.
- (2) Component Thickness Less than 1/8 inch: Qualification documents (WPS, PQR, and WPQ) in accordance with AWS D1.3/D1.3M or JASS 6 and JIS Z 3420.
- (3) Reinforcing Steel: Qualification documents (WPS, PQR, and WPQ) in accordance with AWS D1.4/D1.4M or JASS 6 and JIS Z 3881.

1.3.2 Previous Qualifications

Welding procedures previously qualified by test in accordance with JASS 6, may be accepted for this contract without re-qualification, upon receipt of the test results, 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.

1.3.3 Pre-qualified Procedures

Welding procedures which are considered pre-qualified as specified in JASS 6 will be accepted without further qualification. Submit for approval a listing or an annotated drawing to indicate the joints not pre-qualified. Procedure qualification is mandatory for these joints.

1.3.4 Welder, Welding Operator, and Tacker Qualification

Each welder, welding operator, and tacker assigned to work on this contract must be qualified in accordance with the applicable requirements of JASS 6, JIS Z 3801 and JIS Z 3841, AWS D1.8/D1.8M 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 within the applicable essential variables for welder qualification.

1.3.4.1 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 re-qualification 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 welder, welding operator, and tacker qualification tests conform to the requirements of this specification and are applicable to welding conditions encountered under this contract.

1.3.4.2 Certificates

Before assigning any welder, welding operator, or tacker to work under this contract, submit the names and certification that each individual is qualified as specified. State in the certification 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. Keep the certification current, on file, and furnish 3 copies.

1.3.4.3 Renewal of Qualification

Re-qualification of a welder or welding operator is 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. Submit as evidence of conformance all records showing periods of employment, name of employer where welder, or welding operator, was last employed, and the process for which qualified.
- d. A tacker who passes the qualification test is considered eligible to perform tack welding indefinitely in the positions and with the processes for which he/she is qualified, unless there is some specific reason to question the tacker's ability or there has been a gap greater than 6 months since he/she last used the process. In such a case, the tacker is required to pass the prescribed tack welding test.

1.3.5 Inspector Qualification

Submit certificates indicating that [certified welding inspectors](#) meet the requirements of [JASS 6](#). Submit qualifications for [nondestructive testing personnel](#) in accordance with the requirements of [JIS Z 2305](#) Levels 1 or 2 in the applicable nondestructive testing method. Level I inspectors must have direct supervision of a Level II inspector.

1.3.6 Symbols and Safety

Use symbols in accordance with [AWS A2.4](#) or [JIS Z 3021](#), unless otherwise indicated. Follow safe welding practices and safety precautions during welding in conformance with [WES 9009](#).

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Conform the design of welded connections to [AISC 360](#), unless otherwise indicated or specified. Material with welds will not be accepted unless the welding is specified or indicated on the drawings, in conformance to [JASS 6](#) or [MLIT-SS Chapter 7](#), or otherwise approved. Perform welding as specified in this section, except where additional requirements are shown on the drawings or are specified in other sections. Do not commence welding until welding procedures, inspectors, nondestructive testing personnel, welders, welding operators, and tackers have been qualified and the submittals approved by the Contracting Officer. Perform all testing at or near the work site. Maintain records of the test results obtained in welding procedure, welder, welding operator, and tacker performance qualifications.

2.1.1 Pre-erection Conference

Hold a pre-erection conference 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) (submitted for all welding, including welding done using pre-qualified procedures). Mandatory attendance is required by all Contractor's welding production and inspection personnel and appropriate Government personnel. Include as items for discussion: 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 nondestructive testing; welding schedule; and other items deemed necessary by the attendees.

2.2 WELDING EQUIPMENT AND MATERIALS

Provide all welding equipment, welding electrodes and rods, welding wire, and fluxes capable of producing satisfactory welds when used by a qualified welder or welding operator. Use E70XX welding electrodes. Provide welding equipment and materials that comply with the applicable requirements of AWS D1.1/D1.1M or JASS 6. Submit product data on welding electrodes and rods.

PART 3 EXECUTION

3.1 WELDING OPERATIONS

3.1.1 Requirements

Conform workmanship and techniques for welded construction to the requirements of JASS 6 and JIS Z 3400, and AISC 360. When JASS 6 and JIS Z 3400, AWS D1.8/D1.8M and AISC 360 specification conflict, the requirements of AISC 360 and AWS D1.8/D1.8M govern.

3.1.2 Identification

Identify all welds in one of the following ways:

- a. Submit written records to indicate the location of welds made by each welder, welding operator, or tacker.
- b. Identify all work performed by each welder, welding operator, or tacker with an assigned 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. Place the identification mark for seam welds adjacent to the weld at 3 foot intervals. Identification with die stamps or electric etchers is not allowed.

3.2 QUALITY CONTROL

Perform testing using 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. A Certified Welding Inspector must perform visual inspection on 100 percent of all welds. Document this inspection in the Visual Weld Inspection Log. Test 50 percent of CJP welds using ultrasonic testing per Table 6.2 of AWS D1.1/D1.1M. Randomly test 50 percent of all PJP and fillet welds or as indicated by magnetic particle or dye penetrant testing. Verify the welds conform to paragraph STANDARDS OF ACCEPTANCE. Conform procedures and techniques for inspection with applicable requirements of JASS 6, JIS Z 2343, and JIS Z 2320. Submit a Welding Quality Assurance Plan and records of tests and inspections.

3.3 STANDARDS OF ACCEPTANCE

Conform dimensional tolerances for welded construction, details of welds, and quality of welds with the applicable requirements of JASS 6 and the contract drawings. Submit all records of nondestructive testing.

3.3.1 Nondestructive Testing

The welding is subject to inspection and tests in the mill, shop, and field. Inspection and tests in the mill or shop do 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. Any indication of a defect is regarded as a defect, unless re-evaluation by nondestructive methods or by surface conditioning shows that no unacceptable defect is present. Submit all records of nondestructive testing in accordance with paragraph STANDARDS OF ACCEPTANCE.

3.3.2 Destructive Tests

Make all repairs when metallographic specimens are removed from any part of a structure. Employ only qualified welders or welding operators, and 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 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

If inspection or testing indicates defects in the weld joints, repair defective welds using a qualified welder or welding operator as applicable. Conduct corrections in accordance with the requirements of AWS D1.1/D1.1M or JASS 6 and the specifications. Repair all defects in accordance with the approved procedures. Repair defects discovered between passes before additional weld material is deposited. Wherever a defect is removed and repair by welding is not required, blend the affected area into the surrounding surface to eliminate sharp notches, crevices, or corners. After a defect is thought to have been removed, and before re-welding, examine the area by suitable methods to ensure that the defect has been eliminated. Repaired welds must meet the inspection requirements for the original welds.

-- End of Section --

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SECTION 05 12 00

STRUCTURAL STEEL

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 INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 303	(2016) Code of Standard Practice for Steel Buildings and Bridges
AISC 325	(2017) Steel Construction Manual
AISC 341	(2016) Seismic Provisions for Structural Steel Buildings
AISC 360	(2016) Specification for Structural Steel Buildings
AISC 420	(2010) Certification Standard for Shop Application of Complex Protective Coating Systems

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(2012) Standard Symbols for Welding, Brazing and Nondestructive Examination
AWS D1.1/D1.1M	(2015; Errata 1 2015; Errata 2 2016) Structural Welding Code - Steel

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B46.1	(2009) Surface Texture, Surface Roughness, Waviness and Lay

ASTM INTERNATIONAL (ASTM)

ASTM F959/F959M	(2017a) Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners, Metric Series

JAPANESE ARCHITECTURAL STANDARD SPECIFICATIONS (JASS)

JASS 6	(2015) Structural Steelwork Specification for Building Construction

JAPANESE INDUSTRIAL STANDARDS (JIS)

JIS B 1048	(2007) Fasteners - Hot Dip Galvanized

Coatings

JIS B 1186	(2013) Sets of High Strength Hexagon Bolt, Hexagon Nut and Plain Washers for Friction Grip Joints
JIS B 1220	(2015) Set of Anchor Bolt for Structures
JIS G 3106	(2017) Rolled Steels for Welded Structure (Amendment 1)
JIS G 3136	(2012) Rolled Steel for Building Structures
JIS G 3192	(2014) Dimensions, Mass and Permissible Variations of Hot Rolled Steel Sections
JIS G 3193	(2008) Dimensions, Mass and Permissible Variations of Hot Rolled Steel Plates, Sheets, and Strips
JIS G 3444	(2016) Carbon Steel Tubes for General Structure
JIS G 3466	(2015) Carbon Steel Square and Rectangular Tubes for General Structure
JIS Z2305	(2013) Non-destructive Testing - Qualification and Certification of Personnel
JIS H 8641	(2007) Hot Dip Galvanized Coatings
JIS K 5674	(2019) Lead-Free, Chromium-Free Anticorrosive Paints
JIS Z 3021	(2016) Welding and Allied Processes - Symbolic Representation
JIS Z 3060	(2015) Method of Ultrasonic Testing for Welds of Ferritic Steel

JAPANESE SOCIETY OF STEEL CONSTRUCTION (JSS)

JSS II 09	(2015) Sets of Torshear Type High Strength Bolt, Hexagonal Nut and Plain Washer for Structural Joints

MINISTRY OF LAND, INFRASTRUCTURE, TRANSPORT AND TOURISM,
GOVERNMENT OF JAPAN (MLIT)

MLIT-SS Chapter 7	(2019) Public Building Construction Standard Specifications - Ch.7 Steel Frame Work

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PA 1	(2016) Shop, Field, and Maintenance Coating of Metals

SSPC SP 3 (1982; E 2004) Power Tool Cleaning

SSPC SP 6/NACE No.3 (2007) Commercial Blast Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01 (2019) Structural Engineering

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR Part 1926, Subpart R Steel Erection

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Erection and Erection Bracing Drawings; G

SD-02 Shop Drawings

Fabrication Drawings Including Details of Connections; G

SD-03 Product Data

Welding Electrodes and Rods

Direct Tension Indicator Washers

Non-Shrink Grout

Tension Control Bolts

SD-05 Design Data

Shoring and Temporary Bracing; G

SD-06 Test Reports

Weld Inspection Reports

Bolt Testing Reports

SD-07 Certificates

MLIT Structural Steel Fabricator Quality Certification

MLIT Structural Steel Erector Quality Certification

Welding Procedure Specifications (WPS)

1.3 MLIT QUALITY CERTIFICATION

Work must be fabricated by MLIT Structural Steel Fabricator, Category M. Submit MLIT Structural Steel Fabricator quality certification.

Work must be erected by MLIT Structural Steel Certified Erector. Submit [MLIT Structural Steel erector quality certification](#).

1.4 SEISMIC PROVISIONS

Provide the structural steel system in accordance with [AISC 341](#), Chapter J as amended by [UFC 3-301-01](#).

1.5 QUALITY ASSURANCE

1.5.1 Preconstruction Submittals

1.5.1.1 Erection and Erection Bracing Drawings

Submit for record purposes. Indicate the sequence of erection, temporary shoring and bracing. The erection drawings must conform to [JASS 6](#) and [MLIT-SS Chapter 7](#). Erection drawings must be reviewed, stamped and sealed by a registered professional engineer.

1.5.2 Fabrication Drawing Requirements

Submit [fabrication drawings](#) for approval prior to fabrication. Prepare in accordance with [JASS 6](#) and [MLIT-SS Chapter 7](#). Fabrication drawings must not be reproductions of contract drawings. Sign and seal fabrication drawings by a registered professional engineer. Include complete information for the fabrication and erection of the structure's components, including the location, type, and size of bolts, welds, member sizes and lengths, connection details, blocks, copes, and cuts. Use [AWS A2.4](#) or [JIS Z 3021](#) standard welding symbols. [Shoring and temporary bracing](#) must be designed and sealed by a registered professional engineer and submitted for record purposes, with calculations, as part of the drawings. Clearly highlight any deviations from the details shown on the contract drawings highlighted on the fabrication drawings. Explain the reasons for any deviations from the contract drawings.

1.5.3 Certifications

1.5.3.1 Welding Procedures and Qualifications

Prior to welding, submit certification for each welder stating the type of welding and positions qualified for, the code and procedure qualified under, date qualified, and the firm and individual certifying the qualification tests.

Conform to all requirements specified in [JASS 6](#).

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Conform the design of structural steel system to [AISC 360](#), [AISC 303](#), [AISC 341](#), and [UFC 3-301-01](#).

Provide the structural steel system, including shop primer, complete and ready for use. Provide structural steel systems including materials, installation, workmanship, fabrication, assembly, erection, inspection, quality control, and testing in accordance with [JASS 6](#) and [MLIT-SS Chapter 7](#), except as modified in this contract.

2.2 STEEL

2.2.1 Structural Steel

Wide flange and WT shapes, JIS G 3136, SN490B, 325 MPa. Angles and Channels JIS G 3106, SM400, 235 MPa. Plates, JIS G 3136, SN400B, 235 MPa, unless otherwise indicated on contract drawings. Provide structural steel containing a minimum of 80 percent recycled content.

2.2.2 Structural Steel Tubing

JIS G 3466, STKR400, 245MPa. Provide structural steel tubing containing a minimum of 25 percent recycled content.

2.2.3 Steel Pipe

JIS G 3444, STK 400 and 235 MPa. Provide steel pipe containing a minimum of 50 percent recycled content.

2.3 BOLTS, NUTS, AND WASHERS

Submit the certified manufacturer's mill reports which clearly show the applicable JIS mechanical and chemical requirements together with the actual test results for the supplied fasteners.

2.3.1 High-Strength Bolts

High strength bolts and nuts must be shipped together in the same shipping container. Fasteners indicated to be galvanized shall be tested by the supplier to show that the galvanized nut with the supplied lubricant provided may be rotated from the snug tight condition well in excess of the rotation required for pretensioned installation without stripping. The supplier shall supply nuts that have been lubricated and tested with the supplied bolts.

2.3.1.1 Bolts

JIS B 1186, Type F10T.

2.3.1.2 Nuts

JIS B 1186, F10.

2.3.1.3 Direct Tension Indicator Washers

ASTM F959/F959M. Submit product data for direct tension indicator washers.

2.3.1.4 Washers

JIS B 1186, F35, plain carbon steel.

2.3.2 Tension Control Bolts

MLIT approved JSS II 09, JIS B 1186 S10T twistoff style assemblies consisting of steel structural bolts with splined ends, heavy-hex carbon steel nuts, and hardened carbon steel washers. Assembly finish must be plain. Submit product data for tension control bolts.

2.3.3 Foundation Anchorage

2.3.3.1 Anchor Rods

JIS B 1220 ABR 400 hot dipped galvanized.

2.3.3.2 Anchor Nuts

Hexagon nuts JIS B 1220 ABR 400 hot dipped galvanized.

2.3.3.3 Anchor Washers

JIS B 1220 ABR 400 hot dipped galvanized.

2.3.3.4 Anchor Plate Washers

JIS B 1220 ABR 400 hot dipped galvanized.

2.4 STRUCTURAL STEEL ACCESSORIES

2.4.1 Welding Electrodes and Rods

AWS D1.1/D1.1M or JASS 6. Submit product data for welding electrodes and rods.

2.4.2 Non-Shrink Grout

Packaged dry, hydraulic cement non-shrink grout, that is non-metallic, non-corrosive, non-bleed, with the following performance requirements when prepared using the highest water-to-solids ratio, maximum flow, or most fluid consistency at 23.0 plus/minus 2.0 degrees C:

- a. Minimum compressive strengths: 7.0 MPa at 1 day; 17.0 MPa at 3 day; 24.0 MPa at 7 day; and 34.0 MPa at 28 day.
- b. Early height change (maximum percent at time of final setting): + 4.0 percent.
- c. Height change of moist cured hardened grout: 0.0 to + 0.3 percent at 1-day, 3-day, 14-day and 28-day.

2.5 GALVANIZING

JIS B 1048 for threaded parts or JIS H 8641 for structural steel members, as applicable, unless specified otherwise galvanize after fabrication where practicable.

2.6 FABRICATION

Fabrication must be in accordance with the applicable provisions of AISC 325 and JASS 6. Fabrication and assembly must be done in the shop to the greatest extent possible. Punch, subpunch and ream, or drill bolt holes perpendicular to the surface of the member.

Compression joints depending on contact bearing must have a surface roughness not in excess of 500 micro inch as determined by ASME B46.1, and ends must be square within the tolerances for milled ends specified in JIS G 3192, JIS G 3193, and JASS 6.

Shop splices of members between field splices will be permitted only where indicated on the Contract Drawings. Splices not indicated require the approval of the Contracting Officer.

Provide chord splices at panel joints at approximately the third point of the span. The center of gravity lines of truss members must intersect at panel points unless otherwise approved by the Contracting Officer. When the center of gravity lines do not intersect at a panel point, make provisions for the stresses due to eccentricity. Camber of trusses must be **1/8 inch** in **10 feet** unless otherwise indicated.

2.6.1 Markings

Prior to erection, identify members by a painted erection mark. Connecting parts assembled in the shop for reaming holes in field connections must be match marked with scratch and notch marks. Do not locate erection markings on areas to be welded. Do not locate match markings in areas that will decrease member strength or cause stress concentrations.

2.6.2 Shop Primer

Shop prime structural steel, **JIS K 5674** lead Free, chromium Free, anticorrosive paint, except as modified herein, in accordance with **SSPC PA 1**. Do not prime steel surfaces embedded in concrete, galvanized surfaces, or surfaces within **0.5 inch** of the toe of the welds prior to welding (except surfaces on which metal decking and shear studs are to be welded). If flash rusting occurs, re-clean the surface prior to application of primer. Apply primer of **AISC 420** or approved equal NACE or SSPC certification to a minimum dry film thickness of **2.0 mil**. Submit shop primer product data.

Prior to assembly, prime surfaces which will be concealed or inaccessible after assembly. Do not apply primer in foggy or rainy weather; when the ambient temperature is below **45 degrees F** or over **95 degrees F**; or when the primer may be exposed to temperatures below **40 degrees F** within 48 hours after application, unless approved otherwise by the Contracting Officer. Repair damaged primed surfaces with an additional coat of primer.

2.6.2.1 Cleaning

SSPC SP 6/NACE No.3, except steel exposed in spaces above ceilings, attic spaces, furred spaces, and chases that will be hidden to view in finished construction may be cleaned to **SSPC SP 3** when recommended by the shop primer manufacturer. Maintain steel surfaces free from rust, dirt, oil, grease, and other contaminants through final assembly.

2.6.3 Fireproofing Coated Surfaces

Clean and prepare surfaces to receive sprayed-on fireproofing coatings in accordance with the manufacturer's recommendations.

2.7 DRAINAGE HOLES

Drill adequate drainage holes to eliminate water traps. Hole diameter must be **1/2 inch** and location indicated on the detail drawings. Hole size and locations must not affect the structural integrity.

PART 3 EXECUTION

3.1 ERECTION

- a. Erection of structural steel must be in accordance with the applicable provisions of [AISC 325](#), [AISC 303](#) and [29 CFR Part 1926, Subpart R](#) or [MLIT-SS Chapter 7](#) and JASS 6.

After final positioning of steel members, provide full bearing under base plates and bearing plates using nonshrink grout. Place nonshrink grout in accordance with the manufacturer's instructions or [MLIT-SS Chapter 7](#) and JASS 6.

3.1.1 STORAGE

Store the material out of contact with the ground in such manner and location as to minimize deterioration.

3.2 CONNECTIONS

Except as modified in this section, design connections indicated in accordance with [AISC 360](#). Build connections into existing work. Do not tighten anchor bolts set in concrete with impact torque wrenches. Holes must not be cut or enlarged by burning. Bolts, nuts, and washers must be clean of dirt and rust, and lubricated immediately prior to installation.

3.2.1 High-Strength Bolts

Fastener components shall be protected from dirt and moisture in closed containers at the site of the installation. Fastener components that are not incorporated into the work shall be returned to protected storage at the end of the work shift.

3.2.2 Tension Control Bolts

Bolts must be installed in connection holes and initially brought to a snug tight fit. After the initial tightening procedure, fully tension bolts, progressing from the most rigid part of a connection to the free edges.

3.3 GAS CUTTING

Use of gas-cutting torch in the field for correcting fabrication errors is not permitted on any major member in the structural framing. Use of a gas cutting torch will be permitted on minor members not under stress only after approval has been obtained from the Contracting Officer.

3.4 WELDING

Welding must be in accordance with [JASS 6](#). Grind exposed welds smooth as indicated. Provide [JASS 6](#) qualified welders, welding operators, and tackers.

Develop and submit the [Welding Procedure Specifications \(WPS\)](#) for all welding, including welding done using prequalified procedures. Submit for approval all WPS, whether prequalified or qualified by testing.

3.4.1 Removal of Temporary Welds, Run-Off Plates, and Backing Strips

Remove backing strips from bottom flange of moment connections, backgouge the root pass to sound weld metal and reinforce with a 5/16 inch fillet weld minimum.

3.5 SHOP PRIMER REPAIR

Repair shop primer in accordance with the paint manufacturer's recommendation for surfaces damaged by handling, transporting, cutting, welding, or bolting.

3.5.1 Field Priming

Field prime steel exposed to the weather, or located in building areas without HVAC for control of relative humidity. After erection, the field bolt heads and nuts, field welds, and any abrasions in the shop coat must be cleaned and primed with paint of the same quality as that used for the shop coat.

3.6 GALVANIZING REPAIR

Repair damage to galvanized coatings using JASS 6 zinc rich paint for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces to which repair paint has been applied.

3.7 FIELD QUALITY CONTROL

Perform field tests, and provide labor, equipment, and incidentals required for testing, except that electric power for field tests will be furnished as set forth in Division 1. Notify the Contracting Officer in writing of defective welds, bolts, nuts, and washers within 7 working days of the date of the inspection.

3.7.1 Welds

3.7.1.1 Visual Inspection

Perform in accordance with JASS 6. Furnish the services of certified welding inspectors for fabrication and erection inspection and testing and verification inspections. A Certified Welding Inspector must perform visual inspection on 100 percent of all welds. Document this inspection in the Visual Weld Inspection Log. Submit certificates indicating that certified welding inspectors meet the requirements of Japanese Welding Engineering Society (JWES) and JASS 6.

3.7.1.2 Nondestructive Testing

Nondestructive testing must be in accordance with JASS 6 and JIS Z 3060. Ultrasonic testing must be performed in accordance with Table 6.2 or 6.3 of AWS D1.1/D1.1M. Test locations must be selected by the Contracting Officer. All personnel performing NDT must be certified in accordance with JIS Z2305 in the method of testing being performed. Submit certificates showing compliance with JIS Z2305 for all NDT technicians. If more than 20 percent of welds made by a welder contain defects identified by testing, then all groove welds made by that welder must be tested by ultrasonic testing, and all fillet welds made by that welder must be inspected by magnetic particle testing (MT) or dye penetrant testing (PT) as approved by the Contracting Officer. When groove welds

made by an individual welder are required to be tested, magnetic particle or dye penetrant testing may be used only in areas inaccessible to ultrasonic testing. Retest all repaired areas. Submit [weld inspection reports](#).

Testing frequency: Provide the following types and number of tests:

Test Type	Number of Tests
Ultrasonic	50 percent of CJP Welds
Magnetic Particle	50 percent of PJP and Fillet Welds
Dye Penetrant	50 percent of PJP and Fillet Welds

3.7.2 High-Strength Bolts

3.7.2.1 Testing Bolt, Nut, and Washer Assemblies

Test a minimum of 3 bolt, nut, and washer assemblies from each mill certificate batch in a tension measuring device at the job site prior to the beginning of bolting start-up. Demonstrate that the bolts and nuts, when used together, can develop tension not less than the provisions specified in [AISC 360](#), depending on bolt size and grade. The bolt tension must be developed by tightening the nut. A representative of the manufacturer or supplier must be present to ensure that the fasteners are properly used, and to demonstrate that the fastener assemblies supplied satisfy the specified requirements. Submit [bolt testing reports](#).

3.7.2.2 Inspection

Inspection procedures must be in accordance with [JASS 6](#) and [MLIT-SS Chapter 7](#). As a minimum, high-strength bolting inspection tasks shall be in accordance with Section [01 45 35](#) SPECIAL INSPECTION. Confirm and report to the Contracting Officer that the materials meet the project specification and that they are properly stored. Confirm that the faying surfaces have been properly prepared before the connections are assembled. Observe the specified job site testing and calibration, and confirm that the procedure to be used provides the required tension. Monitor the work to ensure the testing procedures are routinely followed on joints that are specified to be fully tensioned.

Inspect calibration of torque wrenches for high-strength bolts.

3.7.2.3 Testing

The Government has the option to perform nondestructive tests on 5 percent of the installed bolts to verify compliance with pre-load bolt tension requirements. Provide the required access for the Government to perform the tests. The nondestructive testing will be done in-place using an ultrasonic measuring device or any other device capable of determining in-place pre-load bolt tension. The test locations must be selected by the Contracting Officer. If more than 10 percent of the bolts tested contain defects identified by testing, then all bolts used from the batch from which the tested bolts were taken, must be tested at the Contractor's expense. Retest new bolts after installation at the Contractor's expense.

3.7.3 Inspection and Testing of Steel Stud Welding

Perform verification inspection and testing of steel stud welding conforming to the requirements of JASS 6, Stud Welding Clause. The Contracting Officer will serve as the verification inspector. Bend test studs that do not show a full 360 degree weld flash or have been repaired by welding as required by JASS 6, Stud Welding Clause. Studs that crack under testing in the weld, base metal or shank will be rejected and replaced by the Contractor at no additional cost.

-- End of Section --

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SECTION 05 21 00

STEEL JOIST FRAMING

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 WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding
Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M (2019) Standard Specification for Carbon
Structural Steel

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC (2021) International Building Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PA 1 (2016) Shop, Field, and Maintenance
Coating of Metals

SSPC Paint 15 (1999; E 2004) Steel Joist Shop
Primer/Metal Building Primer

SSPC SP 2 (2018) Hand Tool Cleaning

STEEL JOIST INSTITUTE (SJI)

SJI LOAD TABLES (2020) Standard Specifications Load Tables
and Weight Tables for Steel Joists and
Joist Girders - 45th Edition

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1926 Safety and Health Regulations for
Construction

29 CFR 1926.757 Steel Erection; Open Web Steel Joists

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section **01 33 00** SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Welder Qualification

SD-02 Shop Drawings

Steel Joist Framing; G

SD-05 Design Data

Design Calculations; G

SD-06 Test Reports

Erection Inspection

Welding Inspections

SD-07 Certificates

Certification of Compliance

1.3 QUALITY ASSURANCE

Perform all work in compliance with the requirements set forth in
29 CFR 1926.

1.3.1 Drawing Requirements

Submit drawings of steel joist framing including fabrication, specifications for shop painting, and identification markings of joists. Show joist type and size, layout in plan, all applicable loads, deflection criteria, and erection details including methods of anchoring, framing at openings, type, size, and location and connections for and spacing of bridging, requirements for field welding, and details of accessories as applicable. Show profiles for nonstandard joist configurations.

1.3.2 Certification of Compliance

Prior to construction commencement, submit certification for welder qualification, in compliance with AWS D1.1/D1.1M, welding operation, and tacker, stating the type of welding and positions qualified for, the code and procedure qualified under, date qualified, and the firm and individual certifying the qualification tests. Submit certification of compliance for the following:

- a. Steel Joist Institute Member Fabricator
- b. 29 CFR 1926
- c. 29 CFR 1926.757
- d. Statement from steel joist manufacturer, that work was performed in accordance with approved construction documents and with SJI standard specifications, in accordance with ICC IBC Section 1704.2.5.2.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, transport, and store joists in a manner to prevent damage affecting their structural integrity. Verify piece count of all joist products upon delivery and inspect all joists products for damage. Report any damage to the joist supplier. Store all items off the ground in a well drained location protected from the weather and easily accessible for inspection and handling. Store joists with top chord down and with joists in a vertical position. Store deep joists horizontally if they were shipped on their sides.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Designate steel joists 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.

2.2 STEEL JOISTS

Provide steel joists conforming to **SJI LOAD TABLES**. Design joists designated K, KCS, LH and DLH to support the loads given in the applicable standard load tables of **SJI LOAD TABLES**. Submit **design calculations** for net uplift loads, non-SJI standard details, and field splices. Include cover letter signed and sealed by the joist manufacturer's registered design professional.

2.2.1 Steel Joist Camber

Camber joists according to **SJI LOAD TABLES**.

2.3 ACCESSORIES AND FITTINGS

2.3.1 Bridging

Provide bridging of material, size, and type required by **SJI LOAD TABLES** for type of joist, chord size, spacing and span. Furnish additional erection bridging if required for stability.

2.3.2 Bearing Plates

Fabricate steel bearing plats from **ASTM A36/A36M** steel of size and thickness indicated.

2.3.3 Ceiling Extensions

Furnish ceiling extensions, either bottom-chord elements or a separate extension unit of enough strength to support ceiling construction. Extend ends to within **1/2 inch** of finished wall surface unless otherwise indicated.

2.4 SHOP PAINTING

SSPC Paint 15. Shop prime joists, except as modified herein, in accordance with **SSPC PA 1**. Clean joists in accordance with **SSPC SP 2**

before priming. If flash rusting occurs, re-clean the surface prior to application of primer. For joists which require finish painting under Section 09 90 00 PAINTS AND COATINGS, the primer paint must be compatible with the finish paint.

PART 3 EXECUTION

3.1 ERECTION

Install joists in conformance with SJI LOAD TABLES for the joist series indicated, and the requirements of 29 CFR 1926 and 29 CFR 1926.757. Handle and set joists avoiding damage to the members. Place the "tag end" of joists as shown on the joists placement plans. Ensure that square-end joists are erected right side up. Distribute temporary loads so that joist capacity is not exceeded. Remove damaged joists from the site, except when field repair is approved and such repairs are satisfactorily made in accordance with the manufacturer's recommendations. Do not repair, field modify, or alter any joists without specific written instructions from the Designer of Record and/or joist manufacturer.

Install and connect bridging concurrently with joist erection, before construction loads are applied. Do not apply loads to bridging. Anchor ends of bridging lines at top and bottom chords if terminating at walls or beams. Do not cut away vertical leg of bridging where bridging makes an elevation transition; weld a separate piece of bridging at the transition. Perform all welding in accordance with AWS D1.1/D1.1M.

3.2 BEARING PLATES

Provide bearing plates to accept full bearing after the supporting members have been plumbed and properly positioned, but prior to placing superimposed loads. The area under the plate must be damp-packed solidly with bedding mortar, except where nonshrink grout is indicated on the drawings. Provide bedding mortar and grout as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.3 PAINTING

3.3.1 Touch-Up Painting

After erection of joists, touch-up connections and areas of abraded shop coat with paint of the same type used for the shop coat.

3.4 VISUAL INSPECTIONS

Perform the following visual inspections:

- a. Verify that all joists are spaced properly.
- b. Verify that there is sufficient joist bearing on steel beams, concrete, and masonry.
- c. Verify all bridging lines are properly spaced and anchored.
- d. Verify that damage has not occurred to the joists during erection.
- e. Verify the joists are aligned vertically and there is no lateral sweep in the joists.

- f. Where concentrated loads are present on the joists verify that they are located in accordance with the joists placement plan.
- g. Verify welding of bridging and joist seats in accordance with AWS D1.1/D1.1M, Section 6. Perform erection inspection and field welding inspections with AWS certified welding inspectors.
- h. Verify proper bolting of diagonal bridging and joist seats where the bolts are snug-tight.

-- End of Section --

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SECTION 05 30 00

STEEL DECKS

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 IRON AND STEEL INSTITUTE (AISI)

AISI D100 (2017) Cold-Formed Steel Design Manual

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M (2019) Standard Specification for Carbon Structural Steel

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A653/A653M (2022) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A780/A780M (2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

ASTM A1008/A1008M (2021a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

FM GLOBAL (FM)

FM DS 1-28R (1998) Data Sheet: Roof Systems

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 20 (2019) Zinc-Rich Primers (Type I, Inorganic, and Type II, Organic)

STEEL DECK INSTITUTE (SDI)

ANSI/SDI QA/QC (2022) Standard for Quality Control and Quality Assurance for Installation of Steel Deck

ANSI/SDI SD (2022) Standard for Steel Deck

ANSI/SDI C	(2017) Standard for Composite Steel Floor Deck
ANSI/SDI NC	(2017) Standard for Non-Composite Steel Floor Deck
SDI DDM04	(2015; Errata 1-3 2016; Add 1 2015; Add 2 20162006) Diaphragm Design Manual; 4th Edition
SDI DDP	(1987; R 2000) Deck Damage and Penetrations
SDI MOC3	(2016) Manual of Construction with Steel Deck (3rd Edition)

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019, with Change 1, 2022) Structural Engineering

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1926	Safety and Health Regulations for Construction

UNDERWRITERS LABORATORIES (UL)

UL 580	(2006; Reprint Mar 2019) UL Standard for Safety Tests for Uplift Resistance of Roof Assemblies

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings; G

SD-03 Product Data

Accessories

Deck Units

Galvanizing Repair Paint

Mechanical Fasteners

Touch-Up Paint

SD-05 Design Data

Deck Units; G

SD-07 Certificates

Powder-Actuated Tool Operator

Wind Storm Resistance

Manufacturer's Certificate

1.3 QUALITY ASSURANCE

1.3.1 Deck Units

Furnish deck units and accessory products from a manufacturer regularly engaged in manufacture of steel decking. Provide [manufacturer's certificates](#) attesting that the decking material meets the specified requirements.

1.3.2 Certification of [Powder-Actuated Tool Operator](#)

Provide manufacturer's certificate attesting that the operators are authorized to use the low velocity powder-actuated tool.

1.3.3 Regulatory Requirements

1.3.3.1 [Wind Storm Resistance](#)

Provide roof construction assembly capable of withstanding a nominal [net](#) uplift pressure of [40 pounds per square foot](#) when tested in accordance with the uplift pressure test described in the [FM DS 1-28R](#) or as described in [UL 580](#) and in general compliance with [UFC 3-301-01](#).

1.3.4 [Fabrication Drawings](#)

Show type and location of units, location and sequence of connections, bearing on supports, methods of anchoring, attachment of accessories, adjusting plate details, cant strips, ridge and valley plates, metal closure strips, size and location of holes to be cut and reinforcement to be provided, the manufacturer's erection instructions and other pertinent details.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver deck units to the site in a dry and undamaged condition. Store and handle steel deck in a manner to protect it from corrosion, deformation, and other types of damage. Do not use decking for storage or as working platform until units have been fastened into position. Exercise care not to damage material or overload decking during construction. The maximum uniform distributed storage load must not exceed the design live load. Stack decking on platforms or pallets and cover with weathertight ventilated covering. Elevate one end during storage to provide drainage. Maintain deck finish at all times to prevent formation of rust. Repair deck finish using touch-up paint. Replace damaged material.

1.5 DESIGN REQUIREMENTS FOR ROOF DECKS

1.5.1 Properties of Sections

Properties of metal roof deck sections must comply with engineering design width as limited by the provisions of [AISI D100](#).

1.5.2 Allowable Loads

Indicate total uniform dead and live load for detailing purposes.

PART 2 PRODUCTS

2.1 DECK UNITS

Submit manufacturer's design calculations, or applicable published literature for the structural properties of the proposed deck units.

2.1.1 Composite [Roof](#) Deck

Conform to [ASTM A653/A653M](#) or [ASTM A1008/A1008M](#) for composite deck assembly. Fabricate deck used as the tension reinforcing in composite deck the steel design thickness required by the design drawings. Zinc-coat in conformance with [ASTM A653/A653M](#), G90 coating class.

2.1.2 Length of Deck Units

Provide deck units of sufficient length to span three or more spacings where possible.

2.1.3 [Touch-Up Paint](#)

Provide a high zinc-dust content paint for regalvanizing welds in galvanized steel conforming to [ASTM A780/A780M](#).

Provide touch-up paint for shop-painted units of the same type used for the shop painting, and touch-up paint for zinc-coated units of an approved [galvanizing repair paint](#) with a high-zinc dust content. Touch-up welds with paint conforming to [SSPC Paint 20](#) in accordance with [ASTM A780/A780M](#). Maintain finish of deck units and accessories by using touch-up paint whenever necessary to prevent the formation of rust.

2.2 ACCESSORIES

Provide accessories of same material as deck, unless specified otherwise. Provide manufacturer's standard type accessories, as specified.

2.2.1 Adjusting Plates

Provide adjusting plates, or segments of deck units, of same thickness and configuration as deck units in locations too narrow to accommodate full size units. Provide factory cut plates of predetermined size where possible.

2.2.2 End Closures

Fabricated of sheet metal by the deck manufacturer. Provide end closures minimum [0.0295 inch](#) thick to close open ends at exposed edges of floors, parapets, end walls, eaves, and openings through deck.

2.2.3 Closure Plates for Composite Deck

Support and retain concrete at each floor level. Provide edge closures at all edges of the slab of sufficient strength and stiffness to support the wet concrete. Provide metal closures for all openings in composite steel deck $\frac{1}{4}$ inch and over.

2.2.4 Sheet Metal Collar

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.

2.2.5 Cover Plates

Sheet metal to close panel edge and end conditions, and where panels change direction or butt. Polyethylene-coated, self-adhesive, 2 inch wide joint tape may be provided in lieu of cover plates on flat-surfaced decking butt joints.

Fabricate cover plates for abutting floor deck units from the specified structural-quality steel sheets not less than nominal 18 gage thick before galvanizing. Provide 6 inch wide cover plates and form to match the contour of the floor deck units.

2.2.6 Roof Sump Pans

Sump pans must be provided for roof drains and must be minimum 0.075 inch thick steel, flat type. Shape sump pans to meet roof slope by the supplier or by a sheet metal specialist. Provide bearing flanges of sump pans to overlap steel deck a minimum of 3 inch. Shape, size, and reinforce the opening in bottom of the sump pan to receive roof drain.

2.2.7 Column Closures

Sheet metal, minimum 0.0358 inch thick or metal rib lath.

2.2.8 Access Hole Covers

Sheet metal, minimum 0.0474 inch thick.

2.2.9 Hanger

Provide clips or loops for utility systems of one or more of the following types:

- a. Lip tabs or integral tabs where noncellular decking or flat plate of cellular section is 0.0474 inch thick or more, and a structural concrete fill is used over deck.
- b. Slots or holes punched in decking for installation of pigtails.
- c. Tabs driven from top side of decking and arranged so as not to pierce electrical cells.
- d. Decking manufacturer's standard as approved by the Contracting Officer.

2.2.10 Cant Strips for Roof Decks

Fabricate cant strips from the specified commercial-quality steel sheets not less than nominal 0.0358 inch thick before galvanizing. Bend strips to form a 45-degree cant not less than 5 inch wide, with top and bottom flanges a minimum 3 inch wide. Length of strips 10 feet.

2.2.11 Ridge and Valley Plates for Roof Decks

Fabricate plates from the specified structural-quality steel sheets, not less than nominal 0.0358 inch thick before galvanizing. Provide plates of minimum 4-1/2 inch wide and bent to provide tight fitting closures at ridges and valleys. Provide a minimum length of ridge and valley plates of 10 feet.

2.2.12 Metal Closure Strips for Roof Decks

Fabricate strips from the specified commercial-quality steel sheets not less than nominal 0.0358 inch thick before galvanizing. Provide strips from the configuration required to provide tight-fitting closures at open ends and sides of steel roof decking.

2.2.13 Galvanized Steel Angles for Roof Decks

Provide hot-rolled carbon steel angles conforming to ASTM A36/A36M, and hot-dip galvanized in accordance with ASTM A123/A123M.

2.2.14 Mechanical Fasteners

Provide mechanical fasteners, such as powder actuated fasteners, pneumatically driven fasteners or self-drilling screws, for anchoring the deck to structural supports and adjoining units as indicated.

2.2.15 Miscellaneous Accessories

Furnish the manufacturer's standard accessories to complete the deck installation. Furnish metal accessories of the same material as the deck and with the minimum design thickness as follows: saddles, 0.0474 inch welding washers, 0.0598 inch other metal accessories, 0.0358 inch unless otherwise indicated.

PART 3 EXECUTION

3.1 EXAMINATION

Prior to installation of decking units and accessories, examine worksite to verify that as-built structure will permit installation of decking system without modification.

3.2 INSTALLATION

Install steel deck units in accordance with 29 CFR 1926, Subpart R – Steel Erection, ANSI/SDI QA/QC, ANSI/SDI SDDSI DDM04 and approved shop drawings. Place units on structural supports, properly adjusted, leveled, and aligned at right angles to supports before permanently securing in place. Damaged deck and accessories including material which is permanently stained or contaminated, deformed, or with burned holes shall not be installed. Extend deck units over three or more supports unless absolutely impractical. Report inaccuracies in alignment or leveling to the Contracting Officer and make necessary corrections before permanently

anchoring deck units. Locate deck ends over supports only. Lap 2 inch deck ends. Do not use unanchored deck units as a work or storage platform. Do not fill unanchored deck with concrete. Permanently anchor units placed by the end of each working day. Do not support suspended ceilings, light fixtures, ducts, utilities, or other loads by steel deck unless indicated. Distribute loads by appropriate means to prevent damage.

3.2.1 Attachment

Immediately after placement and alignment, and after correcting inaccuracies, permanently fasten steel deck units to structural supports and to adjacent deck units by welding with fastened with screws, powder-actuated fasteners, or pneumatically driven fasteners as indicated on the design drawings and in accordance with manufacturer's recommended procedure and ANSI/SDI SD. Clamp or weight deck units to provide firm contact between deck units and structural supports while performing or fastening. Attachment of adjacent deck units by button-punching is prohibited.

3.2.1.1 Mechanical Fastening

Anchor deck to structural supports and adjoining units with mechanical fasteners. Drive the powder-actuated fasteners with a low-velocity piston tool by an operator authorized by the manufacturer of the powder-actuated tool. Drive pneumatically driven fasteners with a low-velocity fastening tool and comply with the manufacturer's recommendations. Drive screws to properly clamp deck to supporting steel.

3.2.1.2 Sidelap Fastening

Lock sidelaps between adjacent floor deck units together by welding or screws as indicated.

3.2.2 Openings

Cut or drill all holes and openings required and be coordinated with the drawings, specifications, and other trades. Frame and reinforce openings through the deck in conformance with SDI DDP. Reinforce holes and openings 6 to 12 inch across by 0.0474 inch thick steel sheet at least 12 inch wider and longer than the opening and be fastened to the steel deck at each corner of the sheet and at a maximum of 6 inch on center. Reinforce holes and openings larger than 12 inch by steel channels or angles installed perpendicular to the steel joists and supported by the adjacent steel joists. Install steel channels or angles perpendicular to the deck ribs and fasten to the channels or angles perpendicular to the steel joists.

3.2.3 Deck Damage

SDI MOC3, for repair of deck damage.

3.2.4 Touch-Up Paint

3.2.4.1 Roof Deck

After roof decking installation, wire brush, clean, and touchup paint the scarred areas on top and bottom surfaces of metal roof decking. The scarred areas include welds, weld scars, bruises, and rust spots. Touchup

galvanized surfaces with galvanizing repair paint. Touchup painted surfaces with repair paint of painted surfaces.

3.2.5 Accessory Installation

3.2.5.1 Adjusting Plates

Provide in locations too narrow to accommodate full-size deck units and install as shown on shop drawings.

3.2.5.2 End Closures

Provide end closure to close open ends of cells at columns, walls, and openings in deck.

3.2.5.3 Access Hole Covers

Provide access hole covers to seal holes cut in decking to facilitate welding of the deck to structural supports.

3.2.5.4 Hangers

Provide as indicated to support utility system . Space devices as indicated .

3.2.6 Concrete Work

Prior to placement of concrete, inspect installed decking to ensure that there has been no permanent deflection or other damage to decking. Replace decking which has been damaged or permanently deflected as approved by the Contracting Officer. Place concrete on metal deck in accordance with Construction Practice of ANSI/SDI C or ANSI/SDI NC.

3.3 ROOF SUMP PANS

Place sump pans over openings in roof decking and fusion welded to top surface of roof decking. Do not exceed spacing of welds of 12 inch with not less than one weld at each corner. Field cut opening in the bottom of each roof sump pan to receive the roof drain as part of the work of this section.

3.4 CANT STRIPS FOR ROOF DECKS

Provide strips to be fusion welded to surface of roof decking, secured to wood nailers by galvanized screws or to steel framing by galvanized self-tapping screws or welds. Do not exceed spacing of welds and fasteners of 12 inch. Lap end joints a minimum 3 inch and secure with galvanized sheet metal screws spaced a maximum 4 inch on center.

3.5 CLOSURE STRIPS FOR ROOF DECKS

Provide closure strips at open, uncovered ends and edges of the roof decking and in voids between roof decking and top of walls and partitions where indicated. Install closure strips in position in a manner to provide a weathertight installation.

3.6 ROOF INSULATION SUPPORT FOR ROOF DECKS

Provide metal closure strips for support of roof insulation where rib

openings in top surface of metal roof decking occur adjacent to edges and openings. Weld metal closure strips in position.

3.7 CLEANING AND PROTECTION FOR ROOF DECKS

Upon completion of the deck, sweep surfaces clean and prepare for installation of the roofing.

-- End of Section --

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SECTION 05 50 13

MISCELLANEOUS METAL FABRICATIONS

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.

ALUMINUM ASSOCIATION (AA)

AA DAF45 (2003; Reaffirmed 2009) Designation System
for Aluminum Finishes

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 303 (2016) Code of Standard Practice for Steel
Buildings and Bridges

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B18.2.1 (2012; Errata 2013) Square and Hex Bolts
and Screws (Inch Series)

ASME B18.2.2 (2022) Nuts for General Applications:
Machine Screw Nuts, and Hex, Square, Hex
Flange, and Coupling Nuts (Inch Series)

ASME B18.6.2 (2020) Square Head Set Screws and Slotted
Headless Set Screws (Inch Series)

ASME B18.6.3 (2013; R 2017) Machine Screws, Tapping
Screws, and Machine Drive Screws (Inch
Series)

ASME B18.21.1 (2009; R 2016) Washers: Helical
Spring-Lock, Tooth Lock, and Plain Washers
(Inch Series)

ASME B18.21.2M (1999; R 2014) Lock Washers (Metric Series)

ASME B18.22M (1981; R 2017) Metric Plain Washers

AMERICAN SOCIETY OF SAFETY PROFESSIONALS (ASSP)

ASSP A10.3 (2020) Safety Requirements for
Powder-Actuated Fastening Systems American
National Standard for Construction and
Demolition Operations

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding
Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A47/A47M	(1999; R 2022; E 2022) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A108	(2013) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A500/A500M	(2021a) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A653/A653M	(2022) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A786/A786M	(2015; R 2021) Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates
ASTM A924/A924M	(2022a) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B26/B26M	(2018; E 2018) Standard Specification for Aluminum-Alloy Sand Castings
ASTM B108/B108M	(2019) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B209	(2014) Standard Specification for Aluminum

and Aluminum-Alloy Sheet and Plate

ASTM B209M (2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)

ASTM B221 (2021) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

ASTM B221M (2021) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)

ASTM C1513 (2018) Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections

ASTM D1187/D1187M (1997; E 2011; R 2011) Asphalt-Base Emulsions for Use as Protective Coatings for Metal

ASTM F1554 (2020) Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

MASTER PAINTERS INSTITUTE (MPI)

MPI 79 (2016) Primer, Alkyd, Anti-Corrosive for Metal

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 3 (2018) Power Tool Cleaning

SSPC SP 6/NACE No.3 (2007) Commercial Blast Cleaning

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1 (2014) Safety -- Safety and Health Requirements Manual

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Embedded Angles and Plates, Installation Drawings; G

SD-07 Certificates

Certified Mill Test Reports for Chemistry and Mechanical Properties; G

1.3 QUALIFICATION OF WELDERS

Qualify welders in accordance with AWS D1.1/D1.1M. Use procedures, materials, and equipment of the type required for the work.

1.4 DELIVERY, STORAGE, AND PROTECTION

Protect from corrosion, deformation, and other types of damage. Store items in an enclosed area free from contact with soil and weather. Remove and replace damaged items with new items.

1.5 MISCELLANEOUS REQUIREMENTS

1.5.1 Fabrication Drawings

Submit fabrication drawings showing layout(s), connections to structural system, and anchoring details as specified in AISC 303.

1.5.2 Installation Drawings

Submit templates, erection, and installation drawings indicating thickness, type, grade, class of metal, and dimensions. Show construction details, reinforcement, anchorage, and installation in relation to the building construction.

PART 2 PRODUCTS

2.1 MATERIALS

Provide exposed fastenings of compatible materials (avoid contact of dissimilar metals). Coordinate color and finish with the material to which fastenings are applied. Submit the manufacturer's certified mill reports which clearly show the applicable ASTM mechanical and chemical requirements together with the actual test results for the supplied materials.

2.1.1 Structural Carbon Steel

Provide in accordance with ASTM A36/A36M.

2.1.2 Structural Tubing

Provide in accordance with ASTM A500/A500M.

2.1.3 Steel Pipe

Provide in accordance with ASTM A53/A53M, Type E or S, Grade B.

2.1.4 Fittings for Steel Pipe

Provide standard malleable iron fittings in accordance with ASTM A47/A47M.

2.1.5 Floor Plates, Patterned

Provide floor plate in accordance with ASTM A786/A786M. Provide steel plate not less than 14 gage.

2.1.6 Anchor Bolts

Provide in accordance with [ASTM F1554](#). Where exposed, provide anchor bolts of the same material, color, and finish as the metal to which they are applied.

2.1.6.1 Expansion Anchors Adhesive Anchors

Refer to Section 05 05 20 POST-INSTALLED CONCRETE AND MASONRY ANCHORS.

2.1.6.2 Lag Screws and Bolts

Provide in accordance with [ASME B18.2.1](#), type and grade best suited for the purpose.

2.1.6.3 Toggle Bolts

Provide in accordance with [ASME B18.2.1](#).

2.1.6.4 Bolts, Nuts, Studs and Rivets

Provide in accordance with [ASME B18.2.2](#) or [ASTM A307](#).

2.1.6.5 Powder Actuated Fasteners

Follow safety provisions in accordance with [ASSP A10.3](#).

2.1.6.6 Screws

Provide in accordance with [ASME B18.2.1](#), [ASME B18.6.2](#), [ASME B18.6.3](#) and [ASTM C1513](#).

2.1.6.7 Washers

Provide plain washers in accordance with [ASME B18.22M](#), [ASME B18.21.1](#). Provide beveled washers for American Standard beams and channels, square or rectangular, tapered in thickness, and smooth. Provide lock washers in accordance with [ASME B18.21.2M](#), [ASME B18.21.1](#).

2.1.6.8 Welded Headed Shear Studs

Provide in accordance with [ASTM A108](#).

2.1.7 Aluminum Alloy Products

Provide in accordance with [ASTM B209M](#), [ASTM B209](#) for sheet plate, [ASTM B221M](#), [ASTM B221M](#), [ASTM B221](#) for extrusions and [ASTM B26/B26M](#) or [ASTM B108/B108M](#) for castings. Provide aluminum extrusions at least 1/8 inch thick and aluminum plate or sheet at least 0.050 inch thick.

2.2 FABRICATION FINISHES

2.2.1 Galvanizing

Hot-dip galvanize items specified to be zinc-coated, after fabrication where practicable. Provide galvanizing in accordance with [ASTM A123/A123M](#), [ASTM A153/A153M](#), [ASTM A653/A653M](#) or [ASTM A924/A924M](#), Z275 G90.

2.2.2 Galvanize

Anchor bolts, grating fasteners, washers, and parts or devices necessary for proper installation, unless indicated otherwise.

2.2.3 Repair of Zinc-Coated Surfaces

Repair damaged surfaces with galvanizing repair method and paint in accordance with [ASTM A780/A780M](#) or by application of stick or thick paste material specifically designed for repair of galvanizing, as approved by Contracting Officer. Clean areas to be repaired and remove slag from welds. Heat, with a torch, surfaces to which stick or paste material will be applied. Heat to a temperature sufficient to melt the metals in the stick or paste. Spread molten material uniformly over surfaces to be coated and wipe off excess material.

2.2.4 Shop Cleaning and Painting

2.2.4.1 Surface Preparation

Blast clean surfaces in accordance with [SSPC SP 6/NACE No.3](#). Surfaces that will be exposed in spaces above ceiling or in attic spaces, crawl spaces, furred spaces, and chases may be cleaned in accordance with [SSPC SP 3](#) in lieu of being blast cleaned. Wash cleaned surfaces which become contaminated with rust, dirt, oil, grease, or other contaminants with solvents until thoroughly clean. Steel to be embedded in concrete must be free of dirt and grease prior to embed. Do not paint or galvanize bearing surfaces, including contact surfaces within slip critical joints. Shop coat these surfaces with rust prevention.

2.2.4.2 Pretreatment, Priming and Painting

Apply pre-treatment, primer, and paint in accordance with manufacturer's printed instructions. On surfaces concealed in the finished construction or not accessible for finish painting, apply an additional prime coat to a minimum dry film thickness of [1.0 mil](#). Tint additional prime coat with a small amount of tinting pigment.

2.2.5 Nonferrous Metal Surfaces

Protect by plating, anodic, or organic coatings.

2.2.6 Aluminum Surfaces

2.2.6.1 Surface Condition

Before finishes are applied, remove roll marks, scratches, rolled-in scratches, kinks, stains, pits, orange peel, die marks, structural streaks, and other defects which will affect uniform appearance of finished surfaces.

2.2.6.2 Aluminum Finishes

Unexposed sheet, plate and extrusions may have mill finish as fabricated. Sandblast castings' finish, medium, [AA DAF45](#). Unless otherwise specified, provide all other aluminum items with a standard mill finish. Provide a coating thickness 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.

Provide in accordance with AA DAF45. Provide a polished satin finish on items to be anodized.

2.3 MISCELLANEOUS PLATES AND SHAPES

Provide items that do not form a part of the structural steel framework, such as lintels, sill angles, miscellaneous mountings and frames.

Provide angles and plates in accordance with ASTM A36/A36M, for embedment as indicated. Galvanize embedded items exposed to the elements in accordance with ASTM A123/A123M.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Install items at locations indicated in accordance with manufacturer's instructions. Verify all field dimensions prior to fabrication. Include materials and parts necessary to complete each assembly, whether indicated or not. Miss-alignment and miss-sizing of holes for fasteners is cause for rejection. Conceal fastenings where practicable. Joints exposed to weather must be watertight.

3.2 WORKMANSHIP

Provide miscellaneous metalwork that is true and accurate in shape, size, and profile. Make angles and lines continuous and straight. Make curves consistent, smooth and unfaceted. Provide continuous welding along the entire area of contact except where tack welding is permitted. Do not tack weld exposed connections. Unless otherwise indicated and approved, provide a smooth finish on exposed surfaces. Provide countersunk rivets where exposed. Provide coped and mitered corner joints aligned flush and without gaps.

3.3 ANCHORAGE, FASTENINGS, AND CONNECTIONS

Provide anchorage as necessary, whether indicated or not, for fastening miscellaneous metal items securely in place. Include slotted inserts, expansion shields, powder-driven fasteners, toggle bolts (when approved for concrete), through bolts for masonry, headed shear studs, machine and carriage bolts for steel, through bolts, lag bolts, and screws for wood. Do not use wood plugs. Provide non-ferrous attachments for non-ferrous metal. Provide exposed fastenings of compatible materials (avoid contact of dissimilar metals), that generally match in color and finish the surfaces to which they are applied. Conceal fastenings where practicable. Provide all fasteners flush with the surfaces they fasten, unless indicated otherwise.

3.4 BUILT-IN WORK

Where necessary and not otherwise indicated, form built-in metal work for anchorage with concrete or masonry. Provide built-in metal work in ample time for securing in place as the work progresses.

3.5 WELDING

Perform welding, welding inspection, and corrective welding in accordance with AWS D1.1/D1.1M. Use continuous welds on all exposed connections. Grind visible welds smooth in the finished installation. Provide welded

headed shear studs in accordance with AWS D1.1/D1.1M, Clause 7, except as otherwise specified. Provide in accordance with the safety requirements of EM 385-1-1.

3.6 DISSIMILAR METALS

Where dissimilar metals are in contact, protect surfaces with a coating in accordance with MPI 79 to prevent galvanic or corrosive action. Where aluminum is in contact with concrete, plaster, mortar, masonry, wood, or absorptive materials subject to wetting, protect in accordance with ASTM D1187/D1187M, asphalt-base emulsion. Clean surfaces with metal shavings from installation at the end of each work day.

3.7 PREPARATION

3.7.1 Material Coatings and Surfaces

Remove rust preventive coating just prior to field erection, using a remover approved by the metal manufacturer. Surfaces, when assembled, must be free of rust, grease, dirt and other foreign matter.

3.7.2 Environmental Conditions

Do not clean or paint surfaces when damp or exposed to foggy or rainy weather, when metallic surface temperature is less than minus 5 degrees F above the dew point of the surrounding air, or when surface temperature is below 45 degrees F or over 95 degrees F, unless approved by the Contracting Officer. Metal surfaces to be painted must be dry for a minimum of 48 hours prior to the application of primer or paint.

-- End of Section --

SECTION 05 51 00

METAL STAIRS

PART 1 GENERAL

Section 05 05 23.16 STRUCTURAL WELDING applies to work specified in this section.

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 INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360 (2016) Specification for Structural Steel Buildings

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISC/AISI 121 (2007) Standard Definitions for Use in the Design of Steel Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B18.2.1 (2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)

ASME B18.21.1 (2009; R 2016) Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A6/A6M (2021) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

ASTM A29/A29M (2020) Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought

ASTM A36/A36M (2019) Standard Specification for Carbon Structural Steel

ASTM A53/A53M (2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A108 (2013) Standard Specification for Steel

Bar, Carbon and Alloy, Cold-Finished

ASTM A153/A153M

(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A283/A283M

(2013) Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

ASTM A307

(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength

ASTM A500/A500M

(2021a) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A568/A568M

(2019a) Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for

ASTM A575

(2020) Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

ASTM A653/A653M

(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A1008/A1008M

(2021a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

ASTM A1011/A1011M

(2018a) Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

JAPANESE INDUSTRIAL STANDARDS (JIS)

JIS B 1180

(2014) Hexagon Head Bolts and Hexagon Screws

JIS B 1181

(2014) Hexagon Nuts and Hexagon Thin Nuts

JIS G 3101

(2020) Rolled Steels for General Structure

JIS G 3106

(2020) Rolled Steels for Welded Structure

JIS G 3114

(2016) Hot-Rolled Atmospheric Corrosion Resisting Steel for Welded Structure

JIS G 3136

(2022) Rolled Steels for Building Structure

JIS G 3138	(2021) Rolled Steel Bars for Building Structure
JIS G 3302	(2019) Hot-Dip Zinc-Coated Steel Sheet and Strip
JIS G 3444	(2021) Carbon Steel Tubes for General Structure
JIS G 3466	(2021) Carbon Steel Square and Rectangular Tubes for General Structure
JIS G 3475	(2021) Carbon Steel Tubes for Building Structure
JIS H 8641	(2021) Hot Dip Galvanized Coatings
NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)	
NAAMM MBG 531	(2017) Metal Bar Grating Manual

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

- Iron and Steel Hardware; G
- Steel Shapes, Plates, Bars, and Strips; G
- Metal Stair System; G

SD-03 Product Data

- Structural Steel Plates, Shapes, and Bars; G
- Structural Steel Tubing; G
- Hot-Rolled Carbon Steel Sheets and Strips; G
- Cold-Finished Steel Bars; G
- Hot-Rolled Carbon Steel Bars; G
- Cold-Rolled Carbon Steel Sheets; G
- Protective Coating; G
- Steel Stairs; G

SD-07 Certificates

- Welder Qualification; G

SD-08 Manufacturer's Instructions

Protective Coating; G

1.3 QUALITY CONTROL

1.3.1 Qualifications for Welding Work

Certify welder qualification by tests in accordance with AWS D1.1/D1.1M, or under an equivalent approved qualification test. In addition, perform tests on test pieces in positions and with clearances equivalent to those actually encountered. If a test weld fails to meet requirements, ensure that two test welds are retested immediately and that each test weld is made and passes. Failure in the immediate retest requires that the welder be retested after further practice or training and a complete set of test welds be made.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit complete and detailed fabrication drawings for all iron and steel hardware, and for all steel shapes, plates, bars, and strips used in accordance with the design specifications referenced in this section.

2.2 FABRICATION

Preassemble items in the shop to the greatest extent possible. Disassemble units only to the extent necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

For the fabrication of work exposed to view, use only materials that are smooth and free of surface blemishes, including pitting, seam marks, roller marks, rolled trade names, and roughness. Remove blemishes by grinding, or by welding and grinding, before cleaning and treating surfaces and applying surface finishes, including zinc coatings.

2.2.1 General Fabrication

Prepare and submit metal stair system shop drawings with detailed plans and elevations at scales not less than 1 inch to 1 foot and with details of sections and connections at scales not less than 3 inches to 1 foot. Also detail the placement drawings, diagrams, and templates for installation of anchorages, including concrete inserts, anchor bolts, and miscellaneous metal items having integral anchorage devices.

Use materials of size and thicknesses indicated or, if not indicated, of the size and thickness necessary to produce a finished product that is strong enough and durable enough for its intended use. Work the materials to the dimensions indicated on approved detail drawings, using proven methods of fabrication and support. Use the type of materials indicated or specified for the various components of work.

Form exposed work true to line and level, with accurate angles and surfaces and with straight sharp edges. Ease exposed edges to a radius of approximately 1/32 inch, and bend metal corners to the smallest radius possible without causing grain separation or otherwise impairing the work.

Continuously weld corners and seams in accordance with the recommendations of AWS D1.1/D1.1M. Grind exposed welds smooth and flush to match and blend with adjoining surfaces.

Form exposed connections with hairline joints that are flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of the type indicated or, if not indicated, use Phillips flat-head (countersunk) screws or bolts.

Provide and coordinate anchorage of the type indicated for the supporting structure. Fabricate anchoring devices, and space them as indicated and as necessary to provide adequate support for the intended use of the work.

Use hot-rolled steel bars for work fabricated from bar stock unless work is indicated or specified as fabricated from cold-finished or cold-rolled stock.

2.2.2 Floor Grating Treads and Platforms

Provide floor grating treads and platforms conforming to ASTM A6/A6M or JIS G 3138, ASTM A29/A29M or JIS G 3138-2021 and NAAMM MBG 531, "Metal Bar Grating Manual." Provide the pattern, spacing, and bar sizes as indicated:

- a. Manufacturer's baked-on primer for painted finishes.

Fabricate grating treads with steel plate nosings on one edge and with steel angle or steel plate carriers at each end for string connections. Secure treads to strings with bolts.

Match the nosings of grating platforms with the nosing of grating treads at landings. Provide toeplates where the open-sided edges of floor grating meet platform framing members.

2.2.3 Protective Coating

Shop-prime steelwork as indicated in accordance with AISC/AISI 121, except surfaces of steel encased in concrete; welded surfaces; high-strength, bolt-connected surfaces; and surfaces of crane rails.

2.3 COMPONENTS

2.3.1 Steel Stairs

Provide steel stairs complete with stringers, grating treads, landings, columns, handrails, and necessary bolts and other fastenings. Shop-paint steel stairs and accessories.

2.3.1.1 Design Loads

Design stairs to sustain a live load of not less than 500 pounds per square foot, or a concentrated load of 150 kg applied where it is most critical. Except for a commercial product, design and fabricate steel stairs to conform to AISC 360.

2.3.1.2 Materials

Provide steel stairs of welded construction except that bolts may be used where welding is not practicable. Do not use screw or screw-type connections.

- a. Structural Steel: [ASTM A36/A36M](#) or [JIS G 3101](#), [JIS G 3106](#), [JIS G 3114](#), [JIS G 3136](#).
- b. Gratings for Treads and Landings: [NAAMM MBG 531](#) or Plank grating; [ASTM A653/A653M](#) or [JIS G 3302](#), [G-90](#) for steel. Provide gratings with nonslip nosings.
- c. Support steel grating on angle cleats welded to stringers or treads with integral cleats, welded or bolted to the stringer. Close exposed ends. e. Before fabrication, obtain necessary field measurements and verify drawing dimensions.
- d. Clean metal surfaces free of mill scale, flake rust, and rust pitting before shop finishing. Weld permanent connections. Finish welds flush and smooth on surfaces that will be exposed after installation.

2.3.2 Fasteners

Select galvanized zinc-coated fasteners conforming to [ASTM A153/A153M](#) or [JIS H 8641](#) for exterior applications or where the fasteners are built into exterior walls or floor systems. Select the fasteners for the type, grade, and class required for the installation of steel stair items:

- a. Standard/regular hexagon-head bolts and nuts, conforming to [ASTM A307](#), [Grade A](#) or [JIS B 1180](#) / [JIS B 1181](#).
- b. Plain, round, general-assembly-grade, carbon steel washers, conforming to [ASME B18.21.1](#).
- c. Helical-spring, carbon steel lockwashers, conforming to [ASME B18.2.1](#).

2.4 MATERIALS

2.4.1 Structural Steel Plates, Shapes and Bars

Structural size shapes and plates, conforming to [ASTM A36/A36M](#) or [JIS G 3101](#), [JIS G 3106](#), [JIS G 3114](#), [JIS G 3136](#), unless otherwise noted, except bent or cold-formed plates.

Steel plates - bent or cold-formed, conforming to [ASTM A283/A283M](#) or [JIS H 8641](#), Grade C.

Steel bars and bar-size shapes, conforming to [ASTM A36/A36M](#) or [JIS G 3101](#), [JIS G 3106](#), [JIS G 3114](#), [JIS G 3136](#), unless otherwise noted for steel bars and bar-size shapes.

2.4.2 Structural Steel Tubing

Provide the following:

- a. Structural steel tubing, hot-formed, welded or seamless, conforming to [ASTM A500/A500M](#) or [JIS G 3444](#) / [JIS G 3475](#), Grade B, unless otherwise noted.

2.4.3 Hot-Rolled Carbon Steel Bars

Provide the following:

- a. Hot-rolled carbon steel bars and bar-size shapes, conforming to **ASTM A575** or **JIS G 3138**, grade as selected by the fabricator.

2.4.4 Cold-Finished Steel Bars

Provide the following:

- a. Cold-finished steel bars conforming to **ASTM A108** or **JIS G 3138**, grade as selected by the fabricator.

2.4.5 Hot-Rolled Carbon Steel Sheets and Strips

Provide the following:

- a. Hot-rolled carbon sheets and strips conforming to **ASTM A568/A568M** or **JIS G 3136** and **ASTM A1011/A1011M** or **JIS G 3136**, pickled and oiled.

2.4.6 Cold-Rolled Carbon Steel Sheets

Provide the following:

- a. Cold-rolled carbon steel sheets conforming to **ASTM A1008/A1008M** or **JIS G 3136**.

2.4.7 Steel Pipe

Provide the following:

- a. Steel pipe conforming to **ASTM A53/A53M** or **JIS G 3466**, type as selected, Grade B; primed finish, unless galvanizing is required; standard weight (Schedule 40).

PART 3 EXECUTION

3.1 PREPARATION

Clean surfaces thoroughly before installation. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions. Examine materials upon arrival at site. Notify the carrier and manufacturer of any damage.

Protect installed products until completion of project. Touch up, repair or replace, damaged products before substantial completion

3.2 INSTALLATION

Install in accordance with the manufacturer's instructions and approved submittals. Install in proper relationship with adjacent construction.

Install items at locations indicated, according to the manufacturer's instructions. Verify all measurements and take all field measurements necessary before fabrication. Ensure that exposed fastenings are compatible with generally match the color and finish of, and harmonize with the material to which they are applied. Include materials and parts necessary to complete each item, even though such work is not definitely shown or specified. Poor matching of holes for fasteners is cause for rejection. Conceal fastenings where practicable. Select thickness of metal and details of assembly and supports that adequately strengthen and stiffen the construction. Form joints exposed to the weather to exclude

water.

3.2.1 Field Preparation

Remove rust-preventive coating just before field erection, using a remover approved by the coating manufacturer. Provide surfaces, when assembled, free of rust, grease, dirt and other foreign matter.

3.2.2 Field Welding

Comply with AWS D1.1/D1.1M in executing manual shielded-metal arc welding, (for appearance and quality of new welds) and in correcting existing welding.

3.2.3 Safety Nosings

Completely embed nosing in concrete before the initial set of the concrete occurs and finish flush with the top of the concrete surface.

3.2.4 Touchup Painting

Immediately after installation, clean all field welds, bolted connections, and abraded areas of the shop-painted material, and repaint exposed areas with the same paint used for shop painting. Apply paint by brush or spray to provide a minimum dry-film thickness of 2 mils.

-- End of Section --

SECTION 05 52 00

METAL RAILINGS

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.

JAPANESE STANDARDS ASSOCIATION (JSA)

JIS B 1048	(2007) Fasteners - Hot Dip Galvanized Coatings
JIS B 1251	(2018) Spring Lock Washers
JIS B 1256	(2008) Plain Washers
JIS F 2106	(2013) General Chain for Ships
JIS G 3101	(2017) Rolled Steels for General Structure (Amendment 1)
JIS G 3466	(2015) Carbon Steel Square and Rectangular Tubes for General Structure
JIS G 3475	(2014) Carbon Steel Tubes for Building Structure
JIS Z 3410	(2013) Welding Coordination - Tasks and Responsibilities
JIS Z 3420	(2003) Specification and Approval of Welding Procedures for Metallic Materials - General Rules
JIS Z 3604	(2016) Inert Gas Arc Welding Standard for Aluminum
JIS Z 3801	(2018) Standard Qualification Test and Acceptance Requirements for Manual Welding Technique
JIS Z 3841	(2018) Test Method and Criteria in Semi-Automatic Welding Technology Certification

MINISTRY OF LAND, INFRASTRUCTURE, TRANSPORT AND TOURISM,
GOVERNMENT OF JAPAN (MLIT)

MLIT Chapter 14 Metal Work

1.2 ADMINISTRATIVE REQUIREMENTS

1.2.1 Preinstallation Meetings

Within 30 days of contract award, submit [fabrication drawings](#) to the Contracting Officer for the following items:

- a. Iron and steel hardware
- b. Steel shapes, plates, bars and strips
- c. Steel railings and handrails
- d. Anchorage and fastening systems

Submit manufacturer's catalog data, including two copies of manufacturers specifications, load tables, dimension diagrams, and anchor details for the following items:

- a. Structural-steel plates, shapes, and bars
- b. Structural-steel tubing
- c. Protective coating
- d. Steel railings and handrails
- e. Anchorage and fastening systems

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. Submit the following in accordance with Section [01 33 00](#) SUBMITTAL PROCEDURES:

[SD-02 Shop Drawings](#)

[Fabrication Drawings; G](#)

[Iron and Steel Hardware](#)

[Steel Shapes, Plates, Bars and Strips](#)

[SD-07 Certificates](#)

[Welder Qualification; G](#)

[SD-08 Manufacturer's Instructions](#)

[Installation Instructions](#)

1.4 QUALITY CONTROL

1.4.1 Welding Procedures

Section [05 05 23.16](#) STRUCTURAL WELDING applies to work specified in this section.

1.4.2 Welder Qualification

Submit certified welder qualification by tests in accordance with JIS Z 3801 or JIS Z 3841, or under an equivalent approved qualification test. In addition, perform tests on test pieces in positions and with clearances equivalent to those actually encountered. If a test weld fails to meet requirements, conduct an immediate retest of two test welds and ensure that each test weld passes. Failure in the immediate retest will require that the welder be retested after further practice or training and make a complete set of test welds.

PART 2 PRODUCTS

2.1 DESIGN

Design all handrails and guards to resist a concentrated load of 890 N in any direction at any point of the top of the rail or 730 N/m applied horizontally to the top of the rail, whichever is more severe. Intermediate rails, balusters and panel fillers shall be design to resist a concentrated load of 220 N. MLIT Chapter 14, provide the same size rail and post. Provide pipe collars of the same material and finish as the handrail and posts.

2.2 FABRICATION

Preassemble items in the shop to the greatest extent possible. Disassemble units only to the extent necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

For the fabrication of work exposed to view, use only materials that are smooth and free of surface blemishes, including pitting, seam marks, roller marks, rolled trade names, and roughness. Remove blemishes by grinding, or by welding and grinding, before cleaning, treating, and applying surface finishes, including zinc coatings.

Provide railing and handrail detail plans and elevations at not less than 1 inch to 1 foot. Provide details of sections and connections at not less than 3 inches to 1 foot. Also detail setting drawings, diagrams, templates for installation of anchorages, including concrete inserts, anchor bolts, and miscellaneous metal items having integral anchors.

Use materials of size and thicknesses indicated or, if not indicated, of the size and thickness necessary to produce adequate strength and durability in the finished product for its intended use. Work the materials to the dimensions indicated on approved detail drawings, using proven details of fabrication and support. Use the type of materials indicated or specified for the various components of work.

Form exposed work true to line and level, with accurate angles and surfaces and straight sharp edges. Ensure that all exposed edges are eased to a radius of approximately 1/32 inch. Bend metal corners to the smallest radius possible without causing grain separation or otherwise impairing the work.

Weld corners and seams continuously and in accordance with the recommendations of JIS Z 3420 and JIS Z 3604. Grind exposed welds smooth and flush to match and blend with adjoining surfaces.

Form the exposed connections with hairline joints that are flush and

smooth, using concealed fasteners wherever possible. Use exposed fasteners of the type indicated or, if not indicated, use countersunk Phillips flathead screws or bolts.

Provide anchorage of the type indicated and coordinated with the supporting structure. Fabricate anchoring devices and space as indicated and as required to provide adequate support for the intended use of the work.

Use hot-rolled steel bars for work fabricated from bar stock unless work is indicated or specified to be fabricated from cold-finished or cold-rolled stock.

2.2.1 Steel Railings and Handrails

Fabricate joint posts, rail, and corners by one of the following methods:

- a. Flush-type rail fittings of commercial standard, welded and ground smooth, with railing splice locks secured with **3/8 inch** hexagonal-recessed-head setscrews.
- b. Mitered and welded joints made by fitting post to top rail and intermediate rail to post, mitering corners, groove-welding joints, and grinding smooth. Butt railing splices and reinforce them by a tight-fitting interior sleeve not less than **6 inches** long.
- c. Railings may be bent at corners in lieu of jointing, provided that bends are made in suitable jigs and the pipe is not crushed.

Provide removable sections as indicated.

2.2.2 Protective Coating

Shop-prime the steelwork as indicated in accordance with Section **09 90 00** PAINTS AND COATINGS except the following:

- a. steel surfaces encased in concrete
- b. steel surfaces for welding
- c. high-strength bolt-connected contact surfaces
- d. crane rail surfaces

2.3 COMPONENTS

2.3.1 Structural Steel Plates, Shapes And Bars

Provide structural-size shapes and plates, except plates to be bent or cold-formed, conforming to **JIS G 3101**, unless otherwise noted.

Provide steel plates, to be bent or cold-formed, conforming to **JIS G 3101**, SS 400.

Provide steel bars and bar-size shapes conforming to **JIS G 3101**, unless otherwise noted.

2.3.2 Structural-Steel Tubing

Provide structural-steel tubing, hot-formed, welded or seamless, conforming to JIS G 3466 unless otherwise noted.

2.3.3 Steel Pipe

Provide pipe conforming to JIS G 3466 STK 400 and 235 MPa or JIS G 3475, STKN400B and 235 MPa; primed finish, unless galvanizing is required; standard weight (Schedule 40).

2.3.4 Fasteners

Provide galvanized zinc-coated fasteners in accordance with JIS B 1048 used for exterior applications or where built into exterior walls or floor systems. Select fasteners for the type, grade, and class required for the installation of steel stair items.

Provide standard hexagon-head bolts, conforming to.

Provide plain round, general-assembly-grade, carbon steel washers conforming to JIS B 1256.

Provide helical spring, carbon steel lockwashers conforming to JIS B 1251.

2.3.5 Steel Railings and Handrails

2.3.5.1 Steel Handrails

Provide steel handrails, steel pipe conforming to JIS G 3466 or structural tubing conforming to JIS G 3466. Provide steel railings of 1 1/2 inch nominal size, shop-painted.

Provide kickplates between railing posts where indicated and consisting of 1/8 inch steel flat bars not less than 6 inches high. Secure kickplates as indicated.

2.3.6 Safety Chains and Guardrails

Provide safety chains of galvanized steel, straight-link type, 3/16 inch diameter, with at least 12 links per foot, and with snap hooks on each end. Test safety chain in accordance with JIS F 2106. Provide snap hooks of boat type. Provide galvanized 3/8 inch bolt with 3/4 inch eye diameter for attachment of chain, anchored as indicated. Supply two chains, 4 inches longer than the anchorage spacing, for each guarded area. Locate safety chain where indicated. Mount the top chain 3 feet 6 inches above the floor and mount the lower chain 2 feet above the floor.

PART 3 EXECUTION

3.1 PREPARATION

Adjust stair railings and handrails before securing in place in order to ensure proper matching at butting joints and correct alignment throughout their length. Space posts not more than on center. Plumb posts in each direction. Secure posts and rail ends to building construction as follows:

- a. Anchor rail ends to steel with oval or round steel flanges welded to tail ends and bolted to the structural-steel members.

Secure handrails to walls by means of wall brackets and wall return fitting at handrail ends. Provide brackets of malleable iron castings, with not less than 3 inch projection from the finished wall surface to the center of the pipe, drilled to receive one 3/8 inch bolt. Locate brackets not more than 60 inches on center. Provide wall return fittings of cast iron castings, flush type, with the same projection as that specified for wall brackets. Secure wall brackets and wall return fittings to building construction as follows:

Install toe boards and brackets where indicated. Make splices, where required, at expansion joints. Install removable sections as indicated.

3.2 INSTALLATION

Submit manufacturer's installation instructions for the following products to be used in the fabrication of steel stair railing:

- a. Structural-steel plates, shapes, and bars
- b. Structural-steel tubing
- c. Protective coating
- d. Steel railings and handrails
- e. Anchorage and fastening systems

Provide complete, detailed fabrication and installation drawings for all iron and steel hardware, and for all steel shapes, plates, bars, and strips used in accordance with the design specifications cited in this section.

3.2.1 Steel Handrail

Install handrail by means of base plates bolted to stringers or structural-steel frame work. Secure rail ends by steel pipe flanges through-bolted to a back plate or by 1/4 inch lag bolts to studs or solid backing.

3.2.2 Touchup Painting

Immediately after installation, clean field welds, bolted connections, abraded areas of the shop paint, and exposed areas painted with the paint used for shop painting. Apply paint by brush or spray to provide a minimum dry-film thickness of 2 mils.

3.3 FIELD QUALITY CONTROL

3.3.1 Field Welding

Ensure that procedures of manual shielded metal arc welding, appearance and quality of welds made, and methods used in correcting welding work comply with JIS Z 3410, JIS Z 3420, or JIS Z 3604.

-- End of Section --

SECTION 06 10 00

ROUGH CARPENTRY

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 FOREST FOUNDATION (AFF)

ATFS STANDARDS (2015) American Tree Farm System Standards of Sustainability 2015-2020

AMERICAN INSTITUTE OF TIMBER CONSTRUCTION (AITC)

AITC TCM (2012) Timber Construction Manual, 5th Edition

AMERICAN LUMBER STANDARDS COMMITTEE (ALSC)

ALSC PS 20 (2015) American Softwood Lumber Standard

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Eng Man (2017) Manual for Railway Engineering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B18.2.1 (2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)

ASME B18.2.2 (2015) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASME B18.5.2.1M (2006; R 2011) Metric Round Head Short Square Neck Bolts

ASME B18.5.2.2M (1982; R 2010) Metric Round Head Square Neck Bolts

ASME B18.6.1 (2016) Wood Screws (Inch Series)

AMERICAN WOOD COUNCIL (AWC)

AWC NDS (2015) National Design Specification (NDS) for Wood Construction

AWC WFCM (2012) Wood Frame Construction Manual for One- and Two-Family Dwellings

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA BOOK	(2015) AWPB Book of Standards
AWPA M2	(2019) Standard for the Inspection of Preservative Treated Wood Products for Industrial Use
AWPA M6	(2013) Brands Used on Preservative Treated Materials
AWPA P5	(2015) Standard for Waterborne Preservatives
AWPA P18	(2014) Nonpressure Preservatives
AWPA P49	(2015; R 2021) Standard for Fire Retardant FR-1
AWPA T1	(2021) Use Category System: Processing and Treatment Standard
AWPA U1	(2021) Use Category System: User Specification for Treated Wood

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA E445	(2002) Performance Standards and Qualification Policy for Structural-Use Panels (APA PRP-108)
APA EWS T300	(2007) Technical Note: Glulam Connection Details
APA F405	(19) Product Guide: Performance Rated Panels
APA L870	(2010) Voluntary Product Standard, PS 1-09, Structural Plywood
APA S350	(2014) PS 2-10, Performance Standard for Wood-Based Structural-Use Panels

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM C1396/C1396M	(2017) Standard Specification for Gypsum Board
ASTM D198	(2015) Standard Test Methods of Static Tests of Lumber in Structural Sizes

ASTM D696	(2016) Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 degrees C and 30 degrees C With a Vitreous Silica Dilatometer
ASTM D2344/D2344M	(2016) Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates
ASTM D2898	(2010; R 2017) Standard Practice for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing
ASTM D6108	(2013) Standard Test Method for Compressive Properties of Plastic Lumber and Shapes
ASTM D6109	(2013) Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastic Lumber and Related Products
ASTM D6111	(2013a) Standard Test Method for Bulk Density and Specific Gravity of Plastic Lumber and Shapes by Displacement
ASTM D6112	(2013) Compressive and Flexural Creep and Creep-Rupture of Plastic Lumber and Shapes
ASTM D6117	(2016) Standard Test Methods for Mechanical Fasteners in Plastic Lumber and Shapes
ASTM F547	(2017) Standard Terminology of Nails for Use with Wood and Wood-Base Materials
ASTM F1667	(2021) Standard Specification for Driven Fasteners: Nails, Spikes, and Staples

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

CSA GROUP (CSA)

CSA Z809-08	(R2013) Sustainable Forest Management

FM GLOBAL (FM)

FM 4435	(2013) Roof Perimeter Flashing

FOREST STEWARDSHIP COUNCIL (FSC)

FSC STD 01 001	(2015) Principles and Criteria for Forest Stewardship

GREEN SEAL (GS)

GS-36 (2013) Adhesives for Commercial Use

PROGRAMME FOR ENDORSEMENT OF FOREST CERTIFICATION (PEFC)

PEFC ST 2002:2013 (2015) PEFC International Standard Chain
of Custody of Forest Based Products
Requirements

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168 (2017) Adhesive and Sealant Applications

SUSTAINABLE FOREST INITIATIVE (SFI)

SFI 2015-2019 (2015) Standards, Rules for Label Use,
Procedures and Guidance

TRUSS PLATE INSTITUTE (TPI)

TPI 1 (2014) National Design Standard for Metal
Plate Connected Wood Truss Construction,
Including Commentary and Appendices

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1923 (Rev A; Notice 3) Shield, Expansion (Lag,
Machine and Externally Threaded Wedge Bolt
Anchors)

CID A-A-1924 (Rev A; Notice 3) Shield, Expansion (Self
Drilling Tubular Expansion Shell Bolt
Anchors)

CID A-A-1925 (Rev A; Notice 3) Shield Expansion (Nail
Anchors)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Modifications of Structural Members; 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; 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

Plastic Lumber

Fire-retardant Treatment

Adhesives

SD-06 Test Reports

Preservative-treated Lumber and Plywood

SD-07 Certificates

Certificates of Grade

Preservative Treatment

SD-10 Operation and Maintenance Data

Take-back Program

Include contact information, summary of procedures, and the limitations and conditions applicable to the project. Indicate manufacturer's commitment to reclaim materials for recycling or reuse.

1.3 DELIVERY AND STORAGE

Deliver materials to the site in an undamaged condition. Store, protect, handle, and install prefabricated structural elements in accordance with manufacturer's instructions and as specified. Store materials off the ground to provide proper ventilation, with drainage to avoid standing water, and protection against ground moisture and dampness. Store materials with a moisture barrier at both the ground level and as a cover forming a well ventilated enclosure. Store wood I-beams and glue-laminated beams and joists on edge. Adhere to requirements for stacking, lifting, bracing, cutting, notching, and special fastening requirements. Do not use materials that have visible moisture or biological growth. Remove defective and damaged materials and provide new materials. Store separated reusable wood waste convenient to cutting station and area of work.

1.4 GRADING AND MARKING

1.4.1 Lumber

Mark each piece of framing and board lumber or each bundle of small pieces of lumber with the grade mark of a recognized association or independent inspection agency. Such association or agency must be certified by the Board of Review, American Lumber Standards Committee, to grade the species used. Surfaces that are to be exposed to view must 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.

1.4.2 Preservative-Treated Lumber and Plywood

The Contractor is responsible for the quality of treated wood products. Each treated piece must be inspected in accordance with **AWPA M2** and permanently marked or branded, by the producer, in accordance with **AWPA M6**. The Contractor must provide Contracting Officer's Representative (COR) with the inspection report of an approved independent inspection agency that offered products comply with applicable AWPA Standards. The appropriate Quality Mark on each piece will be accepted, in lieu of inspection reports, as evidence of compliance with applicable AWPA treatment standards.

1.4.3 Fire-Retardant Treated Lumber

Mark each piece in accordance with **AWPA M6**, except pieces that are to be natural or transparent finished. In addition, exterior fire-retardant lumber must be distinguished by a permanent penetrating blue stain. Labels of a nationally recognized independent testing agency will be accepted as evidence of conformance to the fire-retardant requirements of **AWPA M6**.

1.4.4 Hardboard, Gypsum Board, and Fiberboard

Mark each sheet or bundle to identify the standard under which the material is produced and the producer.

1.5 SIZES AND SURFACING

ALSC PS 20 for dressed sizes of yard and structural lumber. Lumber must be surfaced four sides. Size references, unless otherwise specified, are nominal sizes, and actual sizes must be within manufacturing tolerances allowed by the standard under which the product is produced. Other measurements are IP or SI standard.

1.6 MOISTURE CONTENT

Air-dry or kiln-dry lumber. Kiln-dry treated lumber after treatment. Maximum moisture content of wood products must be as follows at the time of delivery to the job site:

- a. Framing lumber and board, 19 percent maximum
- b. Timbers **5 inches** and thicker, 25 percent maximum
- c. Roof planking, 15 percent maximum
- d. Materials other than lumber; moisture content must be in accordance with standard under which the product is produced

1.7 PRESERVATIVE TREATMENT

Treat wood products with waterborne wood preservatives conforming to **AWPA P5**. Pressure treatment of wood products must conform to the requirements of **AWPA BOOK Use Category System Standards U1 and T1**. Pressure-treated wood products must not contain arsenic, chromium, or other agents classified as carcinogenic, probably carcinogenic, or possibly carcinogenic to humans (compounds in Groups 1, 2A, or 2B) by the International Agency for Research on Cancer (IARC), Lyon, France. Pressure-treated wood products must not exceed the limits of the U.S.

EPA's Toxic Characteristic Leaching Procedure (TCLP), and must not be classified as hazardous waste. Submit certification from treating plant stating chemicals and process used and net amount of preservatives retained are in conformance with specified standards. In accordance with AWWA U1 provide non-copper preservative treatment such as EL2, PTI or SBX, DOT for products in direct contact with sheet metal.

- a. 0.25 pcf intended for above ground use.
- b. 0.40 pcf intended for ground contact and fresh water use. 0.60 pcf intended for Ammoniacal Copper Quaternary Compound (ACQ)-treated foundations. 0.80 to 1.00 pcf intended for ACQ-treated pilings. All wood must be air or kiln dried after treatment. Specific treatments must be verified by the report of an approved independent inspection agency, or the AWWA Quality Mark on each piece. Do not incise surfaces of lumber that will be exposed. Minimize cutting and avoid breathing sawdust. Brush coat areas that are cut or drilled after treatment with either the same preservative used in the treatment or with a 2 percent copper naphthenate solution. All lumber and woodwork must be preservative treated. The following items must be preservative treated:
 - (1) Wood sills, soles, plates, furring, and sleepers that are less than 24 inches from the ground, furring and nailers that are set into or in contact with concrete or masonry.
 - (2) Nailers, edge strips, crickets, curbs, and cants for roof decks.

1.7.1 New Construction

Use a boron-based preservative conforming to AWWA P18, sodium silicate wood mineralization process, or Ammoniacal Copper Quaternary Compound to treat wood. Use boron-based preservatives for above-ground applications only.

1.8 FIRE-RETARDANT TREATMENT

Fire-retardant treated wood must be pressure treated with fire retardants conforming to AWWA P49. Fire retardant treatment of wood products must conform to the requirements of AWWA U1, Commodity Specification H and AWWA T1, Section H. Treatment and performance inspection must be by an independent and qualified testing agency that establishes performance ratings. Each piece or bundle of treated material must bear identification of the testing agency to indicate performance in accordance with such rating. Treated materials to be exposed to rain wetting must be subjected to an accelerated weathering technique in accordance with ASTM D2898 prior to being tested. Such items which will not be inside a building, and such items which will be exposed to heat or high humidity, must receive exterior fire-retardant treatment. Fire-retardant-treated wood products must be free of halogens, sulfates, ammonium phosphate, and formaldehyde. Items to be treated include the following:

- a. Roof and wall sheathing, wood blocking and nailers.

1.9 QUALITY ASSURANCE

1.9.1 Data Required

Submit calculations and drawings for all proposed modifications of

structural members. Do not proceed with modifications until the submittal has been approved.

1.9.2 Humidity Requirements

Sequence work to minimize use of temporary HVAC to dry out building and control humidity.

1.10 ENVIRONMENTAL REQUIREMENTS

During and immediately after installation of treated wood, engineered wood products, and laminated wood products at interior spaces, provide temporary ventilation.

1.11 CERTIFICATIONS

1.11.1 Certified Wood Grades

Provide certificates of grade from the grading agency on graded but unmarked lumber or plywood attesting that materials meet the grade requirements specified herein.

1.11.2 Certified Sustainably Harvested Wood

Provide wood certified as sustainably harvested by FSC STD 01 001, ATFS STANDARDS, CSA Z809-08, SFI 2015-2019, or other third party program certified by PEFC ST 2002:2013. Provide a letter of Certification of Sustainably Harvested Wood signed by the wood supplier. Identify certifying organization and their third party program name and indicate compliance with chain-of-custody program requirements. Submit sustainable wood certification data; identify each certified product on a line item basis. Submit copies of invoices bearing certification numbers.

1.11.3 Indoor Air Quality Certifications

Submit required indoor air quality certifications in one submittal package.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Plastic Lumber

2.1.1.1 Shear Parallel to Length

Maximum 1,000 psi in accordance with ASTM D2344/D2344M.

2.1.1.2 Density

ASTM D6111.

2.1.1.3 Compressive Strength

a. Secant Modulus: Minimum 70,000 psi in accordance with ASTM D6108.

b. Stress at 3 percent strain: Minimum 1,500 psi in accordance with ASTM D6108.

c. Compression Parallel to Grain: Minimum 3,000 psi in accordance with

ASTM D6112.

- d. Compression Perpendicular to Grain: Minimum 1,000 psi in accordance with ASTM D6112.

2.1.1.4 Flexural Strength

Minimum 2,000 psi in accordance with ASTM D6109.

2.1.1.5 Tensile Strength

Minimum 1,250 psi in accordance with ASTM D198.

2.1.1.6 Coefficient of Thermal Expansion

Maximum 0.000080 in/in/degree F in accordance with ASTM D696.

2.1.1.7 Screw Withdrawal

350 lbs in accordance with ASTM D6117.

2.1.1.8 Nail Withdrawal

150 lbs in accordance with ASTM D6117.

2.2 LUMBER

2.3 PLYWOOD PANELS

APA L870, APA S350, APA E445, and APA F405 respectively.

2.3.1 Wall Sheathing

2.3.1.1 Plywood

C-D Grade, Exposure 1, and a minimum thickness of 1/2 inch, except where indicated to have greater thickness. Provide exterior grade material with phenol resin for interior and exterior applications.

2.4 OTHER MATERIALS

2.4.1 Gypsum Wall Sheathing

ASTM C1396/C1396M 5/8 inch thick; 4 feet wide with square edge for supports 16 inches o.c. with or without corner bracing of framing ; 2 feet wide with V-tongue and groove (T&G) edge for supports 16 inches o.c. with corner bracing of framing.

2.4.2 Miscellaneous Wood Members

2.4.2.1 Nonstress Graded Members

Members must include bridging, corner bracing, furring, grounds, and nailing strips. Members must be in accordance with TABLE I for the species used. Sizes must be as follows unless otherwise shown:

Member	Size inch
Bridging	1 x 3 or 1 x 4 for use between members 2 x 12 and smaller; 2 x 4 for use between members larger than 2 x 12.
Corner bracing	1 x 4.
Furring	1 x 2
Grounds	Plaster thickness by 38.
Nailing strips	1 x 3 or 1 x 4 when used as shingle base or interior finish, otherwise 2 inch stock.

2.4.2.2 Wood Bumpers

AREMA Eng Man, Industrial grade cross ties

2.4.2.3 Sill Plates

Sill plates must be standard or number 2 grade.

2.4.2.4 Blocking

Blocking must be standard or number 2 grade.

2.4.2.5 Rough Bucks and Frames

Rough bucks and frames must be straight standard or number 2 grade.

2.4.3 Adhesives

Comply with applicable regulations regarding toxic and hazardous materials and as specified. Provide non-aerosol adhesive products used on the interior of the building (defined as inside of the weatherproofing system) meeting either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168. Provide aerosol adhesives used on the interior of the building meeting either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of GS-36.

2.5 ROUGH HARDWARE

Unless otherwise indicated or specified, rough hardware must be of the type and size necessary for the project requirements. Sizes, types, and spacing of fastenings of manufactured building materials must be as recommended by the product manufacturer unless otherwise indicated or specified. Rough hardware exposed to the weather or embedded in or in contact with preservative treated wood, exterior masonry, or concrete

walls or slabs must be hot-dip zinc-coated in accordance with [ASTM A153/A153M](#). Nails and fastenings for fire-retardant treated lumber and woodwork exposed to the weather must be copper alloy or hot-dipped galvanized fasteners as recommended by the treated wood manufacturer.

2.5.1 Bolts, Nuts, Studs, and Rivets

[ASME B18.2.1](#), [ASME B18.5.2.1M](#), [ASME B18.5.2.2M](#) and [ASME B18.2.2](#).

2.5.2 Anchor Bolts

[ASTM A307](#), size as indicated, complete with nuts and washers.

2.5.3 Expansion Shields

[CID A-A-1923](#), [CID A-A-1924](#), and [CID A-A-1925](#). Except as shown otherwise, maximum size of devices must be [3/8 inch](#).

2.5.4 Lag Screws and Lag Bolts

[ASME B18.2.1](#).

2.5.5 Wood Screws

[ASME B18.6.1](#).

2.5.6 Nails and Staples

[ASTM F547](#), size and type best suited for purpose. For sheathing and subflooring, length of nails must be sufficient to extend [1 inch](#) into supports. In general, 8-penny or larger nails must be used for nailing through [1 inch](#) thick lumber and for toe nailing [2 inch](#) thick lumber; 16-penny or larger nails must be used for nailing through [2 inch](#) thick lumber. Nails used with treated lumber and sheathing must be hot-dipped galvanized in accordance with [ASTM A153/A153M](#). Nailing must be in accordance with the recommended nailing schedule contained in [AWC WFCM](#). Where detailed nailing requirements are not specified, nail size and spacing must be sufficient to develop an adequate strength for the connection. The connection's strength must be verified against the nail capacity tables in [AWC NDS](#). Reasonable judgment backed by experience must 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 must be used.

2.5.7 Wire Nails

[ASTM F1667](#).

2.5.8 Timber Connectors

Unless otherwise specified, timber connectors must be in accordance with [TPI 1](#), [APA EWS T300](#) or [AITC TCM](#).

2.5.9 Clip Angles

Steel, [3/16 inch](#) thick, size best suited for intended use; or zinc-coated steel or iron commercial clips designed for connecting wood members.

PART 3 EXECUTION

3.1 INSTALLATION

Do not install building construction materials that show visual evidence of biological growth.

Conform to **AWC WFCM** and install in accordance with the **National Association of Home Builders (NAHB) Advanced Framing Techniques: Optimum Value Engineering**, unless otherwise indicated or specified. Select lumber sizes to minimize waste. Fit framing lumber and other rough carpentry, set accurately to the required lines and levels, and secure in place in a rigid manner.

3.1.1 Wood Sheathing

Sheathing end joints must be made over framing members and so alternated that there will be at least two boards between joints on the same support. Each board must bear on at least three supports. Boards must be nailed at each support using two nails for boards **6 inches** and less in width and three nails for boards more than **6 inches** in width. Roof sheathing must not be installed where roof decking is installed.

3.2 MISCELLANEOUS

3.2.1 Wood Roof Nailers, Edge Strips

Provide sizes and configurations indicated or specified and anchored securely to continuous construction.

3.2.1.1 Roof Edge Strips and Nailers

Provide at perimeter of roof, around openings through roof, and where roofs abut walls, curbs, and other vertical surfaces. Except where indicated otherwise, nailers must be **6 inches** wide and the same thickness as the insulation. Anchor nailers securely to underlying construction. Anchor perimeter nailers in accordance with **FM 4435**. Strips must be grooved as indicated for edge venting; install at walls, curbs, and other vertical surfaces with a **1/4 to 1/2 inch** air space.

3.2.2 Wood Blocking

Provide proper sizes and shapes at proper locations for the installation and attachment of wood and other finish materials, fixtures, equipment, and items indicated or specified.

3.2.3 Temporary Closures

Provide with hinged doors and padlocks and install during construction at exterior doorways and other ground level openings that are not otherwise closed. Cover windows and other unprotected openings with polyethylene or other approved material, stretched on wood frames. Provide dustproof barrier partitions to isolate areas as directed.

3.2.4 Temporary Centering, Bracing, and Shoring

Provide for the support and protection of masonry work during construction as specified. Forms and centering for cast-in-place concrete work are specified in Section **03 30 00** CAST-IN-PLACE CONCRETE.

3.3 WASTE MANAGEMENT OF WOOD PRODUCTS

In accordance with the Waste Management Plan and as specified. Separate and reuse scrap sheet materials larger than [2 square feet](#), framing members larger than [16 inches](#), and multiple offcuts of any size larger than [12 inches](#). Clearly separate damaged wood and other scrap lumber for acceptable alternative uses on site, including bracing, blocking, cripples, ties, and shims.

Separate composite wood from other wood types and recycle or reuse. Coordinate with manufacturer for [take-back program](#) and submit manufacturer's policy statement on program.

Separate treated, stained, painted, and contaminated wood and place in designated area for hazardous materials. Dispose of according to local regulations. Do not leave any wood, shavings, sawdust, or other wood waste buried in fill or on the ground. Prevent sawdust and wood shavings from entering the storm drainage system. Compost sawdust. Do not burn scrap lumber that has been pressure treated, or lumber that is less than one year old.

-- End of Section --

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SECTION 07 21 13

BOARD AND BLOCK INSULATION

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.

ASTM INTERNATIONAL (ASTM)

ASTM C553	(2013) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C591	(2019) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C930	(2019) Standard Classification of Potential Health and Safety Concerns Associated with Thermal Insulation Materials and Accessories
ASTM D1621	(2016) Standard Test Method for Compressive Properties of Rigid Cellular Plastics
ASTM D3833/D3833M	(1996; R 2011) Water Vapor Transmission of Pressure-Sensitive Tapes
ASTM E96/E96M	(2016) Standard Test Methods for Water Vapor Transmission of Materials
ASTM E154/E154M	(2008a; R 2013; E 2013) Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2018) International Building Code

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31	(2016) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2018) National Fuel Gas Code
NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA

17-14; TIA 17-15; TIA 17-16; TIA 17-17)
National Electrical Code

NFPA 211

(2019) Standard for Chimneys, Fireplaces,
Vents, and Solid Fuel-Burning Appliances

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS

SCS Global Services (SCS) Indoor Advantage

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.134

Respiratory Protection

UNDERWRITERS LABORATORIES (UL)

UL 2818

(2013) GREENGUARD Certification Program
For Chemical Emissions For Building
Materials, Finishes And Furnishings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation;
submittals not having a "G" designation are for information only. Submit
the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Manufacturer's Standard Details; G

Block or Board Insulation; G

Vapor Retarder; G

Pressure Sensitive Tape; G

Protection Board or Coatings; G

Accessories including sealants; G

Recycled Content for Block or Board Insulation; S

SD-07 Certificates

Block or Board Insulation; G

Vapor Retarder; G

Protection Board or Coating; G

Draft Special Warranties; G

Final Special Warranties; G

Indoor Air Quality For Block Or Board Insulation; S

SD-08 Manufacturer's Instructions

Block or Board Insulation

Adhesive

1.3 MANUFACTURER'S DETAILS

Submit [manufacturer's standard details](#) indicating methods of attachment and spacing, transition and termination details, and installation details. Include verification of existing conditions.

1.4 PRODUCT DATA

Include data for material descriptions, recommendations for product shelf life, requirements for [protection board or coatings](#), and precautions for flammability and toxicity. Include data to verify compatibility of sealants with insulation.

1.5 CERTIFICATIONS

Provide products certified to meet indoor air quality requirements by [UL 2818](#) (Greenguard) Gold, [SCS Global Services Indoor Advantage Gold](#) or provide certification by other third-party programs. Provide current product certification documentation from certification body.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Delivery

Deliver materials to the site in original sealed wrapping bearing manufacturer's name and brand designation, specification number, type, grade, R-value, and class. Store and handle to protect from damage. Do not allow insulation materials to become wet, soiled, crushed, or covered with ice or snow. Comply with manufacturer's recommendations for handling, storing, and protecting of materials before and during installation.

1.6.2 Storage

Inspect materials delivered to the site for damage and store out of weather in manufacturer's original packaging. Store only in dry locations, not subject to open flames or sparks, and easily accessible for inspection and handling. Keep materials wrapped and separated from off-gassing materials (such as drying paints and adhesives). Do not use materials that have visible moisture or biological growth. Comply with manufacturer's recommendations for handling, storage, and protection of materials before and during installation.

1.7 SAFETY PRECAUTIONS

1.7.1 Respirators

Provide installers with dust/mist respirators, training in their use, and protective clothing, all approved by the National Institute for Occupational Safety and Health (NIOSH)/Mine Safety and Health Administration (MSHA) and in accordance with [29 CFR 1910.134](#).

1.7.2 Other Safety Considerations

Comply with the safety requirements of [ASTM C930](#).

1.8 SPECIAL WARRANTIES

1.8.1 Guarantee

Guarantee insulation installation against failure due to ultraviolet light exposure for a period of three years from the date of Beneficial Occupancy.

1.8.2 Warranty

Provide manufacturer's material warranty for all system components for a period of three years from the date of Beneficial Occupancy.

PART 2 PRODUCTS

2.1 BLOCK OR BOARD INSULATION

Provide thermal insulating materials as recommended by manufacturer for each type of application indicated. Provide insulation with the following physical properties and in accordance with the following standards:

- a. Unfaced Preformed Rigid Polyurethane and Polyisocyanurate Board:
ASTM C591

2.1.1 Thermal Resistance

As indicated.

2.1.2 Fire Protection Requirements

- a. Provide insulated assemblies in accordance ICC IBC Chapter Fire and Smoke Protection Features.

2.1.3 Other Material Properties

Provide thermal insulating materials with the following properties:

- a. Rigid cellular plastics: Compressive Resistance at Yield: Not less than 10 pounds per square inch (psi) when measured according to ASTM D1621.
- b. Water Vapor Permeance: Not more than 1.1 perms or less when measured according to ASTM E96/E96M, desiccant method, in the thickness required to provide the specified thermal resistance, including facings, if any.
- c. Water Adsorption: Not more than 1 percent by volume when measured in accordance with paragraph 14 of ASTM C553.

2.1.4 Recycled Materials

Provide thermal insulation containing recycled materials to the extent practicable, provided that the material meets all other requirements of this section. The minimum required recycled material contents (by weight, not volume) are:

Polyisocyanurate/Polyurethane:	9 percent
Phenolic Rigid Foam:	5 percent
Perlite Board:	75 percent post consumer paper

Provide data identifying percentage of [recycled content for block or board insulation](#).

2.1.5 Indoor Air Quality

Provide certification of [indoor air quality for block or board insulation](#).

2.1.6 Prohibited Materials

Do not provide materials containing asbestos.

2.2 [VAPOR RETARDER AND DAMPPROOFING](#)

2.2.1 Vapor Retarder under Floor Slab

- a. Water vapor permeance: [0.2 Perm](#) or less when tested in accordance with [ASTM E96/E96M](#).
- b. Puncture resistance: Maximum load no less than [40 pounds](#) when tested according to [ASTM E154/E154M](#) REV A.

2.3 [PRESSURE SENSITIVE TAPE](#)

As recommended by manufacturer of vapor retarder(s). Match water vapor permeance rating for each vapor retarder specified. Provide tape in accordance with [ASTM D3833/D3833M](#).

2.4 [PROTECTION BOARD OR COATING](#)

As recommended by insulation manufacturer.

2.5 [ACCESSORIES](#)

2.5.1 [Adhesive](#)

As recommended by insulation manufacturer.

2.5.2 Mechanical Fasteners

Corrosion resistant fasteners as recommended by the insulation manufacturer.

PART 3 EXECUTION

3.1 EXISTING CONDITIONS

Prior to installation, ensure all areas that are in contact with the insulation are dry and free of projections that could cause voids, compressed insulation, or punctured vapor retarders. For foundation

perimeter or under slab applications, check that subsurface fill is flat, smooth, dry, and well tamped. Do not proceed with installation if moisture or other conditions are present, and notify the Contracting Officer of such conditions. Do not proceed with the work until conditions have been corrected and verified to be dry.

3.2 PREPARATION

3.2.1 Blocking Around Heat Producing Devices

Provide noncombustible blocking at all spaces between heat producing devices and the floors, ceilings and roofs through which they pass. Provide in accordance with **ICC IBC** Section 2111.12 Fireplace Blocking and with the following clearances:

- a. Recessed lighting fixtures, including wiring compartments, ballasts, and other heat producing devices, unless certified for installation surrounded by insulation: **3 inches** from outside face of fixtures and devices or as required by **NFPA 70** and, if insulation is placed above fixture or device, **24 inches** above fixture.
- b. Vents and vent connectors used for venting products of combustion, flues, and chimneys other than masonry chimneys: Minimum clearances as required by **NFPA 211**.
- c. Gas Fired Appliances: Clearances as required in **NFPA 54**.
- d. Oil Fired Appliances: Clearances as required in **NFPA 31**.

Blocking is not required if flues are certified in writing by or flue manufacturer for use in contact with specific insulating materials.

3.3 INSTALLATION

3.3.1 Installation and Handling

Provide insulation in accordance with the manufacturer's printed installation instructions. Keep material dry and free of extraneous materials.

3.3.2 Electrical Wiring

Do not install insulation in a manner that would enclose electrical wiring between two layers of insulation.

3.3.3 Cold Climate Requirement

Place insulation on the outside of pipes.

3.3.4 Continuity of Insulation

Butt tightly against adjoining boards, studs, rafters, joists, sill plates, headers and obstructions. Provide continuity and integrity of insulation at corners, wall to ceiling joint, roof, and floor. Avoid creating thermal bridges and voids. Provide and verify continuity of insulative barrier throughout the building enclosure.

3.3.5 Coordination

Verify final installed insulation thicknesses comply with thicknesses indicated, R-values specified herein, and with the approved insulation submittal(s).

3.4 INSTALLATION ON WALLS

3.4.1 Installation using Furring Strips

Install insulation on members as recommended by insulation manufacturer.

3.4.2 Installation on Masonry Walls

3.4.3 Adhesive Attachment to Concrete and Masonry Walls

- a. As recommended by the insulation manufacturer.
- b. Butt all edges of insulation and seal edges with tape.

3.4.4 Mechanical Attachment on Concrete and Masonry Walls

Cut insulation to cover walls. Apply adhesive to wall and set clip or other mechanical fastener in adhesive as recommended by manufacturer. After curing of adhesive, install insulation over fasteners and bend split prongs to provide a flush condition with the insulation. Butt all edges of insulation and seal with tape.

3.5 PERIMETER AND UNDER SLAB INSULATION

Install perimeter thermal insulation where heated spaces are adjacent to exterior walls, slab edges in slab-on-grade, or floating slab construction.

3.5.1 Manufacturer's Instructions

Layout insulation, tape edges, provide vapor retarder and other required accessories to protection against vermin, insects, and damage in accordance with manufacturer's printed instructions.

3.5.2 Insulation on Vertical Surfaces

Provide thermal insulation as indicated on drawings. Fasten insulation with adhesive or mechanical fasteners.

3.5.3 Insulation Under Slab

Provide insulation horizontally under entire slab on grade. Turn insulation up at slab edge, and extend full height of slab. Install insulation on top of vapor retarder and turn retarder up over the outside edge of insulation to top of slab.

3.5.4 Protection of Insulation

Protect insulation from damage during construction and back filling by application of protection board or a coating. Do not leave installed vertical insulation unprotected overnight. Protect installed insulation from weather, including rain and ultraviolet light, from mechanical abuse, compression, and dislocation. Install protection over entire exposed exterior insulation board.

3.6 VAPOR RETARDER

Apply vapor retarder continuous across all surfaces. Overlap all joints at least 6 inches and seal with pressure sensitive tape. Seal at sills, header, windows, doors and utility penetrations. Repair punctures or tears with pressure sensitive tape.

3.7 ACCESS PANELS AND DOORS

Attach insulation to all access panels greater than 1 square foot and all access doors in insulated floors and ceilings. Use insulation with same R-Value as that for the floor or ceiling in which each panel occurs.

-- End of Section --

SECTION 07 21 16

MINERAL FIBER BLANKET INSULATION

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.

ASTM INTERNATIONAL (ASTM)

ASTM C665	(2017) Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing
ASTM C930	(2019) Standard Classification of Potential Health and Safety Concerns Associated with Thermal Insulation Materials and Accessories
ASTM D5359	(2015) Standard Specification for Glass Cullet Recovered from Waste for Use in Manufacture of Glass Fiber
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E136	(2019a) Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750 Degrees C

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31	(2020) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2021) National Fuel Gas Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 211	(2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	SCS Global Services (SCS) Indoor Advantage

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.134	Respiratory Protection

UNDERWRITERS LABORATORIES (UL)

UL 2818

(2013) GREENGUARD Certification Program
For Chemical Emissions For Building
Materials, Finishes And Furnishings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Blanket Insulation; G

Recycled Content for Insulation Materials; S

Accessories

SD-07 Certificates

Indoor Air Quality for Insulation Materials; S

SD-08 Manufacturer's Instructions

Insulation

1.3 CERTIFICATIONS

Submit required indoor air quality certifications and validations in one submittal package.

1.3.1 Insulation Products

Provide product certified to meet indoor air quality requirements by UL 2818 (Greenguard) Gold, SCS Global Services Indoor Advantage Gold or provide certification by other third-party programs. Provide current product certification from certification body.

1.3.2 Adhesives and Sealants

Provide products certified to meet indoor air quality requirements by UL 2818 (Greenguard) Gold, SCS Global Services Indoor Advantage Gold or provide certification or validation by other third-party programs that products meet the requirements of this Section. Provide current product certification documentation from certification body. When product does not have certification, provide validation that product meets the indoor air quality product requirements cited herein.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery

Deliver materials to site in original sealed wrapping bearing manufacturer's name and brand designation, specification number, type, grade, R-value, and class. Store and handle to protect from damage. Do

not allow insulation materials to become wet, soiled, crushed, or covered with ice or snow. Comply with manufacturer's recommendations for handling, storing, and protecting of materials before and during installation.

1.4.2 Storage

Inspect materials delivered to the site for damage; unload and store out of weather in manufacturer's original packaging. Store only in dry locations, not subject to open flames or sparks, and easily accessible for inspection and handling.

1.5 SAFETY PRECAUTIONS

1.5.1 Respirators

Provide installers with dust/mist respirators, training in their use, and protective clothing, all approved by National Institute for Occupational Safety and Health (NIOSH)/Mine Safety and Health Administration (MSHA) in accordance with [29 CFR 1910.134](#).

1.5.2 Other Safety Concerns

Consider other safety concerns and measures as outlined in [ASTM C930](#).

PART 2 PRODUCTS

2.1 [BLANKET INSULATION](#)

[ASTM C665](#), Type I, blankets without membrane coverings; Class A, membrane-faced surface with a flame spread of 25 or less and a smoke developed rating of 150 or less when tested in accordance with [ASTM E84](#).

2.1.1 Thermal Resistance Value (R-VALUE)

The R-Value must be as indicated on drawings.

2.1.2 Recycled Materials

Provide insulation materials containing the following minimum percentage of recycled material content by weight:

Fiberglass: 20 percent glass cullet complying with [ASTM D5359](#)

Provide data identifying percentage of [recycled content for insulation materials](#).

2.1.3 Prohibited Materials

Do not provide asbestos-containing materials.

2.1.4 Reduced Volatile Organic Compounds (VOC) for Insulation Materials

Provide certification of [indoor air quality for insulation materials](#).

2.2 BLOCKING

Wood, metal, unfaced mineral fiber blankets in accordance with [ASTM C665](#), Type I, or other approved materials. Use only non-combustible materials

meeting the requirements of [ASTM E136](#) for blocking around chimneys and heat producing devices.

2.3 ACCESSORIES

2.3.1 Wire Mesh

Corrosion resistant and as recommended by the insulation manufacturer.

PART 3 EXECUTION

3.1 EXISTING CONDITIONS

Before installing insulation, ensure that areas that will be in contact with the insulation are dry and free of projections which could cause voids, compressed insulation, or punctured vapor retarders. If moisture or other conditions are found that do not allow the workmanlike installation of the insulation, do not proceed but notify Contracting Officer of such conditions.

3.2 PREPARATION

3.2.1 Blocking Around Heat Producing Devices

Install non-combustible blocking around heat producing devices to provide the following clearances:

- a. Recessed lighting fixtures, including wiring compartments, ballasts, and other heat producing devices, unless these are certified by the manufacturer for installation surrounded by insulation: [3 inches](#) from outside face of fixtures and devices or as required by [NFPA 70](#) and, if insulation is to be placed above fixture or device, [24 inches](#) above fixture.
- b. Vents and vent connectors used for venting the products of combustion, flues, and chimneys other than masonry chimneys: Minimum clearances as required by [NFPA 211](#).
- c. Gas Fired Appliances: Clearances as required in [NFPA 54](#).
- d. Oil Fired Appliances: Clearances as required in [NFPA 31](#).

Blocking around flues and chimneys is not required when insulation blanket, including any attached vapor retarder, passed [ASTM E136](#), in addition to meeting all other requirements stipulated in Part 2.

3.3 INSTALLATION

3.3.1 [Insulation](#)

Install and handle insulation in accordance with manufacturer's instructions. Keep material dry and free of extraneous materials. Any materials that show visual evidence of biological growth due to presence of moisture must not be installed on the building project. Ensure personal protective clothing and respiratory equipment is used as required. Observe safe work practices.

3.3.1.1 Electrical wiring

Do not install insulation in a manner that would sandwich electrical wiring between two layers of insulation.

3.3.1.2 Continuity of Insulation

Install blanket insulation to butt tightly against adjoining blankets and to studs, rafters, joists, sill plates, headers and any obstructions. Provide continuity and integrity of insulation at corners, wall to ceiling joints, roof, and floor. Avoid creating thermal bridges.

3.3.1.3 Installation at Bridging and Cross Bracing

Insulate at bridging and cross bracing by splitting blanket vertically at center and packing one half into each opening. Butt insulation at bridging and cross bracing; fill in bridged area with loose or scrap insulation.

3.3.1.4 Cold Climate Requirement

Place insulation to the outside of pipes.

3.3.1.5 Insulation without Affixed Vapor Retarder

Provide snug friction fit to hold insulation in place. Stuff pieces of insulation into cracks between trusses, joists, studs and other framing, such as at attic access doors, door and window heads, jambs, and sills, band joists, and headers.

3.3.1.6 Sizing of Blankets

Provide only full width blankets when insulating between trusses, joists, or studs. Size width of blankets for a snug fit where trusses, joists or studs are irregularly spaced.

3.3.1.7 Access Panels and Doors

Affix blanket insulation to access panels greater than one square foot and access doors in insulated floors and ceilings. Use insulation with same R-Value as that for floor or ceiling.

-- End of Section --

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SECTION 07 22 00

ROOF AND DECK INSULATION

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.

ASTM INTERNATIONAL (ASTM)

ASTM C552	(2021) Standard Specification for Cellular Glass Thermal Insulation
ASTM C1177/C1177M	(2017) Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing
ASTM C1289	(2021) Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board
ASTM D4263	(1983; R 2018) Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

FM GLOBAL (FM)

FM 4450	(1989) Approval Standard for Class 1 Insulated Steel Deck Roofs
FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	SCS Global Services (SCS) Indoor Advantage

UNDERWRITERS LABORATORIES (UL)

UL 2818	(2013) GREENGUARD Certification Program For Chemical Emissions For Building Materials, Finishes And Furnishings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Insulation Board Layout and Attachment; G

Verification of Existing Conditions; G

SD-03 Product Data

Insulation; G

Cover Board; G

Adhesives; G

Fasteners; G

Recycled Content For Insulation; S

SD-07 Certificates

Installer Qualifications; G

Indoor Air Quality For Insulation; S

SD-08 Manufacturer's Instructions

Adhesive; G

Roof Insulation; G

SD-11 Closeout Submittals Volatile Organic Compounds (VOC) Content; S

1.3 SHOP DRAWINGS

Submit [insulation board layout](#) and attachment indicating methods of attachment and spacing, transitions, tapered components, thicknesses of materials, and closure and termination conditions. Show locations of ridges, valleys, crickets, interface with, and slope to, roof drains. Base shop drawings on verified field measurements and include [verification of existing conditions](#).

1.4 PRODUCT DATA

Include data for material descriptions, recommendations for product shelf life, requirements for [cover board](#) or coatings, and precautions for flammability and toxicity. Include data to verify compatibility of sealants with insulation.

1.5 MANUFACTURER'S INSTRUCTIONS

Include field of roof and perimeter attachment requirements.

Provide a complete description of installation sequencing for each phase of the roofing system. Include weatherproofing procedures.

1.6 QUALITY CONTROL

Provide certification of [installer qualifications](#) from the insulation manufacturer confirming the specific installer has the required

qualifications for installing the specific roof insulation system(s) indicated.

1.7 CERTIFICATIONS

Provide products certified to meet indoor air quality requirements by **UL 2818**(Greenguard) Gold, **SCS** Global Services Indoor Advantage Gold or provide certification by other third-party programs. Provide current product certification documentation from certification body.

1.8 DELIVERY, STORAGE, AND HANDLING

1.8.1 Delivery

Deliver materials to the project 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

Deliver materials in sufficient quantity to allow continuity of the work.

1.8.2 Storage and Handling

Store and handle materials in accordance with manufacturer's printed instructions. Protect from damage, exposure to open flame or other ignition sources, wetting, condensation, and moisture absorption. Keep materials wrapped and separated from off-gassing materials (such as drying paints and adhesives). Do not use materials that have visible moisture or biological growth. Store in an enclosed building or trailer that provides a dry, adequately ventilated environment. Replace damaged material with new material.

1.9 ENVIRONMENTAL CONDITIONS

Do not install roof insulation during inclement weather or when air temperature is below **40 degrees F** and interior humidity is 45 percent or greater, or when there is visible ice, frost, or moisture on the roof deck.

1.10 PROTECTION

1.10.1 Completed Work

Cover completed work with cover board for the duration of construction. Avoid traffic on completed work particularly when ambient temperature is above **80 degrees F**. Replace crushed or damaged insulation prior to roof surface installation.

PART 2 PRODUCTS

2.1 INSULATION

2.1.1 Insulation Types

Provide one, or an assembly of a maximum of three, of the following roof insulation materials. Provide roof insulation that is compatible with attachment methods for the specified insulation and roof membrane.

- a. Polyisocyanurate Board (Flat and tapered): Provide in accordance with ASTM C1289 Type II, Class 1 fibrous felt or glass mat membrane both sides, except minimum compressive strength of 20 pounds per square inch (psi).
- b. Cellular Glass Boards: ASTM C552, Type IV.

2.1.2 Recycled Materials

Provide thermal insulation materials containing recycled content. Unless specified otherwise, the minimum required recycled content for listed materials are:

Perlite Composition Board:	75 percent postconsumer paper
Polyisocyanurate/polyurethane:	9 percent recovered material
Wood Fiberboard:	100 percent recovered material
Cellular Glass Insulation:	75 percent recovered content
Structural Fiberboard:	100 percent recovered content
Fiberglass Insulation:	25 percent recovered content
Fiber (felt) or Fiber composite:	75 percent recovered content
Rubber:	90 percent recovered content
Plastic or Plastic/Rubber composite:	90 percent recovered content
Wood/Plastic Composite:	90 percent total recovered content

Provide data identifying percentage of recycled content for insulation.

2.1.3 Indoor Air Quality

Provide certification of indoor air quality for insulation.

2.1.4 Insulation Thickness

As necessary to provide the thermal resistance (R-value) indicated for average thickness of tapered system. Base calculation on the R-value for aged insulation.

2.1.5 Tapered Roof Insulation

One layer of the tapered roof insulation assembly must be factory tapered to a slope of not less than one in 1/2 inch per foot. Factory fabricate mitered joints from two diagonally cut boards or one board shaped to provide required slopes.

2.2 COVER BOARD

For use as a cover board for adhesive-applied roofing membrane over roof insulation.

2.2.1 Glass Mat Gypsum Roof Board

ASTM C1177/C1177M, 0 Flame Spread and 0 Smoke Developed when tested in accordance with ASTM E84, 500 psi, Class A, non-combustible, 1/2 inch thick, 4 by 4 feet board size Basis of design; DensDeck Prime.

2.3 FASTENERS

2.3.1 Fasteners for Steel Decks

Approved hardened penetrating fasteners or screws in accordance with FM 4450 and listed in FM APP GUIDE for Class I roof deck construction. Quantity and placement to withstand a minimum uplift pressure of 90 psf in accordance with FM APP GUIDE.

PART 3 EXECUTION

3.1 EXAMINATION AND PREPARATION

3.1.1 Surface Inspection

Ensure surfaces are clean, smooth, and dry prior to application. Check roof deck surfaces, including surfaces sloped to roof drains and outlets, for defects before starting work.

The Contractor must inspect and approve the surfaces immediately before starting installation. Prior to installing insulation, perform the following:

- a. 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.
- b. Prior to installing any roof system on a concrete deck, moisture test the deck in accordance with ASTM D4263. The deck is acceptable for roof system application when there is no visible moisture on underside of plastic sheet after 24 hours.

3.1.2 Surface Preparation

Correct defects and inaccuracies in roof deck surface to eliminate poor drainage from hollow or low spots, perform the following:

- a. Cover steel decks with a layer of protection board of sufficient width to span the width of a deck rib opening, and in accordance with fire safety requirements. Secure with piercing or self-drilling, self-tapping fasteners of quantity and placement in accordance with

FM APP GUIDE. Locate **protection board** joints parallel to ribs of deck on solid bearing surfaces only, not over open ribs.

- b. Solidly apply asphalt primer to concrete decks at the rate of **1 gallon per 100 square feet** of roof surface . Allow primer to dry thoroughly. Place felt strips, **4 inches** or more in width, over joints, **2 inches** on each side, between precast concrete units in a heavy coating of cold-applied asphalt roof cement.

3.2 INSULATION INSTALLATION

Apply insulation in two layers with staggered joints when total required thickness of insulation exceeds **1/2 inch**. Lay insulation so that continuous longitudinal joints are perpendicular to direction of roofing, as specified in Section **07 54 23 Thermo Plastic Polyolefin (TPO) Roofing** , and end joints of each course are staggered with those of adjoining courses. When using multiple layers of insulation, provide joints of each succeeding layer that are parallel and offset in both directions with respect to the layer below. Keep insulation **1/2 inch** clear of vertical surfaces penetrating and projecting from roof surface. Verify required slopes to each roof drain.

3.2.1 Special Precautions for Installation of Foam Insulation

3.2.1.1 Polyisocyanurate Insulation

Where polyisocyanurate foam board insulation is provided, install **1/2 inch** thick glass mat gypsum roof board, over top surface of foam board insulation. Stagger joints of insulation with respect to foam board insulation below.

3.2.2 Cant Strips

When recommended by manufacturer, provide cant strips at intersections of roof with walls, parapets, and curbs extending above roof. Wood cant strips must bear on and be anchored to wood blocking. Fit cant strips flush to vertical surfaces. Where possible, nail cant strips to adjoining surfaces. Where cant strips are installed against non-nailable materials, install in an approved adhesive.

3.2.3 Tapered Edge Strips

Where indicated, provide edge strips in the right angle formed by the juncture of roof and wood nailing strips that extend above the level of the roof. Install edge strips flush to vertical surfaces of wood nailing strips. Where possible, nail edge strips to adjoining surfaces. Where installed against non-nailable materials, install in an approved adhesive.

3.3 PROTECTION

3.3.1 Protection of Applied Insulation

Completely cover each day's installation of insulation with finished roofing specified in **07 54 23 THERMOPLASTIC POLYOLEFIN (TPO) ROOFING** on same day. Phased construction is not permitted. 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. Storing, walking, wheeling, or trucking directly on insulation or on roofed surfaces is not permitted. Provide smooth, clean board or

plank walkways, runways, and platforms near supports, as necessary, to distribute weight in accordance with indicated live load limits of roof construction. Protect exposed edges of insulation with cutoffs at the end of each work day or whenever precipitation is imminent. Cutoffs must be installed as described under temporary protection in section 07 54 23 THERMOPLASTIC POLYOLEFIN (TPO) ROOFING. Fill all profile voids in cutoffs to prevent trapping moisture below the membrane. Remove cutoffs when work resumes.

3.3.2 Damaged Work and Materials

Restore work and materials that become damaged during construction to original condition or replace with new materials.

3.4 INSPECTION

Establish and maintain inspection procedures to assure compliance of the installed roof insulation with contract requirements. Remove, replace, correct in an approved manner, any work found not in compliance. Quality control must include, but is not 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 Data Sheets. (<https://www.fmglobal.com/fmgglobalregistration/Downloads.aspx>)
- 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.
- j. Verification of required slope to each roof drain.

-- End of Section --

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SECTION 07 27 19.01

SELF-ADHERING AIR BARRIERS

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 BARRIER ASSOCIATION OF AMERICA (ABAA)

ABAA Accreditation

Accreditation

ABAA QAP

Quality Assurance Program

ASTM INTERNATIONAL (ASTM)

ASTM D146/D146M

(2004; E 2012; R 2012) Sampling and Testing Bitumen-Saturated Felts and Woven Fabrics for Roofing and Waterproofing

ASTM D412

(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension

ASTM D570

(1998; E 2010; R 2010) Standard Test Method for Water Absorption of Plastics

ASTM D903

(1998; R 2017) Standard Test Method for Peel or Stripping Strength of Adhesive Bonds

ASTM D1876

(2008; R 2015; E 2015) Standard Test Method for Peel Resistance of Adhesives (T-Peel Test)

ASTM D4263

(1983; R 2018) Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method

ASTM D4541

(2017) Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

ASTM E84

(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

ASTM E96/E96M

(2016) Standard Test Methods for Water Vapor Transmission of Materials

ASTM E154/E154M

(2008a; R 2013; E 2013) Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground

Cover

ASTM E283	(2019) Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E331	(2000; R 2016) Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
ASTM E2178	(2021a) Standard Test Method for Air Permeance of Building Materials
ASTM E2357	(2017) Standard Test Method for Determining Air Leakage of Air Barrier Assemblies

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 285	(2012) Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components

1.2 RELATED REQUIREMENTS

Provide a complete building air barrier system. Submit all materials, components, and assemblies of the air barrier system together as one complete submittal package.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" classification. Submittals not having a "G" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualifications of Manufacturer; G

Qualifications of Installer; G

SD-02 Shop Drawings

Self-adhering Air Barrier; G

SD-03 Product Data

Self-adhering Air Barrier; G

Primers, Adhesives, and Mastics; G

Safety Data Sheets; G

SD-04 Samples

Self-adhering Air Barrier Mockup; G

SD-06 Test Reports

Field Peel Adhesion Test; G

Flame Propagation of Wall Assemblies; G

Flame Spread and Smoke Developed Index Ratings; G

Site Inspections and Testing; G

SD-07 Certificates

Self-adhering Air Barrier; G

SD-08 Manufacturer's Instructions

Self-adhering Air Barrier; G

Primers, Adhesives, and Mastics; G

1.4 MISCELLANEOUS REQUIREMENTS

For [self-adhering air barrier](#) provide the following:

1.4.1 Shop Drawings

Submit self-adhering air barrier shop drawings showing locations and extent of air barrier assemblies and details of all typical conditions, intersections with other building enclosure assemblies and materials, and membrane counterflashings. Show details for bridging of gaps in construction, treatment of inside and outside corners, expansion joints, methods of attachment of materials covering the self-adhered barrier without compromising the barrier. Indicate how miscellaneous penetrations such as conduit, pipes, electric boxes, brick ties, and similar items will be sealed.

1.4.2 Product Data

Submit manufacturer's technical data indicating compliance with performance and environmental requirements, manufacturer's printed instructions for evaluating, preparing, and treating substrates, temperature and other limitations of installation conditions, safety requirements for installation, and [Safety Data Sheets](#). Indicate flame and smoke spread ratings for all products.

1.4.3 Mockup

Provide a mockup of the self-adhering air barrier system specified. Apply product in an area designated by the Contracting Officer. Apply an area of not less than [54 square feet](#). Include all components specified as representative of the complete system. Notify the Contracting Officer a minimum of 48 hours prior to the test application. Select a test area representative of conditions to be covered including window or door openings, wall to ceiling transitions, flashings, and penetrations, as applicable.

1.4.4 Test Reports

Submit test reports indicating that field peel-adhesion tests on all materials have been performed and the changes made, if required, in order to achieve successful and lasting adhesion. Submit test reports for [flame propagation of wall assemblies](#) tested in accordance with [NFPA 285](#). Submit test reports for [flame spread and smoke developed index ratings](#) of barrier system materials tested in accordance with [ASTM E84](#).

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Deliver and store materials in sufficient quantity to allow for uninterrupted flow of work. Inspect materials delivered to the site for damage and store out of weather. Deliver materials to the jobsite in their original unopened packages, clearly marked with the manufacturer's name, brand designation, description of contents, and shelf life of containerized materials. Store and handle to protect from damage.

1.5.2 Storage

Inspect materials delivered to the site for damage; unload and store out of weather in manufacturer's original packaging. Store only in dry locations, not subject to open flames or sparks, and easily accessible for inspection and handling. Protect stored materials from direct sunlight. Keep materials sealed and separated from absorptive materials, such as wood and insulation.

1.6 FIELD PEEL ADHESION TEST

Perform a [field peel-adhesion test](#) on the construction mockup. Test the self-adhering air barrier for adhesion in accordance with [ASTM D4541](#) using a Type II pull tester except use a disk that is [4 inches](#) in diameter and cut through the membrane to separate the material attached to the dish from the surrounding material. Perform test after curing period in accordance with manufacturer's written recommendations. Record mode of failure and area which failed in accordance with [ASTM D4541](#). Compare adhesion values with the manufacturer's established minimum values for the particular combination of material and substrate. Indicate on the inspection report whether the manufacturer's requirement has been met. Where the manufacturer has not declared a minimum adhesion value for their product and substrate combination, the inspector must record actual values.

1.7 QUALITY ASSURANCE

1.7.1 [Qualifications of Manufacturer](#)

Submit documentation verifying that the manufacturer of the self-adhering air barrier is currently accredited by Air Barrier Association of America ([ABAA Accreditation](#) <https://www.airbarrier.org/>).

1.7.2 [Qualifications of Installer](#)

Submit documentation verifying that installers of the self-adhering air barrier are currently certified in accordance with the [ABAA QAP](#) Quality Assurance Program (<https://www.airbarrier.org/qap/>).

1.8 PRECONSTRUCTION MEETING

Conduct a preconstruction meeting a minimum of two weeks prior to commencing work specified in this Section. Agenda must include, at a minimum, construction and testing of mockup, sequence of construction, coordination with substrate preparation, materials approved for use, compatibility of materials, coordination with installation of adjacent and covering materials, and details of construction. Attendance is required by representatives of related trades including covering materials, substrate materials, adjacent materials, and materials and components of the air barrier system.

1.9 ENVIRONMENTAL CONDITIONS

1.9.1 Temperature

Install air barrier within the range of ambient and substrate temperatures as recommended in writing by the air barrier manufacturer. Verify that the surface to receive self-adhering air barrier is dry for a minimum of 48 hours prior to the installation of the barrier. Do not apply air barrier to damp or wet substrates. Do not apply during inclement weather or when ice, frost, surface moisture, or visible dampness is present on surfaces to be covered, or when precipitation is imminent.

1.9.2 Exposure to Weather and Ultraviolet Light

Protect air barrier products from direct exposure to rain, snow, sunlight, mist, and other extreme weather conditions. Replace, at no additional cost to the government, barrier products that have been exposed to ultraviolet (sun)light longer than allowed by manufacturer's written requirements.

PART 2 PRODUCTS

2.1 SELF ADHERING AIR BARRIER

Provide minimum 0.040 inch thick self-adhering, vapor permeable, air barrier membrane consisting of a cross-laminated high density polyethylene (HDPE) film, fully coated with rubberized asphalt adhesive. Provide membrane in rolls of various widths interleaved with disposable silicone release paper. Self-adhering air barrier must exhibit no visible water leakage when tested in accordance with ASTM E331 and must perform as a liquid water drainage plane flashed to discharge to the exterior any incidental condensation or water penetration. Use regular or low temperature formulation depending on site conditions, within temperature ranges specified by manufacturer.

2.1.1 Physical Properties

- a. Air Permeance (ASTM E2178):
- b. Air Leakage (ASTM E2357, ASTM E283):
- c. Tensile Strength (ASTM D412 die C modified): Not less than 400 psi.
- d. Tensile Elongation (ASTM D412 die C modified): Not less than 200 percent.
- e. Puncture Resistance (ASTM E154/E154M): Not less than 40 lbs.

- f. Pliability (ASTM D146/D146M): Unaffected at minus 25 degrees F, 0.063 inch mandrel.
- g. Lap Adhesion (ASTM D1876 modified): Not less than 4.0 lbs per inch.
- h. Peel Adhesion (ASTM D903): Not less than 5.0 lbs per inch.
- i. Water Vapor Permeance (Vapor Permeable Air Barrier) (ASTM E96/E96M, desiccant method B): greater than 10.0 perms.
- j. Water Absorption (ASTM D570): Not to exceed 0.12 percent by weight.
- k. Flame propagation of wall assemblies (NFPA 285): Pass
- l. Surface Burning Characteristics (ASTM E84):
 - (1) Flame Spread Index Rating not higher than 75.
 - (2) Smoke Developed Index Rating not higher than 150.

2.2 PRIMERS, ADHESIVES, AND MASTICS

Provide primers, adhesives, mastics and other accessory materials as recommended in writing by the manufacturer of the self-adhering air barrier for adequate bonding to each type of substrate.

2.3 SHEET METAL FLASHING

Provide as specified in Section 07 60 00 FLASHING AND SHEET METAL.

2.4 JOINT SEALANTS

Provide as specified in Section 07 92 00 JOINT SEALANTS. Verify compatibility with adjacent products that are or will be in contact with one another.

PART 3 EXECUTION

3.1 EXAMINATION

Before installing air barrier, examine substrates, areas, and conditions under which air barrier assemblies will be applied, with Installer present, for compliance with requirements. Ensure the following conditions are met:

- a. Surfaces are sound, dry, even, and free of oil, grease, dirt, excess mortar or other contaminants.
- b. Concrete surfaces are cured and dry, smooth without large voids, spalled areas or sharp protrusions.
- c. Verify substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method in accordance with ASTM D4263 and take suitable measures until substrate passes moisture test.
- d. Verify sealants used in sheathing are compatible with membrane proposed for use. Perform field peel adhesion test on materials to

which sealants are adhered.

3.2 PREPARATION

Clean, prepare, and treat substrate in accordance with manufacturer's written instructions. Ensure clean, dust-free, and dry substrate for air barrier application.

- a. Prime masonry and concrete substrates with conditioning primer.
- b. Prime gypsum sheathing an adequate number of coats to achieve required bond, with adequate drying time between coats.
- c. Prime wood, metal, and painted substrates with primer.
- d. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through air barrier and at protrusions.

3.3 INSTALLATION

3.3.1 Installation of Self-adhering Air Barrier

Install materials in accordance with manufacturer's recommendations and the following:

- a. Apply primer at rate recommended by manufacturer prior to membrane installation. Allow primer to dry completely before membrane application. Apply as many coats as necessary for proper adhesion.
- b. When membrane is properly positioned, press into place and roll membrane with roller immediately after placement.
- c. Apply membrane sheets to shed water naturally without interception by a sheet edge, unless that edge is sealed with permanently flexible termination mastic.
- d. Position subsequent sheets of membrane applied above so that membrane overlaps the membrane sheet below by a minimum of **2-1/2 inches**, unless greater overlap is recommended by manufacturer. Roll into place with roller.
- e. Make all side laps a minimum of **2-1/2 inches** and all end laps a minimum of **5 inches**, unless greater overlap is recommended by manufacturer. Roll seams with roller.
- f. Roll membrane to adhere to substrate. Cover corners and joints with two layers of reinforcement by first applying a **12 inch** width of membrane centered along the axis. Flash drains and projections with a second ply of membrane for a distance of **6 inches** from the drain or projection.
- g. Seal around all penetrations through the air barrier resulting from pipes, vents, conduit, electrical fixtures, structural members, or other construction passing through it. Seal with termination mastic, extruded silicone sealant, membrane counterflashing or other sealing methods in accordance with manufacturer's written recommendations.
- h. Continuously connect the air barrier between walls, roof, floor and below grade assemblies to form a continuous integrated air barrier

system around the entire building enclosure. Extend the air barrier membrane into rough openings such as doors, windows, louvers, and other exterior penetrations. Seal edges of barrier at junctures with rough openings.

- i. At changes in substrate plane, provide transition material (e.g. bead of sealant, mastic, extruded silicone sealant, membrane counterflashing or other material recommended by manufacturer) under membrane to eliminate all sharp 90 degree inside corners and to make a smooth transition from one plane to another.
- j. Provide mechanically fastened non-corrosive metal sheet to span gaps in substrate plane and to make a smooth transition from one plane to the other. Continuously support membrane with substrate.
- k. At deflection and control joints, provide backup for the membrane to accommodate anticipated movement.
- l. At expansion and seismic joints provide transition to the joint assemblies.
- m. Apply a bead or trowel coat of mastic along membrane seams at reverse lapped seams, rough cuts, and as recommended by the manufacturer.
- n. At end of each working day, seal top edge of membrane to substrate with termination mastic.
- o. Do not allow materials to come in contact with chemically incompatible materials.
- p. Counterflash upper edge of thru-wall flashing and air barrier. Counter flashing and thru-wall flashing are specified in Section 07 60 00 FLASHING AND SHEET METAL.

3.4 FIELD QUALITY CONTROL

3.4.1 Site Inspections and Testing

Provide site inspections and testing in accordance with ABAA protocol to verify conformance with the manufacturer's instructions, the ABAA QAP Quality Assurance Program (<https://www.airbarrier.org/qap/>) and this section.

- a. Conduct inspections and testing at 5, 50, and 95 percent completion of this scope of work. Forward written site inspections and testing reports to the Contracting Officer within five working days of the inspection and test being performed.
- b. If inspections reveal any defects, promptly remove and replace defective work at no additional expense to the Government.

3.5 FIELD PEEL ADHESION TEST

Conduct in accordance with test protocol indicated in Part 1, paragraph FIELD PEEL ADHESION TEST.

3.6 PROTECTION AND CLEANING

3.6.1 Protection

3.6.1.1 Adjacent Surfaces

Protect exposed adjacent surfaces that could be damaged by primers and adhesives associated with air barrier membrane. Provide protection during application and the remainder of construction in accordance with manufacturer's written instructions.

3.6.1.2 The Air Barrier Assembly

Protect finished portions of the air barrier assembly from damage during ongoing application and throughout the remainder of the construction period in accordance with manufacturer's written instructions. Coordinate timing of installation of materials that will cover the air barrier membrane to ensure the exposure period does not exceed that recommended by the air barrier manufacturer's written installation instructions. Remove and replace, at no additional cost to the government, membrane products that exceed the manufacturer's allowed exposure limits.

3.6.2 Cleaning

Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction and as acceptable to the primary material manufacturer.

-- End of Section --

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SECTION 07 27 26

FLUID-APPLIED MEMBRANE AIR BARRIERS

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 BARRIER ASSOCIATION OF AMERICA (ABAA)

ABAA Accreditation

Accreditation

ABAA QAP

Quality Assurance Program

ASTM INTERNATIONAL (ASTM)

ASTM C836/C836M

(2015) High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use With Separate Wearing Course

ASTM D412

(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension

ASTM D4263

(1983; R 2018) Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method

ASTM D4541

(2017) Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

ASTM D5590

(2000; R 2010; E 2012) Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay

ASTM E84

(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

ASTM E96/E96M

(2021) Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials

ASTM E283

(2019) Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

ASTM E331 (2000; R 2016) Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference

ASTM E2178 (2021a) Standard Test Method for Air Permeance of Building Materials

ASTM E2357 (2017) Standard Test Method for Determining Air Leakage of Air Barrier Assemblies

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 285 (2012) Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components

1.2 RELATED REQUIREMENTS

Coordinate the requirements of other building enclosure sections to provide a complete building air barrier system. Submit all materials, components and assemblies of the air barrier system together as one complete submittal package.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualifications of Manufacturer; G

Qualifications of Installer; G

SD-02 Shop Drawings

Fluid-Applied Membrane Air Barrier; G

SD-03 Product Data

Fluid-Applied Membrane Air Barrier; G

Transition Membrane; G

Primers, Adhesives, and Mastics; G

Reinforcement; G

Safety Data Sheets; G

SD-04 Samples

Fluid-Applied Membrane Air Barrier Mockup; G

SD-06 Test Reports

Capillary Moisture Test; G

Field Peel Adhesion Test; G

Flame Propagation of Wall Assemblies; G

Flame Spread and Smoke Developed Index Ratings; G

Site Inspections Reports; G

SD-07 Certificates

Fluid-Applied Membrane Air Barrier; G

Transition Membrane; G

SD-08 Manufacturer's Instructions

Fluid-Applied Membrane Air Barrier; G

Transition Membrane; G

Primers, Adhesives, and Mastics; G

1.4 MISCELLANEOUS REQUIREMENTS

For [fluid-applied membrane air barriers](#) provide the following:

1.4.1 Shop Drawings

Submit fluid-applied membrane air barrier shop drawings showing locations and extent of barrier assemblies, transition membranes, details of all typical conditions, intersections with other envelope assemblies and materials, and membrane counterflashings. Show details for bridging of gaps in construction, treatment of inside and outside corners, expansion joints, methods of attachment of materials covering the self-adhered barrier without compromising the barrier. Indicate how miscellaneous penetrations such as conduit, pipes, electric boxes, brick ties, and similar items will be sealed.

1.4.2 Product Data

Submit manufacturer's technical data indicating compliance with performance and environmental requirements, manufacturer's printed instructions for evaluating, preparing, and treating substrates, temperature and other limitations of installation conditions, safety requirements for installation, and [Safety Data Sheets](#). Indicate flame and smoke spread ratings for all products.

1.4.3 Mockup

Provide a mockup of the fluid-applied membrane air barrier. Apply product in an area designated by the Contracting Officer. Apply an area of not less than [54 square feet](#). Include all components specified as representative of the complete system. Notify the Contracting Officer a minimum of 48 hours prior to the test application. Select a test area

representative of conditions to be covered including window or door openings, wall to ceiling transitions, flashings, and penetrations, as applicable.

1.4.4 Test Reports

Submit test reports indicating that capillary moisture tests and [field peel adhesion tests](#) on all substrate materials have been performed and the changes made, if required, in order to achieve successful and lasting adhesion. Submit test reports for [flame propagation of wall assemblies](#) tested in accordance with [NFPA 285](#). Submit test reports for [flame spread and smoke developed index ratings](#) of barrier materials tested in accordance with [ASTM E84](#).

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Deliver and store materials in sufficient quantity to allow for uninterrupted flow of work. Inspect materials delivered to the site for damage and store out of weather. Deliver materials to the jobsite in their original unopened packages, clearly marked with the manufacturer's name, brand designation, description of contents, and shelf life of containerized materials. Store and handle to protect from damage.

1.5.2 Storage

Inspect materials delivered to the site for damage; unload and store out of weather in manufacturer's original packaging. Store only in dry locations, not subject to open flames or sparks, and easily accessible for inspection and handling. Protect stored materials from direct sunlight.

1.6 CAPILLARY MOISTURE TEST

Perform a [capillary moisture test](#) by plastic sheet method in accordance with [ASTM D4263](#) on the construction mockup and substrate materials. Perform test after curing period as recommended by the air barrier manufacturer. Record mode of failure and area which failed in accordance with [ASTM D4263](#). Once the air barrier material manufacturer has established a minimum adhesion or moisture level for the product on the particular substrate, indicate on the inspection report whether this requirement has been met. Where the manufacturer has not declared a minimum adhesion or moisture value for their product and substrate combination, the inspector must record actual values.

1.7 FIELD PEEL ADHESION TEST

Perform a field peel adhesion test on a construction mockup. Test the applied product for adhesion in accordance with manufacturer's recommendations. Perform test after curing period recommended by the manufacturer. Record mode of failure and area which failed in accordance with [ASTM D4541](#). When the manufacturer has established a minimum adhesion level for the product on the particular substrate, the inspection report must indicate whether this requirement has been met. Where the manufacturer has not declared a minimum adhesion value for their product/substrate combination, the inspector must record actual values.

1.8 QUALITY ASSURANCE

1.8.1 Qualifications of Manufacturer

Submit documentation verifying that manufacturer of fluid-applied membrane air barrier is currently accredited by the Air Barrier Association of America (ABAA Accreditation <https://www.airbarrier.org/>).

1.8.2 Qualifications of Installer

Submit documentation verifying that installers of the fluid-applied membrane air barrier are currently certified in accordance with the ABAA QAP Quality Assurance Program (<https://www.airbarrier.org/qap/>).

1.9 PRECONSTRUCTION MEETING

Conduct a preconstruction meeting a minimum of two weeks prior to commencing work specified in this Section. Agenda must include, at a minimum, construction and testing of construction mock up, sequence of construction, coordination with substrate preparation, materials approved for use, compatibility of materials, coordination with installation of adjacent and covering materials, and details of construction. Attendance is required by representatives of related trades including covering materials, substrate materials, adjacent materials, and materials and components of the fluid-applied membrane air barrier.

1.10 ENVIRONMENTAL CONDITIONS

1.10.1 Temperature

Install fluid-applied membrane air barrier within the range of ambient and substrate temperatures as recommended in writing by the fluid-applied membrane air barrier manufacturer. Do not apply fluid-applied membrane air barrier to a damp or wet substrate. Do not apply during inclement weather or when ice, frost, surface moisture, or visible dampness is present on surfaces to be covered, or when precipitation is imminent.

1.10.2 Exposure to Weather

Protect fluid-applied membrane air barrier products from direct exposure to rain, snow, sunlight, mist, and other extreme weather conditions. Replace, at no additional cost to the government, barrier products that have been exposed to ultraviolet (sun)light longer than allowed by manufacturer's written requirements.

PART 2 PRODUCTS

2.1 FLUID-APPLIED MEMBRANE AIR BARRIER

Provide a fluid-applied, vapor permeable, air barrier. This barrier must exhibit no visible water leakage when tested in accordance with ASTM E331 and must perform as a liquid water drainage plane with thru-wall flashing to discharge incidental condensation and water penetration to the exterior of the building enclosure. Provide products suitable for use within temperature ranges specified by manufacturer for the location of the project.

2.1.1 Physical Properties

- a. Air Permeance (ASTM E2178): less than 0.004 CFM per sf at 1.57 psf.
- b. Air Leakage (ASTM E2357, ASTM E283): Less than 0.04 CFM per sf at 1.57 psf at one inch.
- c. Water Vapor Permeance (Vapor Permeable Membrane) (ASTM E96/E96M, desiccant method A): 10.0 perms.
- d. Tensile Strength (ASTM D412): Not less than 138 psi.
- e. Elongation (ASTM D412): Not less than 300 percent.
- f. Low temperature Flexibility and Crack Bridging (ASTM C836/C836M): Pass at minus 15 degrees F.
- g. Solids by Volume: minimum 50 percent.
- h. Flame propagation of wall assemblies (NFPA 285): Pass
- i. Surface Burning Characteristics (ASTM E84):
 - (1) Flame Spread Index Rating not higher than 25.
 - (2) Smoke Developed Index Rating not higher than 150.
- j. Resistance to Mold, Mildew and Fungal Growth (ASTM D5590): 0, No growth.

2.2 PRIMERS, ADHESIVES, AND MASTICS

Provide primers, adhesives, mastics, sealants and other accessories as recommended by manufacturer of fluid-applied membrane air barrier for a complete installation.

2.3 TRANSITION MEMBRANE

Provide as specified in Section 07 27 19.01 SELF-ADHERING AIR BARRIERS and as recommended by manufacturer.

2.4 SHEET METAL FLASHING

Provide as specified in Section 07 60 00 FLASHING AND SHEET METAL.

2.5 JOINT SEALANTS

Provide as specified in Section 07 92 00 JOINT SEALANTS and as recommended by manufacturer.

2.6 REINFORCEMENT

Provide fiberglass mesh tape, or fluid-applied air barrier manufacturer's approved comparable equal product, reinforcement at seams, edges, projections and penetrations. Reinforce all joints exceeding 1/4 inch with fiberglass mesh.

PART 3 EXECUTION

3.1 EXAMINATION

Before installing fluid-applied membrane air barrier, examine substrates, areas, and conditions under which fluid-applied membrane air barrier assemblies will be applied, with installer present, for compliance with requirements. Ensure the following conditions are met:

- a. Surfaces are sound, dry, even, and free of oil, grease, dirt, excess mortar or other contaminants detrimental to the adhesion of the membranes.
- b. Concrete and masonry surfaces are cured and dry, smooth without large voids, spalled areas or sharp protrusions. Do not proceed with installation until after minimum concrete curing period recommended by fluid-applied membrane air barrier manufacturer.
- c. Fill voids, gaps and spalled areas in substrate to provide an even plane. Strike masonry joints full flush.
- d. Verify substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method in accordance with [ASTM D4263](#) and take suitable measures until substrate passes moisture test.
- e. Verify sealants used in substrates, and in joints between substrates, are compatible with fluid-applied membrane air barrier.

3.2 PREPARATION

Clean, prepare, and treat substrate in accordance with manufacturer's written instructions. Ensure clean, dust-free, and dry substrate for fluid-applied membrane air barrier application.

- a. Remove dust, dirt and other contaminants from joints and cracks before coating surfaces.
- b. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through fluid-applied membrane air barrier.
- c. At changes in substrate plane, provide transition material (bead of sealant, mastic, extruded silicone sealant, membrane counterflashing or other material recommended by manufacturer) under transition membrane to eliminate all sharp 90 degree inside corners and to make a smooth transition from one plane to another.
- d. Provide mechanically fastened non-corrosive metal sheet to span gaps in substrate plane and to make a smooth transition from one plane to the other. Continuously support membrane with substrate.
- e. For exterior sheathing substrates, ensure that exterior sheathing is stabilized, with corners and edges fastened with appropriate screws. Treat all joints in accordance with the air barrier manufacturer's instructions prior to application of air barrier material. Allow sufficient time for joint treatments to fully cure before application of transition membranes and fluid-applied membrane air barrier.

- f. For concrete and masonry substrates, fill all voids and holes, particularly in mortar joints, with non-shrinking grout.
- g. Mask off and cover adjacent surfaces to protect from spillage and overspray.

3.3 INSTALLATION

3.3.1 Installation of Transition Membrane

Install transition membrane materials in accordance with the details on the drawings, Section 07 27 19.01 SELF-ADHERING AIR BARRIERS, and the following:

- a. Install transition membrane at all required locations prior to installation of the fluid-applied membrane air barrier.
- b. Verify transition membrane is fully adhered to substrate and that its surface is clean, dry and wrinkle free prior to installation of the fluid-applied membrane air barrier.
- c. Verify transition membrane completely covers all transition areas and will provide continuity of the finished fluid-applied membrane air barrier without gaps or cracks.
- d. Install in accordance with manufacturer's recommended details and requirements.

3.3.2 Installation of Flashing

Counterflash upper edge of thru-wall flashing and fluid-applied air barrier. Counter flashing and thru-wall flashing are specified in Section 07 60 00 FLASHING AND SHEET METAL.

3.3.3 Installation of Fluid-Applied Membrane Air Barrier

Install materials in accordance with manufacturer's recommendations and the following:

- a. Apply fluid-applied membrane air barrier in single or dual coat application by spray or roller. Apply fluid-applied membrane air barrier within manufacturer's recommended temperature range for application.
- b. Apply fluid-applied membrane air barrier in manner and at rate and wet film thickness recommended by manufacturer to yield a finished dry film thickness of not less than 40 mils or as otherwise required by the manufacturer for the application substrate material and surface roughness..
- c. Apply fluid-applied membrane air barrier around all penetrations ensuring a complete and continuous air barrier. Lap fluid-applied membrane air barrier a minimum of 3 inch over transition membrane to seal leading edge.
- d. Seal membrane terminations, heads of mechanical fasteners, masonry tie fasteners, around penetrations, HVAC assemblies, plumbing and electrical assemblies, doors, windows, louvers, and other assemblies penetrating the fluid-applied membrane air barrier with a termination

sealant recommended by the fluid-applied membrane air barrier manufacturer.

- e. Notify the Contracting Officer and Testing Agency upon completion of fluid-applied membrane air barrier installation. Air barrier materials and assemblies must remain exposed until tested and inspected by the ABAA.
- f. Do not allow materials to come in contact with chemically incompatible materials.

3.3.4 Installation of Reinforcement

Install reinforcement at projections, corners, joints, and penetrations where applicable.

3.4 FIELD QUALITY CONTROL

3.4.1 Site Inspections and Testing

Provide site inspections and testing in accordance with ABAA protocol to verify conformance with the manufacturer's instructions, the ABAA QAP Quality Assurance Program (<https://www.airbarrier.org/qap/>), and this section.

- a. Conduct inspections and testing at 5, 50, and 95 percent completion of this scope of work. Forward written inspection reports to the Contracting Officer within five working days of the inspection and test being performed.
- b. If the inspections reveal any defects, promptly remove and replace defective work at no additional expense to the Government.

3.5 PROTECTION AND CLEANING

3.5.1 Protection

Protect fluid-applied membrane air barrier assemblies from damage during application and remainder of construction in accordance with manufacturer's written instructions.

Coordinate installation, testing, and inspection procedures to ensure exposure period does not exceed that recommended by the product manufacturer. Remove and replace, at no additional cost to the government, membrane products that exceed manufacturer's allowed exposure limits.

3.5.2 Cleaning of Adjacent Surfaces

Clean excess product from adjacent construction using cleaning agents and procedures as recommended in writing by the manufacturer of each type of affected construction and as acceptable to same.

3.6 CLEANUP OF SPILLS

Conduct cleanup of uncured product spillage in accordance with manufacturer's written safe handling instructions.

-- End of Section --

SECTION 07 54 23
THERMOPLASTIC POLYOLEFIN (TPO) ROOFING

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 NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/SPRI ES-1 (2003) Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7 (2010; Errata 2011; Supp 1 2013) Minimum Design Loads for Buildings and Other Structures

AMERICAN SOCIETY OF SAFETY ENGINEERS (ASSE/SAFE)

ASSE/SAFE A10.24 (2014) Roofing - Safety Requirements of Low-Sloped Roofs

ASPHALT ROOFING MANUFACTURER'S ASSOCIATION (ARMA)

ARMA PMBRG98 (1998) Quality Control Guideline for the Application of Polymer Modified Bitumen Roofing

ASTM INTERNATIONAL (ASTM)

ASTM E108 (2011) Fire Tests of Roof Coverings

ASTM D6878/D6878M (2021) Standard Specification for Thermoplastic Polyolefin-Based Sheet Roofing

FM GLOBAL (FM)

FM 4470 (2010) Single-Ply, Polymer-Modified Bitumen Sheet, Built-up Roof (BUR), and Liquid Applied Roof Assemblies for Use in Class 1 and Noncombustible Roof Deck Construction

FM APP GUIDE (updated on-line) Approval Guide
<http://www.approvalguide.com/>

NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA)

NRCA 3740 (2005) The NRCA Waterproofing Manual

UNDERWRITERS LABORATORIES (UL)

UL 790

(2004; Reprint Jul 2014) Standard Test
Methods for Fire Tests of Roof Coverings

1.2 SUMMARY

Fully Adhered thermoplastic polyolefin (TPO) roof membrane system applied over insulation substrate. Incorporate air barrier in the roof assembly as specified in Section 07 22 00 ROOF AND DECK INSULATION.

1.3 ASSEMBLY REQUIREMENTS

Roofing membrane sheet widths shall be consistent with membrane attachment methods and wind uplift requirements, and shall be as large as practical. In order to minimize joints and 3-way overlaps, prefabricated sheets are not accepted. Provide membrane which is free of defects and foreign material. Coordinate flashing work to permit continuous roof-surfacing operations. Insulation shall be applied and weatherproofed on the same day.

1.3.1 Fire Resistance

Complete roof system assembly:

- a. Class A rated in accordance with ASTM E108, FM 4470, or UL 790; and
- b. Be listed as Class I roof deck construction in FM APP GUIDE.

FM or UL approved components of the roof covering assembly shall bear the appropriate FM or UL label.

1.3.2 Wind Uplift Resistance

The complete roof system assembly shall be rated and installed to resist wind loads calculated in accordance with ASCE 7 and validated by uplift resistance testing in accordance with Factory Mutual (FM) test procedures. Do not install non-rated systems. e Submit Engineering calculations, signed, sealed, and dated by a Registered Engineer validating the wind resistance per ASCE 7, and ANSI/SPRI ES-1. Base wind uplift measurements on a design wind speed of as indicated in drawings in accordance with ASCE 7 and other applicable building code requirements.

1.3.3 Solar Reflectance Index (SRI)

SRI measures the roof's ability to reject solar heat, defined such that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. Use roofing materials having minimum appropriate SRI for more than 75 percent of roof surface (low slope (less than 2:12) SRI greater than 78.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" classification. Designation "G" shall be construed to require approval by both Government (G) and Architect-Engineer (AE), whether listed or not. Submittals not having a "G" classification are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G
Roof Plan; G

SD-03 Product Data

TPO Roofing Membrane; G
Bonding Adhesive
Flashing
Membrane Fasteners and Plates
Roof Insulation
Pre-Manufactured Accessories
Water Cutoffs
Information Card

SD-05 Design Data

Wind Uplift Resistance; G

SD-07 Certificates

Qualification of Manufacturer
Qualifications of Applicator
Qualification of Engineer of Record
Wind Uplift Resistance
Fire Resistance classification
Minimum Polymer Thickness
Sample Warranty; G

SD-08 Manufacturer's Instructions

Application Method; G
Membrane Flashing; G
Perimeter Attachment
Auxiliary Fasteners
Pre-Manufactured Accessories
Cold Weather; G

SD-11 Closeout Submittals

Warranty; G
Information Card; G
Instructions to Government Personnel; G

1.5 QUALITY ASSURANCE

1.5.1 Qualification of Manufacturer

Thermoplastic Polyolefin sheet roofing system manufacturer must have a minimum of 5 years experience in manufacturing TPO roofing products.

1.5.2 Qualifications of Applicator

Roofing system applicator must be approved, authorized, or licensed in writing by the TPO sheet roofing system manufacturer and have a minimum of five years experience as an approved, authorized, or licensed applicator with that manufacturer and be approved at a level capable of providing the specified warranty. Supply the names, locations and client contact

information of five projects, within the previous three years, of similar size and scope that the applicator has constructed using the manufacturer's roofing products submitted for this project.

1.5.3 Qualification of Engineer of Record

Engineer of Record must be currently licensed within the jurisdiction of the project.

1.5.4 Conformance and Compatibility

The entire roofing and flashing system shall be in accordance with specified and indicated requirements, including fire and wind resistance.

1.5.5 Preroofing Conference

After approval of submittals and before performing roofing and insulation system installation work, hold a preroofing conference to review the following:

- a. Roof system components installation;
- b. Procedure for the roof manufacturer's technical representative's onsite inspection and acceptance of the roofing substrate, and roofing substrate, the name of the manufacturer's technical representatives, the frequency of the onsite visits, distribution of copies of the inspection reports from the manufacturer's technical representative to roof manufacturer;
- c. Contractor's plan for coordination of the work of the various trades involved in providing the roofing system and other components secured to the roofing; and
- d. Quality control(ARMA PMBRG98) plan for the roof system installation;
- e. Safety requirements.

Coordinate preroofing conference scheduling with the Contracting Officer. The conference shall be attended by the Contractor, the Contracting Officer's designated personnel, personnel directly responsible for the installation of roofing and insulation, flashing and sheet metal work, mechanical and electrical work, other trades interfacing with the roof work, designated safety personnel trained to enforce and comply with ASSE/SAFE A10.24, Fire Marshall, and a representative of the roofing materials manufacturer. Before beginning roofing work, provide a copy of meeting notes and action items to all attending parties. Note action items requiring resolution prior to start of roof work.

1.6 DETAIL DRAWINGS

Submit roof plan depicting wind loads and boundaries of enhanced perimeter and corner attachments of roof system components, spacing of perimeter, corner, and infield fasteners, as applicable. The drawing shall reflect the project roof plan of each roof level and conditions indicated. Submit bids with approved detail drawings and specifications approved and furnished by the TPO membrane manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

1.7.1 Delivery

Deliver materials in the manufacturer's original, unopened containers and rolls with labels intact and legible. Mark and remove wet or damaged materials from the site. Where materials are covered by a referenced specification number, the container shall bear the specification number, type, class, and shelf life expiration date where applicable. Deliver materials in sufficient quantity to allow work to proceed without interruption.

1.7.2 Storage

Protect materials against moisture absorption and contamination or other damage. Avoid crushing or crinkling of roll materials. Store roll materials on end on clean raised platforms or pallets one level high in dry locations with adequate ventilation, such as an enclosed building or closed trailer. Do not store roll materials in buildings under construction until concrete, mortar, and plaster work is finished and dry. Maintain roll materials at temperatures above 50 degrees F for 24 hours immediately before application. Do not store materials outdoors unless approved by the Contracting Officer. Completely cover felts stored outdoors, on and off roof, with waterproof canvas protective covering. Do not use polyethylene sheet as a covering. Tie covering securely to pallets to make completely weatherproof. Provide sufficient ventilation to prevent condensation. Do not store more materials on roof than can be installed the same day and remove unused materials at end of each days work. Distribute materials temporarily stored on roof to stay within live load limits of the roof construction.

- a. Maintain a minimum distance of 35 foot for all stored flammable materials, including materials covered with shrink wraps, craft paper and/or tarps from all torch/welding applications.
- b. Immediately remove wet, contaminated or otherwise damaged or unsuitable materials from the site. Damaged materials may be marked by the Contracting Officer.

1.7.3 Handling

Prevent damage to edges and ends of roll materials. Do not install damaged materials in the work. Select and operate material handling equipment to prevent damage to materials or applied roofing.

1.8 ENVIRONMENTAL REQUIREMENTS

Do not install roofing system when air temperature is below 40 degrees F, during any form of precipitation, including fog, or when there is ice, frost, moisture, or any other visible dampness on the roof deck. Follow manufacturer's printed instructions for Cold Weather Installation.

1.9 SEQUENCING

Coordinate the work with other trades to ensure that components which are to be secured to or stripped into the roofing system are available and that permanent flashing and counterflashing in accordance with NRCA 3740, are installed as the work progresses. Ensure temporary protection measures are in place to preclude moisture intrusion or damage to

installed materials. Application of roofing shall immediately follow application of insulation as a continuous operation. Coordinate roofing operations with insulation work so that all roof insulation applied each day is covered with roof membrane installation the same day.

1.10 WARRANTY

Provide roof system material and workmanship warranties. Provide revision or amendment to standard membrane manufacturer warranty as required to comply with the specified requirements. Minimum manufacturer warranty shall have no dollar limit, cover full system water-tightness, and shall have a minimum duration of 20 years. Submit [sample](#) certificate.

1.10.1 Roof Membrane Manufacturer Warranty

Furnish the roof membrane manufacturer's 20-year, no dollar limit roof system materials and installation workmanship warranty, including flashing, insulation, and accessories necessary for a watertight roof system construction. Provide warranty directly to the Government and commence warranty effective date at time of Government's acceptance of the roof work. The warranty must state that:

- a. If within the warranty period the roof system, as installed for its intended use in the normal climatic and environmental conditions of the facility, becomes non-watertight, shows evidence of moisture intrusion within the assembly, splits, tears, cracks, delaminates, separates at the seams, or shows evidence of excessive weathering due to defective materials or installation workmanship, the repair or replacement of the defective and damaged materials of the roof system assembly and correction of defective workmanship are the responsibility of the roof membrane manufacturer. All costs associated with the repair or replacement work are the responsibility of the roof membrane manufacturer.
- b. When the manufacturer or his approved applicator fail to perform the repairs within 72 hours of notification, emergency temporary repairs performed by others does not void the warranty.

1.10.2 Roofing System Installer Warranty

The roof system installer shall warrant for a minimum period of two years that the roof system, as installed, is free from defects in installation workmanship, to include the roof membrane, flashing, insulation, accessories, attachments, and sheet metal installation integral to a complete watertight roof system assembly. Write the warranty directly to the Government. The roof system installer is responsible for correction of defective workmanship and replacement of damaged or affected materials. The roof system installer is responsible for all costs associated with the repair or replacement work.

1.10.3 Continuance of Warranty

Approve repair or replacement work that becomes necessary within the warranty period and accomplished in a manner so as to restore the integrity of the roof system assembly and validity of the roof membrane manufacturer warranty for the remainder of the manufacturer warranty period.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 TPO Roof Membrane

Provide a minimum polymer thickness 0.080 inch reinforced TPO as specified herein. Provide TPO system capable of obtaining 20 year warranties and as listed in the applicable wind uplift and fire rating classification listings.

Submit Data as required by Section 07 22 00 ROOF AND DECK INSULATION together with requirements of this section. Data shall include written acceptance by the roof membrane manufacturer of the insulation and other products and accessories to be provided by and warranted under the full system guarantee of the roof membrane manufacturer.

- a. Coordinate with other specification sections related to the roof work. Furnish a combination of specified materials that comprise a roof system acceptable to the roof membrane manufacturer and meeting specified requirements. Provide materials free of defects and suitable for the service and climatic conditions of the installation. All warranted roof system components shall be sourced from the TPO roof membrane manufacturer, including but not limited to all insulation, coverboards, accessories, adhesives and edge metal.
- b. For each roof, furnish a typewritten information card for facility records and a card laminated in plastic and framed for interior display at roof access point, or a photoengraved 0.032 inch thick aluminum card for exterior display. Card shall be 8 1/2 by 11 inches minimum. Information card shall identify facility name and number; location; contract number; approximate roof area; detailed roof system description, including deck type, membrane, number of plies, method of application, manufacturer, insulation and cover board system and thickness; presence of tapered insulation for primary drainage, presence of vapor retarder; date of completion; installing Contractor identification and contact information; membrane manufacturer warranty expiration, warranty reference number, and contact information. Install card at roof top or access location as directed by the Contracting Officer and provide a paper copy to the Contracting Officer.

2.1.2 Bonding Adhesive

Provide TPO membrane manufacturer's low volatile organic compound (VOC) or standard membrane adhesive, as supplied by roof membrane manufacturer, and recommended by the manufacturer's printed data for bonding of TPO membrane materials to acceptable insulation, wood, metal, concrete or other acceptable substrate materials. Bonding adhesive shall not be used to bond membrane materials to each other.

2.1.3 Water Cutoff Mastic/Water Block

As supplied by the roof membrane manufacturer and recommended by the manufacturer's printed data.

2.1.4 Membrane Flashing

Membrane flashing, including self-adhering membrane flashing, perimeter

flashing, flashing around roof penetrations and prefabricated pipe seals, shall be minimum polymer thickness 0.080 inch reinforced TPO for 20 year warranties, and shall be utilized as recommended and supplied by the roof membrane manufacturer. Submit certification from TPO membrane manufacturer that the proposed TPO membrane roofing product meets the minimum polymer thickness specified.

2.1.5 Membrane Fasteners and Plates

Coated, corrosion-resistant fasteners as recommended and supplied by the TPO roof membrane manufacturer and meeting the requirements of FM 4470 and FM RoofNav (www.roofnav.com) or FM APP GUIDE for Class I roof deck construction and the wind uplift resistance specified. Fasteners and Plates to be supplied and warranted for the substrate type(s) by TPO membrane manufacturer and recommended by TPO membrane manufacturer's printed data.

2.1.5.1 Stress Plates, Bar or Rail for Fasteners

Corrosion-resistant stress plates as recommended by the roof membrane manufacturer's printed instructions and meeting the requirements of FM 4470 must be utilized and must be supplied by TPO roof membrane manufacturer. Stress plates shall be formed to prevent dishing or cupping. Manufacturer-supplied anchoring bar or rails may be utilized for high wind conditions.

2.1.5.2 Auxiliary Fasteners

Corrosion resistance screws, nails, or anchors must be suitable for intended attachment purpose and be recommended and supplied for use by the TPO roof membrane manufacturer.

2.1.6 Pre-manufactured Accessories

Pre-manufactured accessories shall be manufacturer's standard for intended purpose, must comply with applicable specification section, be compatible with the membrane roof system and approved for use and supplied by the TPO roof membrane manufacturer. Pre-fabricated Curbs shall be 24 gauge G90 galvanized or AZ55 galvalume with minimum 4 inch flange for attachment to roof nailers. Curbs shall provide minimum height of 10 inches above the finished roof membrane surface.

2.1.7 Roof Insulation

Insulation system and facer material shall be compatible with membrane application specified and be approved and supplied by the TPO membrane roof manufacturer and as specified in Section 07 22 00 ROOF AND DECK INSULATION.

2.1.8 Wood Products

As specified in Section 06 10 00 ROUGH CARPENTRY, except that fire retardant treated materials shall not be in contact with TPO membrane or TPO accessory products, unless approved by the membrane manufacturer and the Contracting Officer.

2.2 Reinforced, TPO Membrane

Reinforced thermoplastic polyolefin (TPO) membrane shall contain fabric-

or scrim- reinforcing and shall comply with ASTM D6878/D6878M and in all cases shall provide 0.080 inch minimum thickness for adhered application. Notwithstanding the ASTM standards referenced, reinforced TPO roof membranes provided under this section shall have the minimum, labeled thickness specified. Principal polymer used in manufacture of the membrane sheet shall be TPO. Width and length of TPO membrane roofing sheet shall be consistent with membrane attachment methods and wind uplift requirements, and shall be as large as practical. In order to minimize joints and 3-way overlaps, prefabricated sheets are not accepted. Maximum reinforced TPO membrane roofing sheet dimensions to be the maximum width obtainable from TPO membrane roof manufacturer in order to minimize seams in the field of the roof.

2.2.1 Color

Color of TPO membrane shall be white.

PART 3 EXECUTION

3.1 EXAMINATION

Ensure that the following conditions exist prior to application of the roofing materials:

- a. curbs, expansion joints, perimeter walls, roof penetrating components, and equipment supports are in place.
- b. Surfaces are rigid, clean, dry, smooth, and free from cracks, holes, and sharp changes in elevation.
- c. Substrate is sloped to provide positive drainage.
- d. Walls and vertical surfaces are constructed to receive counterflashing, and will permit mechanical fastening of the base flashing materials.
- e. Treated wood nailers are in place on non-nailable surfaces, to permit nailing of base flashing at minimum height of 8 inches above finished roofing surface.
- f. Pressure-preservative treated wood nailers are fastened in place at eaves, gable ends, openings, and intersections with vertical surfaces for securing of membrane, edging strips, attachment flanges of sheet metal, and roof fixtures. Surface-applied nailers are the same thickness as the roof insulation.
- g. TPO materials are not in contact with fire retardant treated wood, except as approved by the TPO membrane roof manufacturer and Contracting Officer.
- h. Insulation boards are installed smoothly and evenly, and are not broken, cracked, or curled. There are no gaps in insulation board joints exceeding 1/4 inch in width. Insulation is attached as specified in Section 07 22 00 ROOF AND DECK INSULATION. Insulation is being roofed over on the same day the insulation is installed.

3.2 APPLICATION METHOD

Apply entire TPO membrane roofing utilizing adhered application method.

Apply roofing materials as specified herein unless approved otherwise by the Contracting Officer. Submit instructions including pattern and frequency of mechanical attachments required in the field for roof, corners, and perimeters to provide for the specified wind resistance

3.2.1 Special Precautions

- a. Do not dilute coatings or sealants unless specifically recommended by the material manufacturer's printed application instructions. Do not thin liquid materials or cleaners used for cleaning TPO sheet.
- b. Keep liquids in airtight containers, and keep containers closed except when removing materials.
- c. Use liquid components, including adhesives, within their shelf life period. Store adhesives at 60 to 80 degrees F prior to use. Avoid excessive adhesive application and adhesive spills, as they can be destructive to some thermoplastic sheets and insulations; follow adhesive manufacturer's printed application instructions. Mix and use liquid components in accordance with label directions and manufacturer's printed instructions.
- d. Provide clean, dry cloths or pads for applying membrane cleaners and cleaning of membrane.
- e. Do not use heat guns or open flame to expedite drying of adhesives or primers.
- f. Require workmen and others who walk on the membrane to wear clean, soft-soled shoes to avoid damage to roofing materials.
- g. Do not use equipment with sharp edges which could puncture the TPO membrane roofing sheet.
- h. Shut down air intakes and any related mechanical systems and seal open vents and air intakes when applying solvent-based materials in the area of the opening or intake. Coordinate shutdowns with the Contracting Officer.

3.2.2 TPO Roofing Membrane

Provide a watertight roof membrane sheet free of contaminants and defects that might affect serviceability. Provide a uniform, straight, and flat edge. Membrane shall be overlapped a minimum of 3 inches at sides for adhered applications and minimum 4 inches at ends. Direction of laps shall allow water to flow over and not against the lap. Membrane joints shall be free of wrinkles and fishmouths. The entire length of hot-air-welded seams shall be probe-tested and corrected during the day of installation. Defective areas shall be re-welded. Wrinkles, fishmouths, or damaged areas shall be cut out and the area covered with membrane using a continuous hot-air-welded seam on all sides. Repairs shall be probe-tested for continuity. Hot-air-welded seams are to be accomplished in accordance with the TPO membrane roofing manufacturer's published requirements.

3.2.2.1 Nailing

Membrane shall be fastened to nailers in accordance with the membrane manufacturer's approved instructions. Unless otherwise specified, nails

shall be staggered on 4 inch centers maximum; screws for sheet metal shall be staggered on 8 inch centers maximum; and a row of fasteners shall be at least 1/2 inch from edges of sheet metal.

3.2.2.2 Flashing

Roof edges, projections through the roof and changes in roof planes shall be flashed. The seam shall be sealed a minimum of 3 inches beyond the fasteners which attach the membrane to nailers. The installed flashing's shall be secured at the top of the flashing a maximum of 12 inches on centers under the counterflashing or cap. Where possible, prefabricated components shall be used for pipe seals and flashing accessories.

3.2.2.3 Expansion Joints

Expansion joints shall be covered using Prefabricated covers or elastomeric flashing in accordance with the recommendations of the manufacturer.

3.2.2.4 Cutoffs

If work is terminated prior to weatherproofing the entire roof, 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. Asphalt or coal-tar products shall not be used for sealing.

3.2.3 Adhered Membrane Application

Layout membrane and side lap adjoining sheets in accordance with membrane manufacturer's printed installation instructions. Allow for sufficient membrane to form proper membrane terminations. Remove dusting agents and dirt from membrane and substrate areas where bonding adhesives are to be applied. Apply specified adhesive evenly and continuously to substrate and underside of sheets at rates recommended by the roof membrane manufacturer's printed application instructions. When adhesive is spray applied, roll with a paint roller to ensure proper contact and coverage. Do not apply bonding adhesive to surfaces of membrane in seam or lap areas. Allow adhesive to flash off or dry to consistency prescribed by manufacturer before adhering sheets to the substrate. When adhesive is peel & stick release paper-activated, follow manufacturer's printed instructions. Roll each sheet into adhesive slowly and evenly to avoid wrinkles; broom or roll the membrane to remove air pockets and fishmouths and to ensure adequately uniform bonding of sheet to substrate. Form field hot-air-welded laps or seams as specified and ensure that hot-air welded dimension is at width required by the membrane manufacturer's installation instructions. Check all seams and continuous hot-air-weld of all seams and lap seals.

3.2.4 Perimeter Attachment

Adhesive bond or mechanically secure roof membrane sheet at roof perimeter in a manner to comply with wind resistance requirements and in accordance with membrane manufacturer's printed application instructions. When adhesively bonding a mechanically fastened system in perimeter areas, the perimeter boundary of the adhesive bond shall be the same as the boundary required for additional perimeter mechanical fastening to meet wind resistance requirements.

3.2.5 Securement at Base Tie-In Conditions

Mechanically fasten the roof membrane at penetrations, at base of curbs and walls, and at all locations where the membrane turns and angles greater than 4 degrees (1:12). Space fasteners a maximum of 12 inches on center, except where more frequent attachment is required to meet specified wind resistance or where recommended by the roof membrane manufacturer. Cover over fasteners with a layer of flashing material. Hot-air-weld all seams of flashing material as recommended by the roof membrane manufacturer's printed data.

3.2.6 Pre-fabricated Curbs

Securely anchor prefabricated curbs to nailer or other base substrate and flash with TPO membrane flashing materials.

3.2.6.1 Set-On Accessories

Where pipe or conduit blocking, supports and similar roof accessories, or isolated paver block, are set on the membrane, adhere reinforced membrane as recommended by the roof membrane manufacturer, to bottom of accessories prior to setting on roofing membrane. Specific method of installing set-on accessories must permit normal movement due to expansion, contraction, vibration, and similar occurrences without damaging roofing membrane. Do not mechanically secure set-on accessories through roofing membrane into roof deck substrate.

3.3 FLASHINGS

Provide flashings in the angles formed at walls and other vertical surfaces and where required to make the work watertight, except where metal flashings are indicated.

3.3.1 General

Provide a one-ply flashing membrane, as specified for the system used, and install immediately after the roofing membrane is placed and prior to finish coating where a finish coating is required. Provide sheet metal reglet in which sheet metal cap flashings are installed of not more than 16 inch nor less than 8 inch above the roofing surfaces. Exposed joints and end laps of flashing membrane must be made and sealed in the manner required for roofing membrane.

3.3.2 Membrane Flashing

3.3.2.1 Installation

Install flashing and flashing accessories as the roof membrane is installed. Apply flashing to cleaned surfaces and as recommended by the roof membrane manufacturer and as specified. Utilize cured TPO membrane flashing and prefabricated accessory flashings to the maximum extent recommended by the roof membrane manufacturer. Limit uncured flashing material to reinforcing inside and outside corners and angle changes in plane of membrane, and to flashing scuppers, pourable sealer pockets, and other formed penetrations or unusually shaped conditions as recommended by the roof membrane manufacturer where the use of cured material is impractical. Extend base flashing not less than 8 inch above roofing surface and as necessary to provide for seaming overlap on roof membrane

as recommended by the roof membrane manufacturer.

3.3.2.2 Sealing

Seal flashing membrane for a minimum of 3 inch on each side of fastening device used to anchor roof membrane to nailers. Completely adhere flashing sheets in place. Seam flashing membrane in the same manner as roof membrane, except as otherwise recommended by the membrane manufacturer's printed instructions and approved by the Contracting Officer. Reinforce all corners and angle transitions by applying uncured membrane to the area in accordance with roof membrane manufacturer recommendations. Mechanically fasten top edge of base flashing with manufacturer recommended termination bar fastened at maximum 12 inch on center. Install sheet metal flashing over the termination bar in the completed work. Mechanically fasten top edge of base flashing for all other terminations in a manner recommended by the roof membrane manufacturer. Apply membrane liner over top of exposed nailers and blocking and to overlap top edge of base flashing installation at curbs, parapet walls, expansion joints and as otherwise indicated to serve as waterproof lining under sheet metal flashing components.

3.4 CORRECTION OF DEFICIENCIES

Where any form of deficiency is found, additional measures must be taken as deemed necessary by the Contracting Officer to determine the extent of the deficiency and provide corrective action recommendations. Perform corrective action as directed by the Contracting Officer.

3.5 PROTECTION OF APPLIED ROOFING

At the end of the day's work and when precipitation is imminent, protect applied membrane roofing system from water intrusion.

3.5.1 Water Cutoffs

Straighten insulation line using loose-laid cut insulation sheets and seal the terminated edge of the roof membrane system in an effective manner. Seal off flutes in metal decking along the cutoff edge. Remove the water cut-offs to expose the insulation when resuming work, and remove the insulation sheets used for fill-in.

3.5.2 Temporary Flashing for Permanent Roofing

Provide temporary flashing at drains, curbs, walls and other penetrations and terminations of roofing sheets until permanent flashings can be applied. Remove temporary flashing before applying permanent flashing.

3.5.3 Temporary Walkways, Runways, and Platforms

Do not permit storing, walking, wheeling, and trucking directly on applied roofing system. Provide temporary walkways, runways, and platforms of smooth clean boards, mats or planks as necessary to avoid damage to applied roofing materials, and to distribute weight to conform to live load limits of roof construction. Use rubber-tired equipment for roofing work.

3.6 FIELD QUALITY CONTROL

3.6.1 Construction Monitoring

During progress of the roof work, make visual inspections as necessary to ensure compliance with specified parameters. Additionally, verify the following:

- a. Equipment is in working order. Metering devices are accurate.
- b. Materials are not installed in adverse weather conditions.
- c. Substrates are in acceptable condition, in compliance with specification, prior to application of subsequent materials.
 - (1) Nailers and blocking are provided where and as needed.
 - (2) Insulation substrate is smooth, properly secured to its substrate, and without excessive gaps prior to membrane application.
 - (3) The proper number, type, and spacing of fasteners are installed.
 - (4) Materials comply with the specified requirements.
 - (5) All materials are properly stored, handled and protected from moisture or other damages. Liquid components are properly mixed prior to application.
 - (6) Adhesives are applied uniformly to both mating surfaces and checked for proper set prior to bonding mating materials. Mechanical attachments are spaced as required, including additional fastening of membrane in corner and perimeter areas as required.
 - (7) Membrane is properly overlapped.
 - (8) Membrane seaming is as specified by TPO membrane manufacturer. All seams are checked at the end of each work day.
 - (9) Applied membrane is inspected and repaired as necessary prior to paver installation.
 - (10) Membrane is adhered without ridges, wrinkles, kinks, fishmouths.
 - (11) Installer adheres to specified and detailed application parameters.
 - (12) Associated flashing's and sheet metal are installed in a timely manner in accord with the specified requirements.
 - (13) Temporary protection measures are in place at the end of each work shift.

3.6.2 Manufacturer's Inspection

Manufacturer's technical representative shall once per week during the installation for purposes of reviewing materials installation practices and adequacy of work in place. After each inspection, a report, signed by the manufacturer's technical representative shall be submitted by the

roofing Contractor to the Contracting Officer within 3 working days. The report shall note overall quality of work, deficiencies and any other concerns, and recommended corrective action.

3.7 CLEAN UP

Remove debris, scraps, containers and other rubbish and trash resulting from installation of the roofing system from job site each day.

3.8 INSTRUCTIONS TO GOVERNMENT PERSONNEL

Furnish written and verbal instructions on proper maintenance procedures to designated Government personnel. Furnish instructions by a competent representative of the roof membrane manufacturer and include a minimum of 4 hours on maintenance and emergency repair of the membrane. Include a demonstration of membrane repair, and give sources of required special tools. Furnish information on safety requirements during maintenance and emergency repair operations. Include copies of Material Safety Data Sheets for maintenance/repair materials.

-- End of Section --

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SECTION 07 60 00

FLASHING AND SHEET METAL

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 WELDING SOCIETY (AWS)

AWS D1.2/D1.2M (2014; Errata 1 2014; Errata 2 2020)
Structural Welding Code - Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM A480/A480M (2020a) Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

ASTM A653/A653M (2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM B32 (2020) Standard Specification for Solder Metal

ASTM B69 (2021) Standard Specification for Rolled Zinc

ASTM D41/D41M (2011; R 2016) Standard Specification for Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing

ASTM D226/D226M (2017) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing

ASTM D4586/D4586M (2007; E 2012; R 2012) Asphalt Roof Cement, Asbestos-Free

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793 (2012) Architectural Sheet Metal Manual, 7th Edition

1.2 GENERAL REQUIREMENTS

Finished sheet metal assemblies must form a weathertight enclosure without waves, warps, buckles, fastening stresses or distortion, while allowing for expansion and contraction without damage to the system. The sheet

metal installer is responsible for cutting, fitting, drilling, and other operations in connection with sheet metal modifications required to accommodate the work of other trades. Coordinate installation of sheet metal items used in conjunction with roofing with roofing work to permit continuous, uninterrupted roofing operations.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Exposed Sheet Metal Coverings; G

Base Flashing; G

Counterflashing; G

Reglets; G

Flashing at Roof Penetrations and Equipment Supports; G

Recycled Content; S

SD-04 Samples

Finish Samples; G

SD-08 Manufacturer's Instructions

Instructions for Installation; G

SD-10 Operation and Maintenance Data

Cleaning and Maintenance; G

1.4 MISCELLANEOUS REQUIREMENTS

1.4.1 Product Data

Indicate thicknesses, dimensions, fastenings, 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.

1.4.2 Finish Samples

Submit two color charts and two finish sample chips from manufacturer's standard color and finish options for each type of finish indicated. Samples are to match existing copings on buildings.

1.4.3 Operation and Maintenance Data

Submit detailed instructions for installation and quality control during

installation, [cleaning and maintenance](#), for each type of assembly indicated.

1.5 DELIVERY, HANDLING, AND STORAGE

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 installation.

PART 2 PRODUCTS

2.1 RECYCLED CONTENT

Provide products with recycled content. Provide data for each product with recycled content, identifying percentage of recycled content.

2.2 MATERIALS

Do not use lead, lead-coated metal, or galvanized steel. Use any metal listed by [SMACNA 1793](#) for a particular item, unless otherwise indicated. Provide materials, thicknesses, and configurations in accordance with [SMACNA 1793](#) for each material. Different items need not be of the same metal, except that contact between dissimilar metals must be avoided.

Furnish sheet metal items in [8 to 10 foot](#) lengths. Single pieces less than [8 feet](#) long may be used to connect to factory-fabricated inside and outside corners, and at ends of runs. Factory fabricate corner pieces with minimum [12 inch](#) legs. Provide accessories and other items essential to complete the sheet metal installation. Provide accessories made of the same or compatible materials as the items to which they are applied. 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. Provide sheet metal items with mill finish unless specified otherwise. Where more than one material is listed for a particular item in Table I, each is acceptable and may be used, except as follows:

2.2.1 Exposed Sheet Metal Items

Must be of the same material. Consider the following as exposed sheet metal: gutters, including hangers; downspouts; cap, valley, steeped, base, and eave flashings and related accessories.

2.2.2 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.

2.2.3 Steel Sheet, Zinc-Coated (Galvanized)

Provide in accordance with [ASTM A653/A653M](#).

2.2.4 Zinc Sheet and Strip

Provide in accordance with [ASTM B69](#), Type I, a minimum of [0.024 inch](#) thick.

2.2.5 Stainless Steel

Provide in accordance with [ASTM A480/A480M](#), Type 302 or 304, 2D Finish, fully annealed, dead-soft temper.

2.2.6 Finishes

Provide exposed exterior sheet metal and aluminum with a baked on, factory applied color coating of polyvinylidene fluoride (PVF2) or approved equal fluorocarbon coating. Dry film thickness of coatings must be [0.8 to 1.3 mils](#). Color to be selected from manufacturer's standard range of color choices. Field applications of color coatings are prohibited and will be rejected.

2.2.7 Solder

Provide in accordance with [ASTM B32](#), 95-5 tin-antimony.

2.2.8 Reglets

2.2.8.1 Metal Reglets

Provide factory fabricated caulked type or friction type reglets with a minimum opening of [1/4 inch](#) and a depth of [1-1/4 inch](#), as approved.

2.2.8.1.1 Caulked Reglets

Provide with rounded edges, temporary reinforcing cores, and accessories as required for securing to adjacent construction. Provide built-up mitered corner pieces for inside and outside corners.

2.2.9 Bituminous Plastic Cement

Provide in accordance with [ASTM D4586/D4586M](#), Type I.

2.2.10 Roofing Felt

Provide in accordance with [ASTM D226/D226M](#) Type I.

2.2.11 Asphalt Primer

Provide in accordance with [ASTM D41/D41M](#).

2.2.12 Fasteners

Use the same metal as, or a metal compatible with the item fastened. Confirm compatibility of fasteners and items to be fastened to avoid galvanic corrosion due to dissimilar materials.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Nailing

Confine nailing of sheet metal generally to sheet metal having a maximum width of [18 inches](#). Confine nailing of flashing to one edge only. Space nails evenly not over [3 inch](#) on center and approximately [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. Secure flashing at one-half the normal interval to ensure a wind-resistant installation.

3.1.2 Cleats

Provide cleats for sheet metal **18 inches** and over in width. Space cleats evenly not over **12 inches** on center unless otherwise specified or indicated. Unless otherwise specified, provide cleats of **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. Pre-tin cleats for soldered seams.

3.1.3 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. Provide mechanically formed joints in aluminum sheets **0.040 inches** or less in thickness.

3.1.4 Seams

Straight and uniform in width and height with no solder showing on the face.

3.1.4.1 Flat-lock Seams

Finish not less than **3/4 inch** wide.

3.1.4.2 Lap Seams

Finish soldered seams not less than **one inch** wide. Overlap seams not soldered, not less than **3 inches**.

3.1.4.3 Loose-Lock Expansion Seams

Not less than **3 inches** wide; provide minimum **one inch** movement within the joint. Completely fill the joints with the specified sealant, applied at not less than **1/8 inch** thick bed.

3.1.4.4 Standing Seams

Not less than **one inch** high, double locked without solder.

3.1.4.5 Flat Seams

Make seams in the direction of the flow.

3.1.5 Soldering

Where soldering is specified, apply to copper, terne-coated stainless steel, zinc-coated steel, and stainless steel items. Pre-tin edges of sheet metal before soldering is begun. Seal the joints in aluminum sheets of **0.040 inch** or less in thickness with specified sealants. Do not solder aluminum.

3.1.5.1 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 pre-tinned. Seal the joints in aluminum sheets of 0.040 inch or less in thickness with specified sealants. Do not solder aluminum.

3.1.6 Welding and Mechanical Fastening

Use welding for aluminum of thickness greater than 0.040 inch. Aluminum 0.040 inch or less in thickness must 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.

3.1.6.1 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/D1.2M.

3.1.6.2 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 12 inches maximum on center. Where end lap fasteners are required to improve closure, locate the end lap fasteners not more than 2 inches from the end of the overlapping sheet.

3.1.7 Protection from Contact with Dissimilar Materials

3.1.7.1 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.

3.1.7.2 Aluminum

Do not allow aluminum surfaces in direct contact with 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.

3.1.7.3 Metal Surfaces

Paint surfaces in contact with mortar, concrete, or other masonry materials with alkali-resistant coatings such as heavy-bodied bituminous paint.

3.1.7.4 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.

3.1.8 Expansion and Contraction

Provide expansion and contraction joints at not more than 32 foot intervals for aluminum and at not more than 40 foot intervals for other metals. Provide an additional joint where the distance between the last expansion joint and the end of the continuous run is more than half the required interval. Space joints evenly. Join extruded aluminum gravel stops and fascia by expansion and contraction joints spaced not more than 12 feet apart.

3.1.9 Base Flashing

Extend up vertical surfaces of the flashing not less than 8 inches and not less than 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 6 inches. Overlap the flashing strips with the previously laid flashing not less than 3 inches. Fasten the strips 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 on center with 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 curbs, and similar vertical surfaces extending through sloping roofs, the metal flashings. Extend the metal flashings onto the roof covering not less than 4.5 inches at the lower side of vertical surfaces extending through the roof decks. Install and fit the flashings so as to be completely weathertight. Provide factory-fabricated base flashing for interior and exterior corners. Do not use metal base flashing on built-up roofing.

3.1.10 Counterflashing

Except where indicated or specified otherwise, insert counterflashing in reglets located from 9 to 10 inches above roof decks, extend down vertical surfaces over upturned vertical leg of base flashings not less than 3 inches. Fold the exposed edges of counterflashings 1/2 inch. Where stepped counterflashings are required, they may be installed in short lengths a minimum 8 inches by 8 inches or may be of the preformed single piece type. Provide end laps in counterflashings not less than 3 inches and make it weathertight with plastic cement. Do not make lengths of metal counterflashings exceed 10 feet. Form flashings to the required shapes before installation. Factory form corners not less than 12 inches from the angle. Secure the flashings in the reglets with lead wedges and space not more than 18 inches apart; on short runs, place wedges closer together. Fill caulked-type reglets or raked joints which receive counterflashing with caulking compound. Turn up the concealed edge of counterflashings built into masonry or concrete walls not less than 1/4 inch and extend not less than 2 inches into the walls. Install counterflashing to provide a spring action against base flashing.

3.1.11 Metal Reglets

Keep temporary cores in place during installation. Ensure factory fabricated caulked type or friction type, reglets have a minimum opening of 1/4 inch and a minimum depth of 1-1/4 inch, when installed.

3.1.11.1 Caulked Reglets

Wedge flashing in reglets with lead wedges every 18 inches, caulked full

and solid with an approved compound.

3.1.11.2 Friction Reglets

Install flashing snap lock receivers at 24 inches on center maximum. When flashing has been inserted the full depth of the slot, caulk the slot, lock, and fill with sealant.

3.1.12 Polyvinyl Chloride Reglets for Temporary Construction

Rigid polyvinyl chloride reglets may be provided in lieu of metal reglets for temporary construction.

3.1.13 Gravel Stops and fascia

3.1.13.1 Edge Strip

Hook the lower edge of fascia at least 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 6 inches maximum on center. Where fastening is made to concrete or masonry, use screws spaced 12 inches on center 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 1/16 inch thick compatible spacer or washers.

3.1.13.2 Joints

Leave open the section ends of gravel stops and fascia 1/4 inch and backed with a formed flashing plate, mechanically fastened in place and lapping each section end a minimum of 4 inches set laps in plastic cement. Face nailing will not be permitted. Install prefabricated aluminum gravel stops and fascia in accordance with the manufacturer's printed instructions and details.

3.1.14 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, 16 by 18 inches. Fasten sheets to sheathing with metal cleats. Lock seams and solder. Lock aluminum seams as recommended by aluminum manufacturer. Provide an underlayment of roofing felt for all sheet metal covering.

3.1.15 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. Goose-necks, rain hoods, power roof ventilators, and other penetrants are specified in mechanical sections.

3.1.16 Single Pipe Vents

See Table I, footnote (d). Set flange of sleeve in bituminous plastic cement and nail 3 inches on center. Bend the top of sleeve over and extend down into the vent pipe a minimum of 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 4 inches roof flange in bituminous plastic cement and nailed 3 inches on center. Extend sleeve a minimum of 8 inches above the roof deck and lapped a minimum of 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.

3.1.17 Copings

Provide pre-engineered coping with locked and soldered seam. Terminate outer edges in edge strips. Install with sealed lap joints as indicated.

3.2 PAINTING

Touch ups in the field may be applied only after metal substrates have been cleaned and pretreated in accordance with manufacturer's written instructions and products.

Field-paint sheet metal for separation of dissimilar materials.

- 1.Copings: Provide pre-engineered coping system as follows:
 - a.Snap-on coping with intermittent clips for capping parapet walls.
 - b.Does not require exposed fasteners or joint sealants.
- 2.Performance Characteristics:
 - a.Snap-on Coping Cap Sections: Capable of expanding and contracting freely, statically engaged onto mechanically secured clips.
 - b.Snap-on Coping Cap Joints: Underlaid with concealed splices.
- 3.Approvals
 - a.ANSI/SPRI/FM 4435 ES-1 for 24 ga./0.040" - 383 psf Vertical and 221 psf Horizontal, for 22 ga./0.050"/0.063" - 513 psf Vertical and 297 psf Horizontal.
 - b.FM Approved with 24 ga./0.040" cover - 1-225 Perimeter and 1-150 Corner, with 22 ga./0.050"/0.063" cover - 1-300 Perimeter and 1-195 Corner.
 - c.Florida Product Approval.
 - d.Miami-Dade County Approved.
- 4.Intermittent Clips:
 - a.Material: 16 ga. galvanized steel.
 - b.Width: 12"
 - c.Fastener Holes: Pre-Punched.
- 5.Concealed Splices:
 - a.Material: Same as snap-on coping cap.
 - b.Finish and Color: Same as snap-on coping cap to match existing.
 - c.Width: 8"
 - d.Sealant Strips: Factory-applied dual non-curing isocryl butyl sealant strips.

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.

-- End of Section --

SECTION 07 84 00

FIRESTOPPING

PART 1 GENERAL

1.1 SUMMARY

Furnish and install tested and listed firestopping systems, combination of materials, or devices to form an effective barrier against the spread of flame, smoke and gases, and maintain the integrity of fire resistance rated walls, partitions, floors, and ceiling-floor assemblies, including through-penetrations and construction joints and gaps **as required within existing construction**.

- a. Through-penetrations include the annular space around pipes, tubes, conduit, wires, cables and vents.
- b. Construction joints include those used to accommodate expansion, contraction, wind, or seismic movement; firestopping material shall not interfere with the required movement of the joint.

Gaps requiring firestopping include gaps the floor slab and between the top of the fire-rated walls and the roof or floor deck above and at the intersection of shaft assemblies and adjoining fire resistance rated assemblies.

1.2 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.

ASTM INTERNATIONAL (ASTM)

ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E119	(2020) Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E699	(2009) Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components
ASTM E814	(2013a; R 2017) Standard Test Method for Fire Tests of Penetration Firestop Systems
ASTM E1399/E1399M	(1997; R 2017) Standard Test Method for Cyclic Movement and Measuring the Minimum and Maximum Joint Widths of Architectural Joint Systems
ASTM E1966	(2015; R 2019) Standard Test Method for

Fire-Resistive Joint Systems

- ASTM E2174 (2020a) Standard Practice for On-Site Inspection of Installed Firestop Systems
- ASTM E2307 (2020) Standard Test Method for Determining Fire Resistance of Perimeter Fire Barrier Systems Using Intermediate-Scale, Multi-story Test Apparatus
- ASTM E2393 (2020a) Standard Practice for On-Site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers

FM GLOBAL (FM)

- FM 4991 (2013) Approval of Firestop Contractors
- FM APP GUIDE (updated on-line) Approval Guide
<http://www.approvalguide.com/>

UNDERWRITERS LABORATORIES (UL)

- UL 723 (2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
- UL 1479 (2015; Reprint May 2021) Fire Tests of Through-Penetration Firestops
- UL 2079 (2015; Reprint Jul 2020) Tests for Fire Resistance of Building Joint Systems
- UL Fire Resistance (2014) Fire Resistance Directory

1.3 SEQUENCING

Coordinate the specified work with other trades. Apply firestopping materials, at penetrations of pipes and ducts, prior to insulating, unless insulation meets requirements specified for firestopping. Apply firestopping materials, at building joints and construction gaps, prior to completion of enclosing walls or assemblies. Cast-in-place firestop devices shall be located and installed in place before concrete placement. Pipe, conduit or cable bundles shall be installed through cast-in-place device after concrete placement but before area is concealed or made inaccessible. Firestop material shall be inspected and approved prior to final completion and enclosing of any assemblies that may conceal installed firestop.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Firestopping System; G

SD-03 Product Data

Firestopping Materials; G

SD-06 Test Reports

Inspection; G

SD-07 Certificates

Inspector Qualifications
Firestopping Materials
Installer Qualifications; G

1.5 QUALITY ASSURANCE

1.5.1 Installer

Engage an experienced Installer who is:

- a. FM Research approved in accordance with FM 4991, operating as a UL Certified Firestop Contractor, or
- b. Certified, licensed, or otherwise qualified by the firestopping manufacturer as having the necessary staff, training, and a minimum of 3 years experience in the installation of manufacturer's products in accordance with specified requirements. Submit documentation of this experience. A manufacturer's willingness to sell its firestopping products to the Contractor or to an installer engaged by the Contractor does not in itself confer installer qualifications on the buyer. The Installer shall have been trained by a direct representative of the manufacturer (not distributor or agent) in the proper selection and installation procedures. The installer shall obtain from the manufacturer and submit written certification of training, and retain proof of certification for duration of firestop installation.

1.5.2 Inspector Qualifications

The inspector shall meet the criteria contained in ASTM E699 for agencies involved in quality assurance and shall have a minimum of two years experience in construction field inspections of firestopping systems, products, and assemblies. The inspector shall be completely independent of, and divested from, the installer, the manufacturer, and the supplier of any material or item being inspected. The inspector shall not be a competitor of the installer, the contractor, the manufacturer, or supplier of any material or item being inspected. Include in the qualifications submittal a notarized statement assuring compliance with the requirements stated herein.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver materials in the original unopened packages or containers showing name of the manufacturer and the brand name. Store materials off the ground, protected from damage and exposure to elements and temperatures in

accordance with manufacturer requirements. Remove damaged or deteriorated materials from the site. Use materials within their indicated shelf life.

PART 2 PRODUCTS

2.1 FIRESTOPPING SYSTEM

Submit detail drawings including manufacturer's descriptive data, typical details conforming to **UL Fire Resistance** or other details certified by another nationally recognized testing laboratory, installation instructions or UL listing details for a firestopping assembly in lieu of fire-test data or report. For those firestop applications for which no UL tested system is available through a manufacturer, a manufacturer's engineering judgment, derived from similar UL system designs or other tests, shall be submitted for review and approval prior to installation. Submittal must indicate the firestopping material to be provided for each type of application. When more than a total of 5 penetrations and/or construction joints are to receive firestopping, provide drawings that indicate location, "F" "T" and "L" ratings, and type of application.

Also, submit a written report indicating locations of and types of penetrations and types of firestopping used at each location; record type by UL list printed numbers.

2.2 FIRESTOPPING MATERIALS

Provide firestopping materials, supplied from a single domestic manufacturer, consisting of commercially manufactured, asbestos-free, nontoxic products **FM APP GUIDE** approved, or UL listed, for use with applicable construction and penetrating items, complying with the following minimum requirements:

2.2.1 Fire Hazard Classification

Material shall have a flame spread of 25 or less, and a smoke developed rating of 50 or less, when tested in accordance with **ASTM E84** or **UL 723**. Material shall be an approved firestopping material as listed in **UL Fire Resistance** or by a nationally recognized testing laboratory.

2.2.2 Toxicity

Material shall be nontoxic and carcinogen free to humans at all stages of application or during fire conditions and shall not contain hazardous chemicals or require harmful chemicals to clean material or equipment.

2.2.3 Fire Resistance Rating

Firestop systems shall be **UL Fire Resistance** listed or **FM APP GUIDE** approved with "F" rating at least equal to fire-rating of fire wall or floor in which penetrated openings are to be protected. Where required, firestop systems shall also have "T" rating at least equal to the fire-rated floor in which the openings are to be protected.

2.2.3.1 Through-Penetrations

Firestopping materials for through-penetrations, as described in paragraph SUMMARY, shall provide "F", "T" and "L" fire resistance ratings in accordance with **ASTM E814** or **UL 1479**. Fire resistance ratings shall be as follows:

2.2.3.1.1 Penetrations of Fire Resistance Rated Walls and Partitions

F Rating = Rating of wall or partition being penetrated.

2.2.3.2 Construction Joints and Gaps

Fire resistance ratings of construction joints, as described in paragraph SUMMARY, and gaps such as those between floor slabs and curtain walls shall be the same as the construction in which they occur. Construction joints and gaps shall be provided with firestopping materials and systems that have been tested in accordance with [ASTM E119](#), [ASTM E1966](#) or [UL 2079](#) to meet the required fire resistance rating. Curtain wall joints shall be provided with firestopping materials and systems that have been tested in accordance with [ASTM E2307](#) to meet the required fire resistance rating. Systems installed at construction joints shall meet the cycling requirements of [ASTM E1399/E1399M](#) or [UL 2079](#). All joints at the intersection of the top of a fire resistance rated wall and the underside of a fire-rated floor, floor ceiling, or roof ceiling assembly shall provide a minimum class II movement capability.

2.2.4 Material Certification

Submit certificates attesting that firestopping material complies with the specified requirements. For all intumescent firestop materials used in through penetration systems, manufacturer shall provide certification of compliance with [UL 1479](#).

PART 3 EXECUTION

3.1 PREPARATION

Areas to receive firestopping must be free of dirt, grease, oil, or loose materials which may affect the fitting or fire resistance of the firestopping system. For cast-in-place firestop devices, formwork or metal deck to receive device prior to concrete placement must be sound and capable of supporting device. Prepare surfaces as recommended by the manufacturer.

3.2 INSTALLATION

Completely fill void spaces with firestopping material regardless of geometric configuration, subject to tolerance established by the manufacturer. Firestopping systems for filling floor voids [4 inches](#) or more in any direction must be capable of supporting the same load as the floor is designed to support or be protected by a permanent barrier to prevent loading or traffic in the firestopped area. Install firestopping in accordance with manufacturer's written instructions. Provide tested and listed firestop systems in the following locations, except in floor slabs on grade:

- a. Penetrations of duct, conduit, tubing, cable and pipe through floors and through fire-resistance rated walls, partitions, and ceiling-floor assemblies.
- b. Penetrations of vertical shafts such as pipe chases, elevator shafts, and utility chutes.
- c. Gaps at the intersection of floor slabs and curtain walls, including

inside of hollow curtain walls at the floor slab.

- d. Gaps at perimeter of fire-resistance rated walls and partitions, such as between the top of the walls and the bottom of roof decks.
- e. Construction joints in floors and fire rated walls and partitions.
- f. Other locations where required to maintain fire resistance rating of the construction.

3.2.1 Insulated Pipes and Ducts

Thermal insulation shall be cut and removed where pipes or ducts pass through firestopping, unless insulation meets requirements specified for firestopping. Replace thermal insulation with a material having equal thermal insulating and firestopping characteristics.

3.2.2 Fire Dampers

Install and firestop fire dampers in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION. Firestop installed with fire damper must be tested and approved for use in fire damper system. Firestop installed with fire damper must be tested and approved for use in fire damper system.

3.2.3 Data and Communication Cabling

Cabling for data and communication applications shall be sealed with re-enterable firestopping products.

3.2.3.1 Re-Enterable Devices

Firestopping devices shall be pre-manufactured modular devices, containing built-in self-sealing intumescent inserts. Firestopping devices shall allow for cable moves, additions or changes without the need to remove or replace any firestop materials. Devices must be capable of maintaining the fire resistance rating of the penetrated membrane at 0 percent to 100 percent visual fill of penetrants; while maintaining "L" rating of <10 cfm/sf measured at ambient temperature and 400 degrees F at 0 percent to 100 percent visual fill.

3.2.3.2 Re-Sealable Products

Provide firestopping pre-manufactured modular products, containing self-sealing intumescent inserts. Firestopping products shall allow for cable moves, additions or changes. Devices shall be capable of maintaining the fire resistance rating of the penetrated membrane at 0 percent to 100 percent visual fill of penetrants.

3.3 INSPECTION

For all projects, the firestopped areas shall not be covered or enclosed until inspection is complete and approved by the Contracting Officer. Inspect the applications initially to ensure adequate preparations (clean surfaces suitable for application, etc.) and periodically during the work to assure that the completed work has been accomplished according to the manufacturer's written instructions and the specified requirements. Submit written reports indicating locations of and types of penetrations and types of firestopping used at each location; type shall be recorded by UL listed printed numbers.

3.3.1 Inspection Standards

Inspect all firestopping in accordance with [ASTM E2393](#) and [ASTM E2174](#) for firestop inspection, and document inspection results to be submitted.

3.3.2 Inspection Reports

Submit inspection report stating that firestopping work has been inspected and found to be applied according to the manufacturer's recommendations and the specified requirements.

-- End of Section --

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SECTION 07 92 00

JOINT SEALANTS

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.

ASTM INTERNATIONAL (ASTM)

ASTM C734	(2015; R 2019) Low-Temperature Flexibility of Latex Sealants After Artificial Weathering
ASTM C919	(2022) Standard Practice for Use of Sealants in Acoustical Applications
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C1193	(2013) Standard Guide for Use of Joint Sealants
ASTM C1521	(2013) Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints
ASTM D217	(2019b) Standard Test Methods for Cone Penetration of Lubricating Grease
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	SCS Global Services (SCS) Indoor Advantage

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications

UNDERWRITERS LABORATORIES (UL)

UL 2818	(2013) GREENGUARD Certification Program For Chemical Emissions For Building

Materials, Finishes And Furnishings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Sealants; G

Primers; G

Bond Breakers; G

SD-06 Test Reports

Field Adhesion; G

SD-07 Certificates

Indoor Air Quality For Interior Sealants; S

Indoor Air Quality For Interior Floor Joint Sealants; S

Indoor Air Quality For Interior Acoustical Sealants; S

1.3 PRODUCT DATA

Include storage requirements, shelf life, curing time, instructions for mixing and application, and accessories. Provide manufacturer's Safety Data Sheets (SDS) for each solvent, primer and sealant material proposed.

1.4 CERTIFICATIONS

1.4.1 Indoor Air Quality Certifications

Submit required indoor air quality certifications in one submittal package.

1.4.1.1 Adhesives and Sealants

Provide products certified to meet indoor air quality requirements by UL 2818 (Greenguard) Gold, SCS Global Services Indoor Advantage Gold or provide certification or validation by other third-party program that products meet the requirements of this Section. Provide current product certification documentation from certification body.. When product does not have certification, provide validation that product meets the indoor air quality product requirements cited herein.

1.5 ENVIRONMENTAL CONDITIONS

Apply sealant when the ambient temperature is between 40 and 90 degrees F.

1.6 DELIVERY AND STORAGE

Deliver materials to the jobsite in unopened manufacturers' sealed shipping containers, with brand name, date of manufacture, color, and material designation clearly marked thereon. Label elastomeric sealant containers to identify type, class, grade, and use. Handle and store materials in accordance with manufacturer's printed instructions. Prevent exposure to foreign materials or subjection to sustained temperatures exceeding 90 degrees F or lower than 0 degrees F. Keep materials and containers closed and separated from absorptive materials such as wood and insulation.

1.7 QUALITY ASSURANCE

1.7.1 Compatibility with Substrate

Verify that each sealant is compatible for use with each joint substrate in accordance with sealant manufacturer's printed recommendations for each application.

1.7.2 Joint Tolerance

Provide joint tolerances in accordance with manufacturer's printed instructions.

1.7.3 Mock-Up

Provide a mock-up of each type of sealant using materials, colors, and techniques approved for use on the project. Approved mock-ups may be incorporated into the work.

1.7.4 Adhesion

Provide in accordance with ASTM C1193 or ASTM C1521.

PART 2 PRODUCTS

2.1 SEALANTS

Provide sealant products that have been tested, found suitable, and documented as such by the manufacturer for the particular substrates to which they will be applied.

2.1.1 Interior Sealants

Provide ASTM C920, Type S or M, Grade NS, Class 12.5, Use NT. Provide sealant products used on the interior of the building (defined as inside of the weatherproofing system) meeting either emissions requirements of CDPH SECTION 01350 or VOC content requirements of SCAQMD Rule 1168. Provide certification or validation of indoor air quality for interior sealants. Location(s) and color(s) of sealant for the following. Note, color "as selected" refers to manufacturer's full range of color options

LOCATION	COLOR
a. Small voids between walls or partitions and adjacent lockers, casework, shelving, door frames, built-in or surface mounted equipment and fixtures, and similar items.	As selected
b. Perimeter of frames at doors, windows, and access panels which adjoin exposed interior concrete and masonry surfaces.	As selected
c. Joints of interior masonry walls and partitions which adjoin columns, pilasters, concrete walls, and exterior walls unless otherwise detailed.	As selected
d. Joints between edge members for acoustical tile and adjoining vertical surfaces.	White
e. Interior locations, not otherwise indicated or specified, where small voids exist between materials specified to be painted.	As selected
f. Joints between bathtubs and ceramic tile; joints between shower receptors and ceramic tile; joints formed where non-planar tile surfaces meet.	As selected
g. Joints formed between tile floors and tile base cove; joints between tile and dissimilar materials; joints occurring where substrates change.	As selected
h. Behind escutcheon plates at valve pipe penetrations and showerheads in showers.	As selected

2.1.2 Exterior Sealants

For joints in vertical surfaces, provide **ASTM C920**, Type S or M, Grade NS, Class 25, Use NT. For joints in horizontal surfaces, provide **ASTM C920**, Type S or M, Grade P, Class 25, Use T. Provide location(s) and color(s) of sealant as follows. Note, color "as selected" refers to manufacturer's full range of color options:

LOCATION	COLOR
a. Joints and recesses formed where frames and subsills of windows, doors, louvers, and vents adjoin masonry, concrete, or metal frames. Use sealant at both exterior and interior surfaces of exterior wall penetrations.	Match adjacent surface color
b. Expansion and control joints.	Match adjacent surface color

LOCATION	COLOR
c. Interior face of expansion joints in exterior concrete or masonry walls where metal expansion joint covers are not required.	Match adjacent surface color
d. Voids where items pass through exterior walls.	Match adjacent surface color
e. Metal reglets, where flashing is inserted into masonry joints, and where flashing is penetrated by coping dowels.	Match adjacent surface color
f. Metal-to-metal joints where sealant is indicated or specified.	Match adjacent surface color
g. Joints between ends of gravel stops, fascia, copings, and adjacent walls.	Match adjacent surface color

2.1.3 Floor Joint Sealants

ASTM C920, Type S or M, Grade P, Class 25, Use T. Provide sealant products used on the interior of the building (defined as inside of the weatherproofing system) meeting either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168. Provide certification or validation of indoor air quality for interior floor joint sealants. Provide location(s) and color(s) of sealant as follows. Note, color "as selected" refers to manufacturer's full range of color options:

LOCATION	COLOR
a. Seats of metal thresholds for exterior doors.	Gray

2.1.4 Acoustical Sealants

Rubber or polymer based acoustical sealant in accordance with ASTM C919 to have a flame spread of 25 or less and a smoke developed rating of 50 or less when tested in accordance with ASTM E84. Provide non-staining acoustical sealant with a consistency of 250 to 310 when tested in accordance with ASTM D217. Acoustical sealant must remain flexible and adhesive after 500 hours of accelerated weathering as specified in ASTM C734. Provide sealant products used on the interior of the building (defined as inside of the weatherproofing system) meeting either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168. Provide certification or validation of indoor air quality for interior acoustical sealants.

2.1.5 Preformed Sealants

Provide preformed sealants of polybutylene or isoprene-butylene based pressure sensitive weather resistant tape or bead sealants capable of

sealing out moisture, air and dust when installed as recommended by the manufacturer. At temperatures from minus 30 to plus 160 degrees F, sealants must be non-bleeding and have no loss of adhesion.

2.2 PRIMERS

Non-staining, quick drying type and consistency as recommended by the sealant manufacturer for the particular application. Provide primers for interior applications that meet the indoor air quality requirements of the paragraph SEALANTS above.

2.3 BOND BREAKERS

Type and consistency as recommended by the sealant manufacturer to prevent adhesion of the sealant to the backing or to the bottom of the joint. Provide bond breakers for interior applications that meet the indoor air quality requirements of the paragraph SEALANTS above.

2.4 CLEANING SOLVENTS

Provide type(s) recommended by the sealant manufacturer and in accordance with environmental requirements herein. Protect adjacent aluminum and bronze surfaces from solvents. Provide solvents for interior applications that meet the indoor air quality requirements of the paragraph SEALANTS above.

PART 3 EXECUTION

3.1 FIELD QUALITY CONTROL

Perform a field adhesion test in accordance with manufacturer's instructions and ASTM C1193, Method A or ASTM C1521, Method A, Tail Procedure. Remove sealants that fail adhesion testing; clean substrates, reapply sealants, and re-test. Test sealants adjacent to failed sealants. Submit field adhesion test report indicating tests, locations, dates, results, and remedial actions taken.

3.2 SURFACE PREPARATION

Prepare surfaces according to manufacturer's printed installation instructions. Clean surfaces from dirt, frost, moisture, grease, oil, wax, lacquer, paint, or other foreign matter that would destroy or impair adhesion. Remove oil and grease with solvent; thoroughly remove solvents prior to sealant installation. Wipe surfaces dry with clean cloths. When resealing an existing joint, remove existing caulk or sealant prior to applying new sealant. For surface types not listed below, provide in accordance with sealant manufacturer's printed instructions for each specific surface.

3.2.1 Steel Surfaces

Remove loose mill scale by sandblasting or, if sandblasting is impractical or would damage finished work, scraping and wire brushing. Remove protective coatings by sandblasting or using a residue free solvent. Remove resulting debris and solvent residue prior to sealant installation.

3.2.2 Concrete and Masonry Surfaces

Where surfaces have been treated with curing compounds, oil, or other such

materials, remove materials by sandblasting or wire brushing. Remove laitance, efflorescence and loose mortar from the joint cavity. Remove resulting debris prior to sealant installation.

3.2.3 Wood Surfaces

Ensure wood surfaces that will be in contact with sealants are free of splinters, sawdust and other loose particles.

3.3 SEALANT PREPARATION

Do not add liquids, solvents, or powders to sealants. Mix multicomponent elastomeric sealants in accordance with manufacturer's printed instructions.

3.4 APPLICATION

3.4.1 Joint Width-To-Depth Ratios

Acceptable Ratios:

<u>JOINT WIDTH</u>	<u>JOINT DEPTH</u>	
	Minimum	Maximum
For metal, glass, or other nonporous surfaces:		
1/4 inch (minimum)	1/4 inch	1/4 inch
over 1/4 inch	1/2 of width	Equal to width
For wood, concrete, masonry, or :		
1/4 inch (minimum)	1/4 inch	1/4 inch
over 1/4 inch to 1/2 inch	1/4 inch	Equal to width
over 1/2 inch to 1 inch	1/2 inch	5/8 inch
Over 1 inch	prohibited	

Unacceptable Ratios: Where joints of acceptable width-to-depth ratios have not been provided, clean out joints to acceptable depths and grind or cut to acceptable widths without damage to the adjoining work. Grinding is prohibited at metal surfaces.

3.4.2 Unacceptable Sealant Use

Do not install sealants in lieu of other required building enclosure weatherproofing components such as flashing, drainage components, and joint closure accessories, or to close gaps between walls, floors, roofs, windows, and doors, that exceed acceptable installation tolerances. Remove sealants that have been used in an unacceptable manner and correct building enclosure deficiencies to comply with contract documents requirements.

3.4.3 Masking Tape

Place masking tape on the finished surface on one or both sides of joint cavities to protect adjacent finished surfaces from primer or sealant smears. Remove masking tape within 10 minutes of joint filling and tooling.

3.4.4 Backstops

Provide backstops dry and free of tears or holes. Tightly pack the back or bottom of joint cavities with backstop material to provide joints in specified depths. Provide backstops where indicated and where backstops are not indicated but joint cavities exceed the acceptable maximum depths specified in JOINT WIDTH-TO-DEPTH RATIOS Table.

3.4.5 Primer

Clean out loose particles from joints immediately prior to application of. Apply primer to joints in concrete masonry units, wood, and other porous surfaces in accordance with sealant manufacturer's printed instructions. Do not apply primer to exposed finished surfaces.

3.4.6 Bond Breaker

Provide bond breakers to surfaces not intended to bond in accordance with, sealant manufacturer's printed instructions for each type of surface and sealant combination specified.

3.4.7 Sealants

Provide sealants compatible with the material(s) to which they are applied. Do not use a sealant that has exceeded its shelf life or has jelled and cannot be discharged in a continuous flow from the sealant gun. Apply sealants in accordance with the manufacturer's printed instructions with a gun having a nozzle that fits the joint width. Work sealant into joints so as to fill the joints solidly without air pockets. Tool sealant after application to ensure adhesion. Apply sealant uniformly smooth and free of wrinkles. Upon completion of sealant application, roughen partially filled or unfilled joints, apply additional sealant, and tool smooth as specified. Apply sealer over sealants in accordance with the sealant manufacturer's printed instructions.

3.5 PROTECTION AND CLEANING

3.5.1 Protection

Protect areas adjacent to joints from sealant smears. Masking tape may be used for this purpose if removed 5 to 10 minutes after the joint is filled and no residual tape marks remain.

3.5.2 Final Cleaning

Upon completion of sealant application, remove remaining smears and stains and leave the work in a clean and neat condition.

- a. Masonry and Other Porous Surfaces: Immediately remove fresh sealant that has been smeared on adjacent masonry, rub clean with a solvent, and remove solvent residue, in accordance with sealant manufacturer's

printed instructions. Allow excess sealant to cure for 24 hour then remove by wire brushing or sanding. Remove resulting debris.

- b. Metal and Other Non-Porous Surfaces: Remove excess sealant with a solvent moistened cloth. Remove solvent residue in accordance with solvent manufacturer's printed instructions.

-- End of Section --

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SECTION 08 11 13

STEEL DOORS AND FRAMES

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 WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding
Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M (2020) Standard Specification for Steel
Sheet, Zinc-Coated (Galvanized) or
Zinc-Iron Alloy-Coated (Galvannealed) by
the Hot-Dip Process

ASTM A879/A879M (2012; R 2017) Standard Specification for
Steel Sheet, zinc Coated by the
Electrolytic Process for Applications
Requiring Designation of the Coating Mass
on Each Surface

ASTM A924/A924M (2022) Standard Specification for General
Requirements for Steel Sheet,
Metallic-Coated by the Hot-Dip Process

ASTM C591 (2021) Standard Specification for Unfaced
Preformed Rigid Cellular Polyisocyanurate
Thermal Insulation

ASTM C612 (2014; R 2019) Standard Specification for
Mineral Fiber Block and Board Thermal
Insulation

ASTM D2863 (2019) Standard Test Method for Measuring
the Minimum Oxygen Concentration to
Support Candle-Like Combustion of Plastics
(Oxygen Index)

ASTM F2247 (2018) Standard Test Method for Metal
Doors Used in Blast Resistant Applications
(Equivalent Static Load Method)

ASTM F2927 (2012) Standard Test Method for Door
Systems Subject to Airblast Loadings

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

ANSI/BHMA A156.115 (2016) Hardware Preparation in Steel Doors

and Steel Frames

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80 (2022) Standard for Fire Doors and Other
Opening Protectives

NFPA 252 (2022) Standard Methods of Fire Tests of
Door Assemblies

STEEL DOOR INSTITUTE (SDI/DOOR)

SDI/DOOR 111 (2009) Recommended Details for Standard
Steel Doors, Frames, and Accessories and
Related Components

SDI/DOOR 113 (2013; R2018) Standard Practice for
Determining the Steady-State Thermal
Transmittance of Steel Door and Frame
Assemblies

SDI/DOOR A250.4 (2018) Test Procedure and Acceptance
Criteria for Physical Endurance for Steel
Doors, Frames and Frame Anchors

SDI/DOOR A250.6 (2015) Recommended Practice for Hardware
Reinforcing on Standard Steel Doors and
Frames

SDI/DOOR A250.8 (2017) Specifications for Standard Steel
Doors and Frames

SDI/DOOR A250.11 (2012) Recommended Erection Instructions
for Steel Frames

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 4-010-01 (2018; with Change 1, 2020) DoD Minimum
Antiterrorism Standards for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 10C (2016; Reprint May 2021) UL Standard for
Safety Positive Pressure Fire Tests of
Door Assemblies

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Doors; G

Frames; G

Accessories

Schedule of Doors; G

Schedule of Frames; G

SD-03 Product Data

Doors; G

Recycled Content for Steel Door Product; S

Frames; G

Recycled Content for Steel Frame Product; S

Accessories

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 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

SDI/DOOR A250.8, except as specified otherwise. Prepare doors to receive door hardware as specified in Section 08 71 00 DOOR HARDWARE. Undercut where indicated. Provide exterior doors with top edge closed flush and sealed to prevent water intrusion. Provide doors at 1-3/4 inch thick, unless otherwise indicated. Provide door material that uses a minimum of 25 percent recycled content. Provide data indicating percentage of recycled content for steel door product. Exterior doors must be tested in accordance with ASTM F2247 or ASTM F2927 to meet requirements of UFC 4-010-01.

2.1.1 Classification - Level, Performance, Model

2.1.1.1 Heavy Duty Doors

SDI/DOOR A250.8, Level 2, physical performance Level B, Model 1, with core construction as required by the manufacturer for interior doors, of size(s) and design(s) indicated.

2.1.1.2 Extra Heavy Duty Doors

SDI/DOOR A250.8, Level 3, physical performance Level A, Model 1 with core construction as required by the manufacturer for indicated exterior doors, of size(s) and design(s) indicated.

2.2 INSULATED STEEL DOOR SYSTEMS

Provide insulated steel doors and frames in accordance with [SDI/DOOR 113](#) at entrances to dwelling units and where indicated. Meet energy requirements including Solar Heat Gain Coefficient (SHGC) and U-factor. Provide insulated steel doors with a core of polyurethane foam; face sheets, edges, and frames of galvanized steel not lighter than [23 gage](#), [16 gage](#), and [16 gage](#) respectively; magnetic weatherstripping; nonremovable-pin hinges; thermal-break aluminum threshold; and vinyl door bottom. Provide to doors and frames a phosphate treatment, rust-inhibitive primer, and baked acrylic enamel finish. Test doors in accordance with [SDI/DOOR A250.4](#) and meet the requirements for Level C. Prepare doors to receive specified hardware. Provide doors [1-3/4 inch](#) thick.

2.3 ACCESSORIES

2.3.1 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.

2.4 INSULATION CORES

Provide insulating cores at all exterior doors and other specific doors noted in the door schedule, and provide an apparent U-factor of .48 in accordance with [SDI/DOOR 113](#) and conforming to:

- a. Rigid Cellular Polyisocyanurate Foam: [ASTM C591](#), Type I or II, foamed-in-place or in board form, with oxygen index of not less than 22 percent when tested in accordance with [ASTM D2863](#); or
- b. Mineral board: [ASTM C612](#), Type I.

2.5 STANDARD STEEL FRAMES

[SDI/DOOR A250.8](#), Level 2, except as otherwise specified. Form frames to sizes and shapes indicated, with welded corners. Provide steel frames for doors, interior glazed panels, unless otherwise indicated. Provide frame product that uses a minimum of 25 percent recycled content. Provide data indicating percentage of [recycled content for steel frame product](#).

2.5.1 Welded Frames

Continuously weld frame faces at corner joints. Mechanically interlock or continuously weld stops and rabbets. Grind welds smooth.

Weld frames in accordance with the recommended practice of the Structural Welding Code Sections 1 through 6, [AWS D1.1/D1.1M](#) and in accordance with the practice specified by the producer of the metal being welded.

2.5.2 Stops and Beads

Provide form and loose stops and beads from [20 gage](#) 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 12 to 16 inch on center. Miter molded shapes at corners. Butt or miter square or rectangular beads at corners.

2.5.3 Terminated Stops

Where indicated, terminate interior door frame stops 6 inch above floor. Do not terminate stops of frames for soundproof, doors.

2.5.4 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.

2.5.5 Anchors

Provide anchors to secure the frame to adjoining construction. Provide steel anchors, zinc-coated not lighter than 18 gage.

2.5.5.1 Wall Anchors

Provide at least three anchors for each jamb. For frames which are more than 7.5 feet in height, provide one additional anchor for each jamb for each additional 2.5 feet or fraction thereof.

- a. Masonry: Provide anchors of corrugated or perforated steel straps or 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 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/DOOR 111; and

2.5.5.2 Floor Anchors

Provide floor anchors drilled for 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.

2.6 FIRE DOORS AND FRAMES

Provide fire doors and frames in accordance with NFPA 80 and this specification. Include insulated core materials in fire doors where indicated in the door schedule.

2.6.1 Labels

Provide fire doors and frames bearing the label of Underwriters Laboratories (UL), Factory Mutual Engineering and Research (FM), or Warnock Hersey International (WHI) attesting to the rating required. Testing must be in accordance with NFPA 252 or UL 10C. Provide labels that are metal with raised letters, bearing the name or file number of the

door and frame manufacturer. Labels must be permanently affixed at the factory to frames and to the hinge edge of the door. Do not paint door and labels.

2.7 EXTERIOR FRAMES

Provide thermal insulation in all exterior frames. Provide frames of a minimum Level 4, with frames of a minimum thickness of 0.067 inch, 14 gage.

2.8 HARDWARE PREPARATION

Drill and tap doors and frames to receive finish hardware. Prepare doors and frames for hardware in accordance with the applicable requirements of SDI/DOOR A250.8 and SDI/DOOR A250.6. For additional requirements refer to ANSI/BHMA A156.115. Drill and tap for surface-applied hardware at the project site. Build additional reinforcing for surface-applied hardware into the door at the factory. Punch door frames, with the exception of frames that will have weatherstripping or lightproof or soundproof gasketing, 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.

2.9 FINISHES

2.9.1 Hot-Dip Zinc-Coated and Factory-Primed Finish

Fabricate doors and frames from hot dipped zinc coated steel, alloyed type, that complies with ASTM A924/A924M and ASTM A653/A653M. The coating weight must meet or exceed the minimum requirements for coatings having 0.4 ounces per square foot, total both sides, i.e., A40. 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 SDI/DOOR A250.8. Provide for exterior doors and interior doors.

2.9.2 Electrolytic Zinc-Coated Anchors and Accessories

Provide electrolytically deposited zinc-coated steel in accordance with ASTM A879/A879M, Commercial Quality, Coating Class A. Phosphate treat and factory prime zinc-coated surfaces as specified in SDI/DOOR A250.8.

2.10 FABRICATION AND WORKMANSHIP

Provide finished doors and frames that are strong and rigid, neat in appearance, and free from defects, waves, scratches, cuts, dents, ridges, holes, warp, and buckle. Provide molded members that are 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 must be well formed and in true alignment. Conceal fastenings where practicable.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Frames

Set frames in accordance with SDI/DOOR A250.11. 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.

3.1.2 Doors

Hang doors in accordance with clearances specified in [SDI/DOOR A250.8](#). After erection and glazing, clean and adjust hardware.

3.1.3 Fire Doors and Frames

Install fire doors and frames, including hardware, in accordance with [NFPA 80](#).

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.

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SECTION 08 31 00

ACCESS DOORS AND PANELS

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 WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M (2019) Standard Specification for Carbon Structural Steel

ASTM A653/A653M (2022) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A666 (2015) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar

ASTM A1008/A1008M (2021a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

ASTM E90 (2009; R2016) Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

ASTM E119 (2022) Standard Test Methods for Fire Tests of Building Construction and Materials

ASTM E413 (2022) Classification for Rating Sound Insulation

ASTM E1332 (2016) Standard Classification for Rating Outdoor-Indoor Sound Attenuation

MASTER PAINTERS INSTITUTE (MPI)

MPI 79 (2016) Primer, Alkyd, Anti-Corrosive for Metal

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80	(2022) Standard for Fire Doors and Other Opening Protectives
NFPA 252	(2022) Standard Methods of Fire Tests of Door Assemblies
NFPA 288	(2017) Standard Methods of Fire Tests of Horizontal Fire Door Assemblies Installed in Horizontal Fire Resistance-Rated Assemblies

UNDERWRITERS LABORATORIES (UL)

UL 10B	(2008; Reprint May 2020) Fire Tests of Door Assemblies
UL 263	(2011; Reprint Aug 2021) UL Standard for Safety Fire Tests of Building Construction and Materials

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Access Doors And Panels

SD-03 Product Data

Access Doors And Panels

Hardware Including Locks and Keys

Accessories

Recycled Content; S

SD-04 Samples

Finishes

SD-06 Test Reports

Acoustical Ratings of Assemblies; G

1.3 MISCELLANEOUS REQUIREMENTS

For access doors and panels provide the following:

1.3.1 Product Data

For shop assembled access doors and panels, provide literature indicating sizes, types, frame and edge construction, finishes, hardware, accessories

such as gaskets, seals and weatherstripping, and location of each door and panel in the project. Indicate [acoustical ratings of assemblies](#), fire-ratings of assemblies. Provide details of adjoining work for each condition indicated.

1.3.2 Finish Samples

Submit two color charts from manufacturer's standard color and finish options for each type of frame and panel assembly finish indicated.

1.3.3 Test Reports

Provide test reports for acoustical assemblies when tested in accordance with [ASTM E90](#) and classified in accordance with [ASTM E413](#) and [ASTM E1332](#). Provide test reports for fire-rated assemblies when tested in accordance with [NFPA 252](#) or [UL 10B](#) for fire-rated access door assemblies installed vertically and [NFPA 288](#) for fire-rated access door assemblies installed horizontally.

1.4 PERFORMANCE REQUIREMENTS

1.4.1 Structural Requirements

Provide floor access assemblies to support live loads indicated for floors. Deflection must not exceed 1/180 of span.

1.4.2 Acoustical Requirements

Provide access panels with a minimum sound transmission class (STC) of [33](#). Provide gasketing in accordance with manufacturer's written recommendations.

1.4.3 Fire-Rating Requirements

Provide access panels with a minimum fire-rating of [-Hour of existing assembly encountered](#).

1.4.4 Insulated Access Panels

Provide panels [adjacent existing assembly in which panel is to be located within](#). Provide gasketing as necessary for an airtight installation.

1.4.5 Access Panels for Wet Areas

Provide panel assemblies that will be located in wet areas with corrosion resistant finishes and hardware and water resistant gasketing.

1.5 DELIVERY, STORAGE, AND PROTECTION

Protect from corrosion, deformation, and other types of damage. Store items in an enclosed area free from contact with soil and weather. Remove and replace damaged items with new items.

PART 2 PRODUCTS

2.1 [RECYCLED CONTENT](#)

Provide products with recycled content. Provide data for each product with recycled content, identifying percentage of recycled content.

2.2 MATERIALS

2.2.1 Steel Plates, Shapes, and Bars

Provide in accordance with [ASTM A36/A36M](#).

2.2.2 Sheet Steel

Provide cold rolled steel sheet substrate in accordance with [ASTM A1008/A1008M](#), Commercial Steel (CS), exposed.

2.2.3 Stainless Steel

Provide in accordance with [ASTM A666](#), type 302 or 304.

2.2.4 Metallic Coated Steel Sheet

Provide in accordance with [ASTM A653/A653M](#), Commercial Steel (CS), Type B; with minimum G60 (Z180) or A60 (ZF180) metallic coating.

2.2.5 Hardware

Provide automatic closing devices. Provide latch releases operable from insides of doors. Provide anchors in accordance with applicable fire test parameters.

2.2.6 Hinges

Provide concealed spring hinges, 175 degrees of opening, with non-removable hinge pins to allow removal of door panel from frame. Provide hinges of same steel as door and frame or in accordance with manufacturer's written recommendations. If providing non-continuous hinges, provide in numbers required to maintain alignment of door panel with frame. Provide coatings as necessary to permanently protect dissimilar metals from contact with one another; see Part 3 herein for more information.

2.2.7 Locks

Unless otherwise indicated, provide flush screwdriver operated cam lock. Provide plastic sleeve or stainless steel bushings to protect holes in surface finishes for screwdriver to access lock. tamper proof screws (spanner head locks) for access panels in locations requiring such security.

2.2.8 [Accessories](#)

Provide anchors in size, number and location on four sides to secure access door to substrate. Provide anchors in types as recommended by manufacturer's written installation instructions for each substrate indicated. Provide shims, bushings, clips, gaskets, and other devices as necessary for a complete installation.

2.3 FABRICATION

2.3.1 Thickness, Size, Edges

Fabricate frames for access doors of steel not lighter than 16 gage with

welded joints and anchorage for securing to adjacent construction. Provide doors a minimum of 24 by 24 inches and of not lighter than 16 gage steel, with stiffened edges and welded attachments. Provide with eased (lightly rounded) edges, without burrs, snags or sharpness and exposed welds ground smooth.

2.3.2 Welding

Provide in accordance with AWS D1.1/D1.1M.

2.4 ACCESS ASSEMBLY TYPES

Unless indicated otherwise, provide flush-face steel access doors and panels with steel frames and flanges.

2.4.1 Recessed Doors

Provide recessed access doors with gypsum wallboard bead flanges. Depth of door panel recess must accommodate the installed thickness of the finish material of the wall assembly for a flush finished condition of the wall and the access panel face. Reinforce panel and frame to prevent sagging.

2.4.2 Fire-rated Doors

2.4.2.1 Door Construction

Provide ceiling access door construction in accordance with ASTM E119 or UL 263. Provide wall access doors in accordance with NFPA 252 or UL 10B.

2.4.2.2 Labels

Provide class B opening according to UL 10B or test by another nationally recognized laboratory, approved by the Contracting Officer. Provide fire-rating as indicated herein, with a maximum temperature rise of 216 degrees F.

2.4.2.3 Door Panel and Frame

Steel sheet, with mineral fiber insulation core, insulated sandwich type construction.

2.4.3 Acoustical Doors

Manufacturer's standard assembly rated in accordance with STC requirements indicated herein. Acoustical insulating materials must have a flame spread rating of no more than 25.

2.4.4 Insulated Doors

Provide access door panels with 25 pounds per square inch density polystyrene 5 pound per cubic foot density, chlorofluorocarbon (CFC) free, foamed urethane with a flame spread rating of no more than 25.

Provide ceiling access panels for terminal air blenders as indicated.

2.5 FINISHES

Provide steel frames and panel surfaces with a powder coated finish.

Provide manufacturer's standard two coat finish system consisting of one coat primer and one thermoset topcoat. Provide dry film thickness in 2 mils minimum. Provide steel frame and panel surfaces with a shop applied prime coat. Provide exposed fastenings that approximately match the color and finish of the each material to which fastenings are applied.

PART 3 EXECUTION

3.1 PREPARATION

Field verify all measurements prior to fabrication. Verify access door locations and sizes provide required maintenance access to installed building services components. Protect existing construction and completed work from damage during installation.

3.2 GENERAL INSTALLATION REQUIREMENTS

Install items at locations indicated, in accordance with manufacturer's written instructions. Include materials and parts as necessary for a complete installation of each item. Conceal fastenings where practicable. Poor matching of holes to fasteners is cause for rejection of the work.

3.3 ACCESS LOCATIONS

Install removable access panels directly below each valve, flow indicator, damper, air splitter or other utility requiring access that is located above ceilings, other than at acoustical panel ceilings, and that would otherwise not be accessible. Install access doors and panels permitting access to service valves, traps, dampers, cleanouts, and other mechanical, electrical and conveyor control items concealed in walls and partitions.

3.4 ACCESS LOCATIONS IN WET AREAS

When possible, avoid locating access panels in wet areas. When such locations cannot be avoided, provide moisture resistant assemblies as indicated in Part I herein.

3.5 RECESSED ACCESS DOORS

Install fire-rated access doors in fire-rated partitions and ceilings in accordance with NFPA 80.

3.6 DISSIMILAR MATERIALS

Where dissimilar metals are in contact, protect surfaces with a coating in accordance with MPI 79 to prevent galvanic or corrosive action.

3.7 ADJUSTMENT

Adjust hardware so that door panel opens freely. Adjust door when closed center door panel in frame.

3.8 ENVIRONMENTAL CONDITIONS

Do not paint surfaces when damp or exposed to weather, when surface temperature is below 45 degrees F or over 95 degrees F, unless approved by the Contracting Officer.

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SECTION 08 71 00

DOOR HARDWARE

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.

ASTM INTERNATIONAL (ASTM)

ASTM E283 (2019) Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

ASTM F883 (2013; R 2022) Standard Performance Specification for Padlocks

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

ANSI/BHMA A156.1 (2021) Butts and Hinges

ANSI/BHMA A156.2 (2017) Bored and Preassembled Locks and Latches

ANSI/BHMA A156.3 (2020) Exit Devices

ANSI/BHMA A156.4 (2013) Door Controls - Closers

ANSI/BHMA A156.5 (2020) Cylinder and Input Devices for Locks

ANSI/BHMA A156.6 (2021) Architectural Door Trim

ANSI/BHMA A156.7 (2016) Template Hinge Dimensions

ANSI/BHMA A156.8 (2021) Door Controls - Overhead Stops and Holders

ANSI/BHMA A156.13 (2017) Mortise Locks & Latches Series 1000

ANSI/BHMA A156.15 (2021) Release Devices Closer Holder, Electromagnetic and Electromechanical

ANSI/BHMA A156.16 (2018) Auxiliary Hardware

ANSI/BHMA A156.17 (2019) Self Closing Hinges & Pivots

ANSI/BHMA A156.18 (2020) Materials and Finishes

ANSI/BHMA A156.21 (2019) Thresholds

ANSI/BHMA A156.22 (2021) Gasketing

ANSI/BHMA A156.25	(2013) Electrified Locking Devices
ANSI/BHMA A156.26	(2012) Continuous Hinges
ANSI/BHMA A156.29	(2012) Exit Locks, Exit Alarms, Alarms for Exit Devices
ANSI/BHMA A156.30	(2014) High Security Cylinders
ANSI/BHMA A156.31	(2013) Electric Strikes and Frame Mounted Actuators
ANSI/BHMA A156.36	(2010) Auxiliary Locks

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code
NFPA 72	(2022) National Fire Alarm and Signaling Code
NFPA 80	(2022) Standard for Fire Doors and Other Opening Protectives
NFPA 101	(2021) Life Safety Code
NFPA 252	(2022) Standard Methods of Fire Tests of Door Assemblies

STEEL DOOR INSTITUTE (SDI/DOOR)

SDI/DOOR A250.8	(2017) Specifications for Standard Steel Doors and Frames

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

36 CFR 1191	Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines

UNDERWRITERS LABORATORIES (UL)

UL Bld Mat Dir	(updated continuously online) Building Materials Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Manufacturer's Detail Drawings; G

Verification of Existing Conditions; G

Hardware Schedule; G

Keying System; G

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; G

SD-11 Closeout Submittals

Key Bitting

1.3 SHOP DRAWINGS

Submit [manufacturer's detail drawings](#) indicating all hardware assembly components and interface with adjacent construction. Indicate power components and wiring coordination for electrified hardware. Base shop drawings on verified field measurements and include [verification of existing conditions](#).

1.4 PRODUCT DATA

Indicate fire-ratings at applicable components. Provide documentation of ABA/ADA accessibility compliance of applicable components, as required by [36 CFR 1191](#) Appendix D - Technical.

1.5 [HARDWARE SCHEDULE](#)

Provide Hardware Item List and Hardware Schedule containing the following information, and additional information as needed to identify the complete make up of each hardware set and its application to each opening:

1.5.1 Hardware Item List:

- a. Hardware Type
- b. Item Number
- c. Quantity
- d. Size(s)

- e. Reference Publication / Type Number
- f. Manufacturer's Name / Catalog Number
- g. Key Control Symbols
- h. UL Mark (If fire rated and listed)
- i. BHMA Finish(es)
- j. Remarks

1.5.2 Hardware Schedule

- a. Hardware Set Number
- b. Opening Number(s)
- c. Opening Description (single/double leaf, hand, size, door/frame material)
- d. Fire Rating
- e. Sound Rating
- f. Hardware Items
- g. Quantity
- h. Size
- i. BHMA Finish
- j. Remarks

In addition, submit hardware schedule data package 1 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.6 KEY BITTING CHART REQUIREMENTS

1.6.1 Requirements

Submit [key bitting](#) charts to the Contracting Officer prior to completion of the work. Include:

- a. Complete listing of all keys (e.g. AA1 and AA2).
- 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.

1.7 QUALITY ASSURANCE

1.7.1 Hardware Manufacturers and Modifications

Provide, as far as feasible, locks, hinges, and closers of one lock, hinge, or closer manufacturer's make. Modify hardware as necessary to provide features indicated or specified.

1.7.2 Key Shop Drawings Coordination Meeting

Prior to the submission of the key shop drawing, the Contracting Officer, Contractor, Door Hardware Subcontractor, using Activity and Base Locksmith must meet to discuss and coordinate key requirements for the facility.

1.8 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 on hardware schedule.

PART 2 PRODUCTS

2.1 TEMPLATE HARDWARE

Hardware applied to metal or to prefinished doors must be manufactured using a template. Provide templates to door and frame manufacturers in accordance with ANSI/BHMA A156.7 for template hinges. 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 72 for door alarms, NFPA 80 for fire doors, NFPA 101 for exit doors, NFPA 252 for fire tests of door assemblies, ABA/ADA accessibility requirements, and all other requirements indicated, even if such hardware is not specifically mentioned in paragraph HARDWARE SCHEDULE. Provide Underwriters Laboratories, Inc. labels for such hardware in accordance with UL Bld Mat Dir or equivalent labels in accordance with another testing laboratory approved in writing by the Contracting Officer.

2.3 HARDWARE ITEMS

Clearly and permanently mark with the manufacturer's name or trademark, hinges, pivots, locks, latches, exit devices, bolts and closers where the identifying mark is visible after the item is installed. For closers with covers, the name or trademark may be beneath the cover. Coordinate electrified door hardware components with corresponding components specified in Division 28 ELECTRONIC SECURITY SYSTEMS (ESS) if applicable.

2.3.1 Hinges

Provide in accordance with ANSI/BHMA A156.1. Provide hinges that are 4-1/2 by 4-1/2 inch unless otherwise indicated. Construct loose pin hinges for interior doors and reverse-bevel exterior doors so that pins are non-removable when door is closed. Other anti-friction bearing hinges may be provided in lieu of ball bearing hinges.

2.3.2 Continuous Hinges

Where continuous hinges are required, provide in accordance with [ANSI/BHMA A156.26](#).

2.3.3 Pivots

Provide in accordance with [ANSI/BHMA A156.17](#).

2.3.4 Spring Hinges

Provide in accordance with [ANSI/BHMA A156.17](#).

2.3.5 Locks and Latches

- a. At exterior locations provide locksets of full stainless steel type 302 or 304 construction including fronts, strike, escutcheons, knobs, bolts and all interior working parts. Marine Grade I, fully non-ferrous.

2.3.5.1 Mortise Locks and Latches

Provide in accordance with [ANSI/BHMA A156.13](#), Series 1000, Operational Grade 1, Security Grade 2. Provide knobs and roses of mortise locks with screwless shanks and no exposed screws.

2.3.5.2 Bored Locks and Latches

Provide in accordance with [ANSI/BHMA A156.2](#), Series 4000, Grade 1.

2.3.5.3 Auxiliary Locks

Provide in accordance with [ANSI/BHMA A156.36](#), Grade 1.

2.3.5.4 Combination Locks

Heavy-duty, mechanical combination lockset with five push buttons, standard sized knobs, $\frac{3}{4}$ inch deadlocking latch, $2\frac{3}{4}$ inch backset. Locks to operate by pressing two or more of the buttons in unison or individually in the proper sequence. Inside knob operates the latch. Provide a keyed cylinder on the interior to permit setting the combination. Provide a thumb turn on the interior to activate passage set function so that outside knob operates latch without using the combination.

2.3.6 Exit Devices

Provide in accordance with [ANSI/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.

2.3.7 Exit Locks With Alarm

Provide in accordance with [ANSI/BHMA A156.3](#) and [ANSI/BHMA A156.29](#), 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. Provide door alarms integrated with the fire alarm system in accordance with [NFPA 72](#).

2.3.8 Cylinders and Cores

Provide cylinders and cores for new locks, including locks provided under other sections of this specification. Provide cylinders and cores with seven pin tumblers. Provide cylinders from the products of one manufacturer, and provide cores from the products of one manufacturer. Rim cylinders, mortise cylinders, and knobs of bored locksets have interchangeable cores which are removable by special control keys. Stamp each interchangeable core with a key control symbol in a concealed place on the core.

2.3.8.1 High Security Cylinders

Provide in accordance with ANSI/BHMA A156.30, security level A for all high security cylinder components.

2.3.9 Push Button Mechanisms

Provide in accordance with ANSI/BHMA A156.5, Grade 1.

2.3.10 Electrified Hardware

Comply with the requirements of NFPA 70 for wiring of electrified hardware.

2.3.10.1 Electric Strikes and Frame Mounted Actuators

Provide in accordance with ANSI/BHMA A156.31, Grade 1. Provide electric strikes and actuators as required to meet operational requirements. Provide electric strikes that remain maintained during power failure. Provide battery backup for continued operation during power failure. Provide strikes and actuators with a minimum opening force of 2300 pounds.

Provide facility interface devices that use direct current (dc) power to energize the solenoids. Provide electric strikes and actuators that incorporate end-of-line resistors to facilitate line supervision by the system. If not incorporated into the electric strike or local controller, provide metal oxide resistors (MOVs) to protect the controller from reverse current surges.

2.3.10.1.1 Solenoid

Provide actuating solenoid for strikes and actuators that are rated for continuous duty, cannot dissipate more than 12 Watts and must operate on 12 or 24 Volts dc. Inrush current cannot exceed 1 ampere and the holding current cannot be greater than 500 milliamperes. Actuating solenoid must move from fully secure to fully open positions in less than 500 milliseconds.

2.3.10.1.2 Signal Switches

Provide strikes and actuators with signal switches to indicate to the system when the bolt is not engaged or the strike mechanism is unlocked. Signal switches must report a forced entry to the system.

2.3.10.1.3 Tamper Resistance

Provide strike guards that prevent tampering with the latch bolt of the locking hardware or the latch bolt keeper of the electric strike. Strike guards to bolt through the door using tamper resistant screws. Provide

strike guards made of $\frac{1}{8}$ inch thick brass and that are $11\text{-}\frac{1}{14}$ inch high by $1\text{-}\frac{5}{8}$ inch wide, with a minimum $\frac{5}{32}$ inch wide offset.

2.3.10.1.4 Coordination

Provide electric strikes and actuators of a size, weight and profile compatible with each specified door frame. Field verify installation clearances prior to procurement.

2.3.10.1.5 Mounting Method

Provide electric strikes and actuators suitable for use with single and double doors, with mortise or rim type hardware specified, and for right or left hand mounting as specified. In double door installations, locate the lock in the active leaf and monitor the fixed leaf.

2.3.10.2 Card Readers and Keypad Access Control Hardware

Provide in accordance with ANSI/BHMA A156.5 and ANSI/BHMA A156.25, Grade 1 components. Provide devices that are tamper alarmed, tamper and vandal resistant, solid state, and do not contain electronics which could compromise the access control subsystem should the subsystem be attacked. Provide surface, semi-flush, pedestal, or weatherproof mountable devices as specified for each individual location. Each device to contain a visual display, either mounted on the face, or on an integral part of the device, to indicate access or exit request processing, request approval, and request denial. Provide proximity type card readers capable of reading user-specified type access control cards. Provide keypads that contain an integral 12-digit tactile keyboard with digits arranged in numerical order. Provide keypads that are integrated into the card reader. Coordinate access control hardware with corresponding devices and systems specified in Division 28 ELECTRONIC SECURITY SYSTEMS (ESS).

2.3.10.3 Release Devices

In accordance with ANSI/BHMA A156.15, Grade 1.

2.3.11 Keying System

Provide an extension of the existing keying system.

2.3.12 Lock Trim

Provide cast, forged, or heavy wrought construction and commercial plain design for lock trim.

2.3.12.1 Lever Handles

Provide lever handles. Provide in accordance with ANSI/BHMA A156.3 for mortise locks of lever handles for exit devices. Provide lever handle locks with a breakaway feature (such as a weakened spindle or a shear key) to prevent irreparable damage to the lock when force in excess of that specified in ANSI/BHMA A156.13 is applied to the lever handle. Provide lever handles return to within $\frac{1}{2}$ inch of the door face.

2.3.13 Keys

Provide one file key, one duplicate key, and one working key for each key change. Provide one additional working key for each lock of each

keyed-alike group. Stamp each key with appropriate key control symbol and "U.S. property - do not duplicate." Do not place room number on keys.

2.3.14 Door Bolts

Provide in accordance with ANSI/BHMA A156.16. Provide dustproof strikes for bottom bolts, except at doors having metal thresholds. Provide automatic latching flush bolts in accordance with ANSI/BHMA A156.3, Type 25.

2.3.15 Closers

Provide in accordance with ANSI/BHMA A156.4, Series C02000, Grade 1, with PT 4C. Provide with brackets, arms, mounting devices, fasteners, and other features necessary for the particular application. Size closers in accordance with manufacturer's printed recommendations, or provide multi-size closers, Sizes 1 through 6, and list sizes in the Hardware Schedule. Provide manufacturer's 10 year warranty.

2.3.15.1 Identification Marking

Engrave each closer with manufacturer's name or trademark, date of manufacture, and manufacturer's size designation in locations that will be visible after installation.

2.3.16 Overhead Holders

Provide in accordance with ANSI/BHMA A156.8.

2.3.17 Door Protection Plates

Provide in accordance with ANSI/BHMA A156.6.

2.3.17.1 Sizes of Kick Plates

2 inch less than door width for single doors; 1 inch less than door width for pairs of doors. Provide 8 inch kick plates for flush doors.

2.3.18 Door Stops and Silencers

Provide in accordance with ANSI/BHMA A156.16. Silencers Type L03011. Provide three silencers for each single door, two for each pair.

2.3.19 Padlocks

Provide in accordance with ASTM F883.

2.3.20 Thresholds

Provide in accordance with ANSI/BHMA A156.21. Use J35100, with vinyl or silicone rubber insert in face of stop, for exterior doors opening out, unless specified otherwise.

2.3.21 Weatherstripping Gasketing

Provide in accordance with ANSI/BHMA A156.22. Provide the type and function designation where specified in paragraph HARDWARE SCHEDULE. Provide a set to include head and jamb seals, sweep strips,. Air leakage of weatherstripped doors not to exceed 0.5 cubic feet per minute of air

per square foot of door area when tested in accordance with ASTM E283.
Provide weatherstripping with one of the following:

2.3.21.1 Extruded Aluminum Retainers

Extruded aluminum retainers not less than 0.050 inch wall thickness with vinyl, neoprene, silicone rubber, or polyurethane inserts. Provide clear (natural) anodized aluminum.

2.3.21.2 Interlocking Type

Zinc or bronze not less than 0.018 inch thick.

2.3.21.3 Spring Tension Type

Spring bronze or stainless steel not less than 0.008 inch thick.

2.3.22 Soundproofing Gasketing

Provide in accordance with ANSI/BHMA A156.22. Provide adjustable doorstops at heads, jams and automatic door bottoms in accordance with the hardware set, of extruded aluminum, clear (natural) anodized, surface applied, with vinyl fin seals between plunger and housing. Provide doorstops with solid neoprene tube, silicone rubber, or closed cell sponge gasket. Provide door bottoms with adjustable operating rod and silicone rubber or closed cell sponge neoprene gasket. Provide doorstops that are mitered at corners. Provide type and function designation where specified in paragraph HARDWARE SETS.

2.3.23 Rain Drips

Provide in accordance with ANSI/BHMA A156.22. Provide extruded aluminum rain drips, not less than 0.08 inch thick, factory primed finish. Provide the manufacturer's full range of color choices to the Contracting Officer for color selection. Set drips in sealant and fasten with stainless steel screws.

2.3.23.1 Overhead Rain Drips

Approximately 1-1/2 inch high by 2-1/2 inch projection. Align bottom with door frame rabbet.

2.3.24 Auxiliary Hardware (Other than locks)

Provide in accordance with ANSI/BHMA A156.16, Grade 1.

2.3.25 Special Tools

Provide special tools, such as spanner and socket wrenches and dogging keys, as required to service and adjust hardware items.

2.4 FASTENERS

Provide fasteners of type, quality, size, and quantity appropriate to the specific application. Fastener finish to match hardware. Provide stainless steel or nonferrous metal fasteners in locations exposed to weather. Verify metals in contact with one another are compatible and will avoid galvanic corrosion when exposed to weather.

2.5 FINISHES

Provide in accordance with ANSI/BHMA A156.18. Provide hardware in 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 aluminum paint finish for surface door closers, and except BHMA 652 finish (satin chromium plated) for steel hinges. Provide hinges for exterior doors in stainless steel with BHMA 630 finish. Furnish exit devices in BHMA 626 finish in lieu of BHMA 630 finish except where BHMA 630 is specified under paragraph HARDWARE SETS. Match exposed parts of concealed closers to lock and door trim. Match hardware finish for aluminum doors to the doors.

2.6 KEY CABINET AND CONTROL SYSTEM

Provide in accordance with ANSI/BHMA A156.5, Type required to yield a capacity (number of hooks) 50 percent greater than the number of key changes used for door locks.

PART 3 EXECUTION

3.1 INSTALLATION

Provide hardware in accordance with manufacturers' printed installation 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 Weatherstripping Installation

Provide full contact, weathertight seals that allow operation of doors without binding the weatherstripping.

3.1.1.1 Stop Applied Weatherstripping

Fasten in place with color matched sheet metal screws not more than 9 inch on center after doors and frames have been finish painted.

3.1.1.2 Interlocking Type Weatherstripping

Provide interlocking, self adjusting type on heads and jambs and flexible hook type at sills. Nail weatherstripping to door 1 inch on center and to heads and jambs at 4 inch on center.

3.1.1.3 Spring Tension Type Weatherstripping

Provide spring tension type on heads and jambs. Provide bronze nails with bronze. Provide stainless steel nails with stainless steel. Space nails not more than 1-1/2 inch on center.

3.1.2 Soundproofing Installation

Provide as specified for stop applied weatherstripping.

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. For aluminum thresholds placed on top of concrete surfaces, coat the underside surfaces that are in contact with the concrete with fluid applied waterproofing as a separation measure prior to placement.

3.2 FIRE DOORS AND EXIT DOORS

Provide hardware in accordance with NFPA 72 for door alarms, NFPA 80 for fire doors, NFPA 101 for exit doors, and NFPA 252 for fire tests of door assemblies.

3.3 HARDWARE LOCATIONS

Provide in accordance with SDI/DOOR A250.8, unless indicated or specified otherwise.

- a. Kick and Armor Plates: Push side of single-acting doors. Both sides of double-acting doors.

3.4 KEY CABINET AND CONTROL SYSTEM

Locate where directed. Tag one set of file keys and one set of duplicate keys. Place other keys in appropriately marked envelopes, or tag each key. Provide 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, errors in cutting and fitting and damage to adjoining work.

3.6 HARDWARE SETS

-- End of Section --

SECTION 08 91 00

METAL WALL LOUVERS

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 MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 500-L (2015) Laboratory Methods of Testing
Louvers for Rating

AMCA 511 (2010; R 2016) Certified Ratings Program
for Air Control Devices

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M (2017) Standard Specification for Zinc
(Hot-Dip Galvanized) Coatings on Iron and
Steel Products

ASTM A653/A653M (2020) Standard Specification for Steel
Sheet, Zinc-Coated (Galvanized) or
Zinc-Iron Alloy-Coated (Galvannealed) by
the Hot-Dip Process

ASTM A780/A780M (2020) Standard Practice for Repair of
Damaged and Uncoated Areas of Hot-Dip
Galvanized Coatings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Wall Louvers

SD-03 Product Data

Metal Wall Louvers

SD-04 Samples

Wall Louver Samples; G

1.3 DELIVERY, STORAGE, AND PROTECTION

Deliver materials to the site in an undamaged condition. Carefully store materials off the ground to provide proper ventilation, drainage, and protection against dampness. Louvers must be free from nicks, scratches, and blemishes. Replace defective or damaged materials with new.

1.4 DETAIL DRAWINGS

Show all information necessary for fabrication and installation of wall louvers. Indicate materials, sizes, thicknesses, fastenings, and profiles.

1.5 COLOR SAMPLES

Colors of finishes for wall louver samples and must closely approximate colors indicated. Where color is not indicated, submit the manufacturer's standard colors to the Contracting Officer for selection.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Galvanized Steel Sheet

ASTM A653/A653M, coating designation G90.

2.2 METAL WALL LOUVERS

Weather resistant type, with bird screens and made to withstand a wind load of not less than 30 pounds per square foot. Wall louvers must bear the AMCA certified ratings program seal for air performance and water penetration in accordance with AMCA 500-L and AMCA 511. The rating must show a water penetration of 0.20 or less ounce per square foot of free area at a free velocity of 800 feet per minute.

2.2.1 Formed Metal Louvers

Formed of zinc-coated steel sheet not thinner than 16 U.S. gage, or aluminum sheet not less than 0.08 inch thick.

2.2.2 Mullions and Mullion Covers

Same material and finish as louvers. Provide mullions where indicated. Provide mullion covers on both faces of joints between louvers.

2.2.3 Screens and Frames

For aluminum louvers, provide 1/2 inch square mesh, 14 or 16 gage aluminum or 1/4 inch square mesh, 16 gage aluminum bird screening. For steel louvers, provide 1/2 inch square mesh, 12 or 16 gage zinc-coated steel; 1/2 inch square mesh, 16 gage copper; or 1/4 inch square mesh, 16 gage zinc-coated steel or copper bird screening. Mount screens in removable, rewirable frames of same material and finish as the louvers.

2.3 FASTENERS AND ACCESSORIES

Provide stainless steel screws and fasteners for aluminum louvers and zinc-coated or stainless steel screws and fasteners for steel louvers. Provide other accessories as required for complete and proper installation.

2.4 FINISHES

2.4.1 Steel

Surfaces specified must have a zinc coating, a phosphate treatment, and a shop prime coat of rust-inhibitive paint. The galvanized coating must conform to **ASTM A653/A653M**, coating designation Z275 (G90). The weight of zinc coatings must be as designated in Table I of **ASTM A123/A123M** for the thickness of base metal to be coated. The prime coat must be a type especially developed for materials treated by phosphates and adapted to application by dipping or spraying. Repair damaged zinc-coated surfaces by the materials and methods conforming to **ASTM A780/A780M** and spot prime. At the option of the Contractor, a two-part system including bonderizing, baked-on epoxy primer, and baked-on enamel top coat may be applied before forming, in lieu of prime coat specified.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Wall Louvers

Install using stops or moldings, flanges, strap anchors, or jamb fasteners as appropriate for the wall construction and in accordance with manufacturer's recommendations.

3.1.2 Screens and Frames

Attach frames to louvers with screws or bolts.

3.2 PROTECTION FROM CONTACT OF DISSIMILAR MATERIALS

3.2.1 Copper or Copper-Bearing Alloys

Paint copper or copper-bearing alloys in contact with dissimilar metal with heavy-bodied bituminous paint or separate with inert membrane.

3.2.2 Aluminum

Where aluminum contacts metal other than zinc, paint the dissimilar metal with a primer and two coats of aluminum paint.

3.2.3 Metal

Paint metal in contact with mortar, concrete, or other masonry materials with alkali-resistant coatings such as heavy-bodied bituminous paint.

-- End of Section --

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SECTION 09 22 00

SUPPORTS FOR PLASTER AND GYPSUM BOARD

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.

ASTM INTERNATIONAL (ASTM)

ASTM A463/A463M	(2015; R 2020; E 2020) Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM C645	(2014; E 2015) Nonstructural Steel Framing Members
ASTM C754	(2020) Standard Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products
ASTM C841	(2003; R 2013) Installation of Interior Lathing and Furring
ASTM C847	(2014a) Standard Specification for Metal Lath

NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM)

NAAMM EMLA 920	(2009) Guide Specifications for Metal Lathing and Furring

UNDERWRITERS LABORATORIES (UL)

UL Fire Resistance	(2014) Fire Resistance Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Metal Support Systems; G

Submit for the erection of metal framing, furring, and ceiling suspension systems. Indicate materials, sizes, thicknesses, and fastenings.

SD-03 Product Data

Metal Support Systems

Recycled Content for Metal Support Systems; S

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the job site and store in ventilated dry locations permitting easy access for inspection and handling. If materials are stored outdoors, stack materials off the ground, supported on a level platform, and fully protected from the weather. Handle materials carefully to prevent damage. Remove damaged items and provide new items.

PART 2 PRODUCTS

2.1 MATERIALS

Provide steel materials for metal support systems with galvanized coating ASTM A653/A653M, G-60; aluminum coating ASTM A463/A463M, T1-25; or a 55-percent aluminum-zinc coating. Provide support systems and attachments per UFC 3-301-01, "Structural Engineering" in seismic zones.

Provide metal support systems containing a minimum of 20 percent recycled content. Provide data identifying percentage of recycled content for metal support systems.

2.1.1 Materials for Attachment of Lath

2.1.1.1 Suspended and Furred Ceiling Systems and Wall Furring

ASTM C841, and ASTM C847.

2.1.1.2 Non-load Bearing Wall Framing

NAAMM EMLA 920.

2.1.2 Materials for Attachment of Gypsum Wallboard

2.1.2.1 Suspended and Furred Ceiling Systems

ASTM C645.

2.1.2.2 Non-load Bearing Wall Framing and Furring

ASTM C645, but not thinner than 0.0179 inch thickness, with 0.0329 inch minimum thickness supporting wall hung items such as cabinetwork, equipment and fixtures.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Systems for Attachment of Lath

3.1.1.1 Suspended and Furred Ceiling Systems and Wall Furring

ASTM C841, except as indicated otherwise.

3.1.1.2 Non-load Bearing Wall Framing

NAAMM EMLA 920, except provide framing members 16 inches o.c. unless indicated otherwise.

3.1.2 Systems for Attachment of Gypsum Wallboard

3.1.2.1 Suspended and Furred Ceiling Systems

ASTM C754, except provide framing members 16 inches o.c. unless indicated otherwise.

3.1.2.2 Non-load Bearing Wall Framing and Furring

ASTM C754, except as indicated otherwise.

3.1.2.3 Furring Structural Steel Columns

Install studs or galvanized steel clips and support angles for erection of gypsum wallboard around structural steel columns in accordance with the UL Fire Resistance, design number(s) of the fire resistance rating indicated on existing construction or in drawings.

3.2 ERECTION TOLERANCES

Provide framing members which will be covered by finish materials such as wallboard, plaster, or ceramic tile set in a mortar setting bed, within the following limits:

- a. Layout of walls and partitions: 1/4 inch from intended position;
- b. Plates and runners: 1/4 inch in 8 feet from a straight line;
- c. Studs: 1/4 inch in 8 feet out of plumb, not cumulative; and
- d. Face of framing members: 1/4 inch in 8 feet from a true plane.

Provide framing members which will be covered by ceramic tile set in dry-set mortar, latex-portland cement mortar, or organic adhesive within the following limits:

- a. Layout of walls and partitions: 1/4 inch from intended position;
- b. Plates and runners: 1/8 inch in 8 feet from a straight line;

- c. Studs: 1/8 inch in 8 feet out of plumb, not cumulative; and
- d. Face of framing members: 1/8 inch in 8 feet from a true plane.

-- End of Section --

SECTION 09 24 23

CEMENT STUCCO

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.

ASTM INTERNATIONAL (ASTM)

ASTM A489	(2018; E 2018) Standard Specification for Carbon Steel Eyebolts
ASTM A580/A580M	(2023) Standard Specification for Stainless Steel Wire
ASTM A653/A653M	(2023) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A1008/A1008M	(2021a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM A1064/A1064M	(2022) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM B633	(2023) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C206	(2014; R 2022) Standard Specification for Finishing Hydrated Lime
ASTM C636/C636M	(2013) Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels
ASTM C841	(2023) Installation of Interior Lathing and Furring
ASTM C847	(2014a) Standard Specification for Metal Lath
ASTM C897	(2015; R 2020) Aggregate for Job-Mixed

Portland Cement-Based Plasters

ASTM C926	(2023) Standard Specification for Application of Portland Cement-Based Plaster
ASTM C933	(2014) Welded Wire Lath
ASTM C1032	(2014) Standard Specification for Woven Wire Plaster Base
ASTM C1063	(2022) Standard Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lath

SD-03 Product Data

Proportions and Mixing

Recycled percentage of fly ash in Portland cement; S

Recycled Content for steel framing; S

Recycled Content for metal lath; S

SD-04 Samples

Colored Stucco Finish Coat

Sample Panel; G

1.3 QUALITY ASSURANCE

Submit a SAMPLE PANEL as follows: One 12 inch square stucco panel showing finish texture and color and exposed reinforcement at the edges, one 12 inch square of reinforcement, and a 12 inch length of each accessory proposed, prior to proceeding with stucco work. A sample panel of stucco, constructed at the jobsite, and located as directed, to demonstrate

installation procedures, texture and color, prior to proceeding with any stucco work; panel size must be a minimum of 4 feet wide x 8 feet high; containing each type accessory proposed for use and constructed in the vertical position. Sample panel must have exposed reinforcement at the edges. Each phase of installation such as framing, scratch coat, brown coat, finish coat and curing procedures must be demonstrated in the construction of the panel. Submit one 12 inch square of reinforcement and one 12 inch length of each accessory proposed for use, prior to constructing the sample panel.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver packaged materials to the site in the original packages and containers with labels intact and seals unbroken. Keep cementitious materials dry and stored off the ground, under cover and away from damp surfaces until ready to be used. Aggregate must be covered to prevent the absorption or loss of moisture.

1.5 ENVIRONMENTAL REQUIREMENTS

Do not apply stucco when the ambient temperature is 40 degrees F or lower, or when a drop in temperature below 40 degrees F is expected within 48 hours after application.

PART 2 PRODUCTS

2.1 PORTLAND CEMENT

Portland cement must conform to ASTM C150/C150M, white Portland cement, Type I II. Provide system that has a minimum of 15% and maximum 40% fly ash. Provide data from installation contractor identifying recycled percentage of fly ash in Portland cement.

2.2 COLORED STUCCO FINISH COAT

Colored stucco finish coat must be a mill mixed product using white Portland cement and requiring only the addition of and mixing with water for application. Color must match existing stucco. Submit samples including both a fabricated portion of unit of work and color samples.

2.3 LIME

Lime must conform to ASTM C206, Type S.

2.4 SAND

Sand aggregate for job-mixed base coat and job-mixed finish coat stucco must conform to ASTM C897.

2.5 ACCESSORIES

Accessories must be rigid polyvinyl chloride (PVC), except that cornerite and striplath must be formed from steel sheets with manufacturer's standard galvanized coating. Vinyl members must be in accordance with ASTM D1784. Welded wire corner reinforcements must be zinc coated, galvanized 17 gauge steel wire conforming to ASTM A1064/A1064M. Furring must include hangers, bolts, inserts, clips, fastenings, and attachments of number, size, and design to develop the full strength of the members.

2.6 STEEL FRAMING

Steel framing must be as shown and must be manufacturer's standard products with shop applied protective coating. Refer to Section 09 22 00 SUPPORTS FOR PLASTER AND GYPSUM BOARD.

Provide steel framing containing a minimum of 20 percent recycled content, as calculated by the sum of the percentage of post-consumer and ½ the percentage of pre-consumer recycled steel content. Provide data identifying percentage of recycled content for steel framing.

2.7 METAL LATH

Metal lath must conform to ASTM C847, types and weights in accordance with the various spacing shown in ASTM C841. Lath for vertical application on steel and wood framing supports must be expanded metal or welded or woven wire and must have paper backing with a minimum vapor permeance of 5 perms. Woven wire lath must be a maximum 1-1/2 x 1-1/2 inch mesh wire of not less than 0.0540 inch nominal diameter and must conform to ASTM C1032. Welded wire lath must conform to ASTM C933, with openings not to exceed 2 x 2 inches. Expanded metal or wire lath must be fabricated in a manner to provide not less than 1/4 inch keying between wire and paper backing and keying must be obtained by a uniform series of slots in a perforated face paper woven between the wires.

Provide Metal Lath containing a minimum of 20 percent recycled content, as calculated by the sum of the percentage of post-consumer and ½ the percentage of pre-consumer recycled steel content. Provide data identifying percentage of recycled content for metal lath.

2.8 WATER

Provide clean, fresh, potable water, free from amounts of oils, acids, alkalis and organic matter that would be injurious to the stucco.

2.9 HANGERS

Provide hangers and attachment capable of supporting a minimum 300 pound ultimate vertical load without failure of supporting material or attachment.

2.9.1 Wires

Conform wires to ASTM A580/A580M, composition 302 or 304, condition annealed stainless steel, 0.08 inch (12 gauge) in diameter.

2.9.2 Straps

Provide straps of 1 by 3/16 inch galvanized steel conforming to ASTM A653/A653M, with a light commercial zinc coating or ASTM A1008/A1008M with an electrodeposited zinc coating conforming to ASTM B633, Type RS.

2.9.3 Rods

Provide 3/16 inch diameter threaded steel rods, zinc or cadmium coated.

2.9.4 Eyebolts

Provide eyebolts of weldless, forged-carbon-steel, with a straight-shank in accordance with ASTM A489. Eyebolt size must be a minimum 1/4 inch,

zinc coated.

2.9.5 Masonry Anchorage Devices

Comply with [ASTM C636/C636M](#) for anchorage devices for eyebolts machine screwswood screws.

PART 3 EXECUTION

3.1 INSTALLATION

Do not install building construction materials that show visual evidence of biological growth.

3.2 FRAMING

Framing must be installed as indicated.

3.3 CONTROL JOINTS

Locate control joints as indicated on the drawingsso that unbroken areas of stucco do not exceed [144 square feet](#) with no dimension between control joints greater than [18 ft](#). Install prefabricated control joint members prior to the application of the stucco. Clear control joints of all stucco within the control area after stucco application and prior to final stucco set.

3.4 LATH

Install lath in accordance with [ASTM C841](#) or [ASTM C1063](#) except as otherwise specified. Metal and wire lath must be applied straight, without buckles and with joints staggered. End laps of metal lath must be not less than [1 inch](#). When paper-backed lath is used, the paper must be split from the lath at all lap areas to provide a paper to paper and lath to lath lap. Horizontal joints must be shiplapped. Lath must be interrupted at all control joints. Submit drawings showing details of construction for reinforcement, furring, and grounds; including manufacturer's installation instructions for stucco materials, and locations where each mix and coating thickness will be used.

3.4.1 Steel and Wood Supports

Apply metal lath over vertical open or solid wood and steel backing frame construction only after sheathing and air barrier has been applied to the area to receive the stucco. Fasten lath every [8 inches](#) vertically and every [16 inches](#) horizontally; and where sheets of lath are lapped. Drive fasteners to hold both lapped edges securely in place.

3.4.2 On Concrete and Masonry

Fasten lath every [8 inches](#) vertically and every [16 inches](#) horizontally. Where wood supports adjoin masonry or concrete in the same direction, provide casing bead, control joints, or reinforcement as indicated.

3.4.3 Over Metal Lintels and Flashings

Lath over metal lintels must be extended vertically over the angles to a height of not less than [6 inches](#) and horizontally across the underside of the lintels and must be secured in an approved manner. Lath over metal

flashings must lap the flashings not less than 2 inches and must be extended vertically for a height of not less than 6 inches.

3.4.4 Special Shapes, Profiles, and Contours

Special shapes, profiles, and contours must be formed with wood, metal or aluminum furring and reinforcing.

3.5 FURRING

Furring must be installed to true lines and surfaces and must be rigidly supported and secured in place.

3.6 PREPARATION OF SURFACES

Preparation of surfaces for application of stucco to solid bases such as stone, masonry or concrete must conform to the applicable requirements of ASTM C926.

3.7 PROPORTIONS AND MIXING

Proportions and mixing for job-mixed base coat and finish coat must conform to the applicable requirements of ASTM C926. Mixing of mill-mixed finish coat must be in accordance with the manufacturer's directions. Submit detailed description of the proposed job-mix proportions for base and finish coats; including identification of thickness of coats.

3.8 STUCCO APPLICATION

Stucco must be applied in three coats to a thickness of not less than 1 inch as measured from the back plane of metal reinforcement, exclusive of ribs or dimples or from the face of solid backing or support, with or without metal reinforcement, to the finished stucco surface, including moderate texture variations. Stucco application must conform to the applicable requirements of ASTM C926 and the following:

3.8.1 Workmanship

Items or features of the work in connection with or adjoining the stucco must be in place, plumb, straight, and true prior to beginning the stucco work. Metal and wire lath, where required, must be in place and positioned to provide a good key at back of lath. Where lath is applied over copper, the copper must be given a heavy coat of bituminous paint. Masonry surfaces to receive stucco must be evenly dampened immediately prior to application of stucco. Each stucco coat must be applied continuously in one general direction, without allowing mortar to dry at edges. Where it is impossible to work the full dimension of a wall surface in a continuous operation, jointing must be made at a break, opening, or other natural division of the surface. Edges to be joined must be dampened slightly to produce a smooth confluence. Exterior corners of stucco must be slightly rounded. Stucco on soffit surfaces must be pitched forward to form a drip.

3.8.2 Scratch Coat

Apply scratch coat not less than 3/8 inch thick under sufficient pressure to form good keys and to completely embed the reinforcement. Before the scratch coat has set, it must be lightly scratched in one direction and vertical surfaces must be scratched in the horizontal direction only. The

scratch coat must be fog cured for a minimum of 72 hours.

3.8.3 Brown Coat

Evenly dampen the scratch coat to obtain uniform suction before the brown coat is applied. There must be no visible water on the surface when the brown coat is applied. The brown coat must be applied to the scratch coat with sufficient pressure to force the stucco into the scratches and must be brought to a plumb, true, even plane with rod or straightedge. When set sufficiently, the brown coat must be uniformly floated with a dry float to promote densification of the coat and to provide a surface receptive to bonding of the finish coat. Brown coat must be fog cured for a minimum of 72 hours.

3.8.4 Finish Coat

Dampen surfaces of the brown coat not more than 1 hour before the finish coat is to be applied to a uniform wetness with no free-standing water on the surface. The finish coat must have a smooth trowel finish and must conform to **match existing**. Fog cure the finish coat for a minimum of 48 hours. Take care to prevent staining.

3.8.5 Surface Tolerance

When a **10 foot** straightedge is placed at any location on the finished surface of the stucco, excluding rough-textured finish, the surface must not vary more than **1/8 inch** from the straightedge.

3.9 CURING AND PROTECTION

Perform fog curing by applying a fine mist of water to the stucco. Exercise care during fog curing to avoid erosion damage of the stucco surfaces. Do not use a solid stream of water. Fog not less than three times daily. Protect the stucco from the direct rays of the sun during severe drying conditions using canvas, cloth or other approved sheet material.

3.10 PATCHING AND POINTING

Replace or patch loose, cracked, damaged or defective work as directed. Patching must match existing work in texture and color and must be finished flush.

-- End of Section --

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SECTION 09 29 00

GYPSUM BOARD

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 NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A108.11 (1992; Reaffirmed 2005) Specifications for Interior Installation of Cementitious Backer Units

ASTM INTERNATIONAL (ASTM)

ASTM C475/C475M (2017; R 2022) Standard Specification for Joint Compound and Joint Tape for Finishing Gypsum Board

ASTM C514 (2004; R 2020) Standard Specification for Nails for the Application of Gypsum Board

ASTM C840 (2020) Standard Specification for Application and Finishing of Gypsum Board

ASTM C954 (2018) Standard Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs from 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness

ASTM C1002 (2020) Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs

ASTM C1047 (2019) Standard Specification for Accessories for Gypsum Wallboard and Gypsum Veneer Base

ASTM C1396/C1396M (2017) Standard Specification for Gypsum Board

ASTM C1629/C1629M (2018a) Standard Classification for Abuse-Resistant Nondecorated Interior Gypsum Panel Products and Fiber-Reinforced Cement Panels

ASTM D1037 (2012) Evaluating Properties of Wood-Base Fiber and Particle Panel Materials

ASTM D2394	(2017) Standard Test Methods for Simulated Service Testing of Wood and Wood-Base Finish Flooring
ASTM D3273	(2016) Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber
ASTM D5420	(2016) Standard Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Strike Impacted by a Falling Weight (Gardner Impact)
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E336	(2020) Standard Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings
ASTM E695	(2003; R 2015; E 2015) Measuring Relative Resistance of Wall, Floor, and Roof Construction to Impact Loading

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

GREEN SEAL (GS)

GS-36	(2013) Adhesives for Commercial Use

GYPSUM ASSOCIATION (GA)

GA 214	(2010) Recommended Levels of Gypsum Board Finish
GA 216	(2010) Application and Finishing of Gypsum Panel Products
GA 600	(2009) Fire Resistance Design Manual

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	SCS Global Services (SCS) Indoor Advantage

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications

UNDERWRITERS LABORATORIES (UL)

UL 2818 (2013) GREENGUARD Certification Program
For Chemical Emissions For Building
Materials, Finishes And Furnishings

UL Fire Resistance (2014) Fire Resistance Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Cementitious Backer Units

Abuse Resistant Gypsum Board

Accessories

Submit for each type of gypsum board and for cementitious backer units.

Gypsum Board

Recycled Content for Gypsum Board; S

VOC Content of Joint Compound; S

SD-04 Samples

Submit for each color and pattern of predecorated gypsum board. Where colors are not indicated, submit color selection samples of not less than eight of the manufacturer's standard colors.

SD-06 Test Reports

ASTM E90 Factory Test Report; G

ASTM E336 Field Test Report; G

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.

Indoor Air Quality for Gypsum Board; S

Indoor Air Quality for Non-aerosol Adhesives; S

Indoor Air Quality for Aerosol Adhesives; S

SD-08 Manufacturer's Instructions

Safety Data Sheets

SD-10 Operation and Maintenance Data

Manufacturer Maintenance Instructions

1.3 CERTIFICATIONS

1.3.1 Indoor Air Quality Certifications

Submit required indoor air quality certifications in one submittal package.

1.3.1.1 Ceiling and Wall Systems

Provide products certified to meet indoor air quality requirements by **UL 2818** (Greenguard) Gold, **SCS** Global Services Indoor Advantage Gold or provide certification or validation by other third-party program that products meet the requirements of this Section. Provide current product certification documentation from certification body. When product does not have certification, provide validation that product meets the indoor air quality product requirements cited herein.

1.3.1.2 Adhesives and Sealants

Provide products certified to meet indoor air quality requirements by **UL 2818** (Greenguard) Gold, **SCS** Global Services Indoor Advantage Gold or provide certification or validation by other third-party program that products meet the requirements of this Section. Provide current product certification documentation from certification body. When product does not have certification, provide validation that product meets the indoor air quality product requirements cited herein.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 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.

1.4.2 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. Store per manufacturer's recommendations for allowable temperature and humidity range. **Do not store gypsum wallboard with materials which have high emissions of volatile organic compounds (VOCs) or other contaminants.** Do not store panels near materials that may offgas or emit harmful fumes, such as kerosene heaters, fresh paint, or adhesives. Do not use materials that have visible moisture or biological growth.

1.4.3 Handling

Neatly stack gypsum board and cementitious backer units flat to prevent sagging or damage to the edges, ends, and surfaces.

1.5 QUALIFICATIONS

Furnish type of gypsum board work specialized by the installer with a minimum of 3 years of documented successful experience.

1.6 ENVIRONMENTAL REQUIREMENTS

Do not expose the gypsum board to excessive sunlight prior to gypsum board application. Maintain a continuous uniform temperature of not less than 50 degrees F and not more than 80 degrees F for at least one week prior to the application of gypsum board work, while the gypsum board application is being done, and for at least one week after the gypsum board is set. Shield air supply and distribution devices to prevent any uneven flow of air across the plastered surfaces. Provide ventilation to exhaust moist air to the outside during gypsum board application, set, and until gypsum board jointing is dry. In glazed areas, keep windows open top and bottom or side to side 3 to 4 inches. Reduce openings in cold weather to prevent freezing of joint compound when applied. For enclosed areas lacking natural ventilation, provide temporary mechanical means for ventilation. In unglazed areas subjected to hot, dry winds or temperature differentials from day to night of 20 degrees F or more, screen openings with cheesecloth or similar materials. Avoid rapid drying. During periods of low indoor humidity, provide minimum air circulation following gypsum boarding and until gypsum board jointing complete and is dry.

1.7 FIRE RESISTIVE CONSTRUCTION

Comply with specified fire-rated assemblies for design numbers indicated per UL Fire Resistance or FM APP GUIDE.

PART 2 PRODUCTS

2.1 MATERIALS

Conform to specifications, standards and requirements specified. Provide gypsum board types, gypsum backing board types, cementitious backing units, and joint treating materials manufactured from asbestos free materials only. Submit Safety Data Sheets and manufacturer maintenance instructions for gypsum materials including adhesives.

2.1.1 Gypsum Board

ASTM C1396/C1396M. Gypsum board must contain a minimum of 10 percent post-consumer recycled content, or a minimum of 40 percent post-industrial recycled content. Provide data identifying percentage of recycled content for gypsum board. Provide gypsum wall board and panels meeting the emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type). Provide certification or validation of indoor air quality for gypsum board.

2.1.1.1 Regular

48 inch wide, 5/8 inch thick, tapered edges.

2.1.1.2 Type X (Special Fire-Resistant)

48 inch wide, 5/8 inch thick, tapered edges.

2.1.1.3 Mold Resistant / Anti-Microbial Gypsum

ASTM D3273. 48 inch wide, 5/8 inch thick, tapered edges.

2.1.2 Abuse Resistant Gypsum Board

48 inch wide, 5/8 inch thick, tapered edges.

Reinforced gypsum panel with imbedded fiber mesh or lexan backing tested in accordance with the following tests. Hard body impact test must attain a Level 2 performance in accordance with ASTM C1629/C1629M. Provide fasteners that meet manufacturer requirements and specifications stated within this section. Abuse resistant gypsum board, when tested in accordance with ASTM E84, have a flame spread rating of 25 or less and a smoke developed rating of 50 or less .

2.1.2.1 Soft Body Impact Test

ASTM E695 or ASTM D2394 for impact penetration and deformation. ASTM E695 using a 60 lb leather bag filled with steel pellets, resisting no less than 300 ft. lb. cumulative impact energy before failure or ASTM D2394 using 5.5 inch hemispherical projectile resisting no less than 264 ft. lb. before failure. Provide test specimen stud spacing a minimum 16 inch on center.

2.1.2.2 Hard Body Impact Test

Comply with hard body impact test in accordance with ASTM C1629/C1629M Classification Level 2.

2.1.2.3 Surface Abrasion Test

Comply with test surface abrasion test in accordance with ASTM C1629/C1629M.

2.1.2.4 Indentation Test

ASTM D5420 or ASTM D1037 for indentation resistance. ASTM D5420 using a 32 oz weight with a 5/8 inch hemispherical impacting head dropped once 3 feet creating not more than 0.137 inch indentation or ASTM D1037 using no less than 470 lb weight applied to the 0.438 inch diameter ball to create not more than a 0.0197 inch indentation depth.

2.1.3 Cementitious Backer Units

In accordance with the Tile Council of America (TCA) Handbook.

2.1.4 Joint Treatment Materials

ASTM C475/C475M. Product must be low emitting VOC types with VOC limits not exceeding 50 g/L. Provide data identifying VOC content of joint compound. Use all purpose joint and texturing compound containing inert fillers and natural binders, including lime compound. Pre-mixed compounds must be free of antifreeze, vinyl adhesives, preservatives, biocides and other slow releasing compounds.

2.1.4.1 Embedding Compound

Specifically formulated and manufactured for use in embedding tape at gypsum board joints and compatible with tape, substrate and fasteners.

2.1.4.2 Finishing or Topping Compound

Specifically formulated and manufactured for use as a finishing compound.

2.1.4.3 All-Purpose Compound

Specifically formulated and manufactured to serve as both a taping and a finishing compound and compatible with tape, substrate and fasteners.

2.1.4.4 Setting or Hardening Type Compound

Specifically formulated and manufactured for use with fiber glass mesh tape.

2.1.4.5 Joint Tape

Use cross-laminated, tapered edge, reinforced paper, or fiber glass mesh tape recommended by the manufacturer.

2.1.5 Fasteners

2.1.5.1 Nails

ASTM C514.

2.1.5.2 Screws

ASTM C1002, 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 0.033 inch thick. ASTM C954 steel drill screws for fastening gypsum board to steel framing members 0.033 to 0.112 inch thick. Provide cementitious backer unit screws with a polymer coating.

2.1.5.3 Staples

No. 16 USS gage flattened galvanized wire staples with 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	Thickness of Gypsum Board
1-1/8 inches	1/2 inch
1-1/4 inches	5/8 inch

2.1.6 Adhesives

Provide non-aerosol adhesive products used on the interior of the building (defined as inside of the weatherproofing system) meeting either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168. Provide aerosol adhesive products used on the interior of the building (defined as inside of the weatherproofing system)

meeting either emissions requirements of **CDPH SECTION 01350** (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of **GS-36**. Provide certification or validation of **indoor air quality for non-aerosol adhesives** applied on the interior of the building (inside of the weatherproofing system). Provide certification or validation of **indoor air quality for aerosol adhesives** used on the interior of the building (inside of the weatherproofing system).

2.1.6.1 Adhesive for Fastening Gypsum Board to Metal Framing

Type recommended by gypsum board manufacturer.

2.1.7 Gypsum Studs

Provide **one inch** minimum thickness and **6 inch** minimum width. Studs may be of **one inch** thick gypsum board or multilayers fastened to required thickness. Conform to **ASTM C1396/C1396M** for material and **GA 216** for installation.

2.1.8 Accessories

ASTM C1047. Fabricate from corrosion protected steel or plastic designed for intended use. Accessories manufactured with paper flanges are not acceptable. Flanges must be free of dirt, grease, and other materials that may adversely affect bond of joint treatment. Provide prefinished or job decorated materials.

2.1.9 Water

Provide clean, fresh, and potable water.

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 Building Construction Materials

Do not install building construction materials that show visual evidence of biological growth.

3.2 APPLICATION OF GYPSUM BOARD

Apply gypsum board to framing and furring members in accordance with [ASTM C840](#) or [GA 216](#) and the requirements specified. 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; select panel sizes to minimize waste. Cut out gypsum board to make neat, close, and tight 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. Lay out panels to minimize waste; reuse cutoffs whenever feasible. Surfaces of gypsum board and substrate members may be bonded together with an adhesive. Treat edges of cutouts for plumbing pipes, screwheads, and joints with water-resistant compound as recommended by the gypsum board manufacturer. [Minimize framing by floating corners with single studs and drywall clips. Install 5/8 inch gypsum or ceiling board over framing at 24 inch on center.](#) Provide type of gypsum board for use in each system specified herein as indicated.

3.2.1 Solid Gypsum Board Partitions

Provide in accordance with [ASTM C840](#), System V or [GA 216](#).

3.2.2 Application of Gypsum Board to Steel Framing and Furring

Apply in accordance with [ASTM C840](#), System VIII or [GA 216](#).

3.2.3 Arches and Bending Radii

Apply gypsum board in accordance with [ASTM C840](#), System IX or [GA 216](#).

3.2.4 Floating Interior Angles

Minimize framing by floating corners with single studs and drywall clips. Locate the attachment fasteners adjacent to ceiling and wall intersections in accordance with [ASTM C840](#), System XII or [GA 216](#), for single-ply applications of gypsum board to wood framing.

3.2.5 Control Joints

Install expansion and contraction joints in ceilings and walls in accordance with [ASTM C840](#), System XIII or [GA 216](#). [Fill control joints between studs in fire-rated construction with firesafing insulation to match the fire-rating of construction.](#)

3.2.6 Application of Abuse Resistant Gypsum Board

Apply in accordance with applicable system of [ASTM C840](#) 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](#). Place a [15 lb](#) asphalt impregnated, continuous felt paper membrane behind cementitious backer units, between backer units and studs or base layer of

gypsum board. Place membrane with a minimum 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 C840, GA 214 and GA 216. Finish plenum areas above ceilings to Level 1 in accordance with GA 214. Finish water resistant gypsum backing board, ASTM C1396/C1396M, to receive ceramic tile to Level 2 in accordance with GA 214. Finish walls and ceilings to receive a heavy-grade wall covering or heavy textured finish before painting to Level 3 in accordance with GA 214. Finish walls and ceilings without critical lighting to receive flat paints, light textures, or wall coverings to Level 4 in accordance with GA 214. Unless otherwise specified, finish all gypsum board walls, partitions and ceilings to Level 5 in accordance with GA 214. Provide joint, fastener depression, and corner treatment. Tool joints as smoothly as possible to minimize sanding and dust. Do not use self-adhering 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. Protect workers, building occupants, and HVAC systems from gypsum dust.

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 with 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 07 92 00 JOINT SEALANTS. Apply material with exposed surface flush with gypsum board or cementitious backer units.

3.6 FIRE-RESISTANT ASSEMBLIES

Wherever fire-rated construction is indicated and/or encountered, provide materials and application methods, including types and spacing of fasteners, in accordance with the specifications contained in UL Fire Resistance for the Design Number(s) indicated, or GA 600 for the File Number(s) indicated. Joints of fire-rated gypsum board enclosures must be closed and sealed in accordance with UL test requirements or GA requirements. Seal penetrations through rated partitions and ceilings tight in accordance with tested systems.

3.7 SOUND RATED ASSEMBLIES

When sound rated assemblies are required, provide materials and application methods, including panels, insulation, types and spacing of fasteners, wall framing in accordance with the contract document and the description of the assembly in the ASTM E90 Factory Test Report. Seal

partitions continuously with acoustical foam or sealant (both sides) and finished to match wall wherever it abuts another element such as the floor, ceiling, wall, column, mullion, or another system or assembly.

3.8 PATCHING

Patch surface defects in gypsum board to a smooth, uniform appearance, ready to receive finishes.

3.9 SOUND RATED ASSEMBLY FIELD TESTING

Provide third party testing of sound rated assemblies tested in accordance with [ASTM E336](#). Provide the [ASTM E336 Field Test Report](#) verifying that the installed assemblies perform no less than five ASTC rating points below the [ASTM E90 Factory Test Report](#). Examine, modify adjust, and retest any installation not meeting the STC Rating until compliance is obtained.

-- End of Section --

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SECTION 09 51 00

ACOUSTICAL CEILINGS

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.

ASTM INTERNATIONAL (ASTM)

ASTM A489	(2018; E 2018) Standard Specification for Carbon Steel Eyebolts
ASTM A641/A641M	(2019) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A1008/A1008M	(2021a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM B633	(2019) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM C423	(2009a) Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
ASTM C635/C635M	(2017) Standard Specification for Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings
ASTM C636/C636M	(2013) Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels
ASTM C834	(2017) Standard Specification for Latex Sealants
ASTM E413	(2022) Classification for Rating Sound Insulation
ASTM E580/E580M	(2022) Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas

Subject to Earthquake Ground Motions

ASTM E1111/E1111M	(2014; R 2022) Standard Test Method for Measuring the Interzone Attenuation of Open Office Components
ASTM E1414/E1414M	(2021a) Standard Test Method for Airborne Sound Attenuation Between Rooms Sharing a Common Ceiling Plenum
ASTM E1477	(1998a; R 2017; E 2018) Standard Test Method for Luminous Reflectance Factor of Acoustical Materials by Use of Integrating-Sphere Reflectometers

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

GREEN SEAL (GS)

GS-36	(2013) Adhesives for Commercial Use

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS	SCS Global Services (SCS) Indoor Advantage

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019, with Change 1, 2022) Structural Engineering

UNDERWRITERS LABORATORIES (UL)

UL 2818	(2013) GREENGUARD Certification Program For Chemical Emissions For Building Materials, Finishes And Furnishings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Recycled Content for Suspension Systems; S

Acoustical Performance; G

SD-04 Samples

Acoustical Ceiling Tiles; G

SD-07 Certificates

Indoor Air Quality for Adhesives; S

Indoor Air Quality for Sealants; S

1.3 CERTIFICATIONS

1.3.1 Indoor Air Quality Certifications

1.3.1.1 Acoustical Ceiling Tiles

Provide products certified to meet indoor air quality requirements by **UL 2818** (Greenguard) Gold, **SCS** Global Services Indoor Advantage Gold or provide certification or validation by other third-party programs that products meet the requirements of this section. Provide current product certification documentation from certification body.

1.3.1.2 Adhesives and Sealants

Provide products certified to meet indoor air quality requirements by **UL 2818** (Greenguard) Gold, **SCS** Global Services Indoor Advantage Gold or provide certification or validation by other third-party programs that products meet the requirements of this Section. Provide current product certification documentation from certification body. When product does not have certification, provide validation that product meets the indoor air quality product requirements cited in this Section.

1.4 DELIVERY, STORAGE. AND HANDLING

Deliver materials to the site in the manufacturer's original unopened containers with brand name and type clearly marked. Carefully handle and store materials in dry, watertight enclosures. Immediately before installation, store acoustical units 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

Maintain a uniform temperature of not less than **60 degrees F** nor more than **85 degrees F** and a relative humidity of not more than 70 percent for 24 hours before, during, and 24 hours after installation of acoustical units.

1.6 SCHEDULING

Complete and dry interior finish work such as plastering, concrete and terrazzo work before ceiling installation. Complete mechanical, electrical, and other work above the ceiling line; install and start operating heating, ventilating, and air conditioning systems in order to maintain temperature and humidity requirements.

1.7 WARRANTY

Provide manufacturer's warranty to repair or replace defective materials

and workmanship including but not limited to, sagging and warping of panels and rusting and of grid systems, for a period of ten years from date of final acceptance of the work.

1.8 EXTRA MATERIALS

Furnish spare tiles, from the same lot as those installed, of each color at the rate of 5 tiles for each 1000 tiles installed.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide sound controlling units mechanically mounted on a ceiling suspension system for acoustical treatment. Provide the unit size, texture, finish, and color to match existing adjacent construction or as specified. Coordinate the entire ceiling system with other details, like the location of access panels and ceiling penetrations. The Contractor is responsible for the final assembly and performance of the specified work. Provide the location and extent of acoustical treatment to match existing adjacent construction.

2.1.1 Acoustical Performance

2.1.1.1 Ceiling Sound Transmission

Provide ceiling systems with the specified Ceiling Attenuation Class (CAC) ratings as determined in accordance with ASTM E1414/E1414M and ASTM E413. Provide sound attenuators over light fixtures, air terminals and other ceiling penetrations, provide acoustical blanket insulation on top of the ceiling or adjacent to partitions to provide lightweight acoustical plenum barriers above partitions as required to match existing construction and achieve the specific CAC ratings.

2.1.1.2 Ceiling Sound Absorption

Determine the Noise Reduction Coefficient (NRC) in accordance with ASTM C423. Determine Articulation Class (AC) in accordance with ASTM E1111/E1111M.

2.1.2 Light Reflectance

Determine light reflectance factor in accordance with ASTM E1477 test method.

2.2 SUSPENSION SYSTEM

Provide standard suspension system conforming to ASTM C635/C635M for intermediate-duty systems. Provide surfaces exposed to view of aluminum or steel with a factory-applied white baked-enamel finish. Provide wall molding having a flange of not less than 15/16 inch to match existing. Provide standard corners. Provide a suspension system with a maximum deflection of 1/360 of the span length capable of supporting the finished ceiling, light fixtures, air diffusers, and accessories, as shown. Conform seismic details to the guidance in UFC 3-301-01 and ASTM E580/E580M.

Provide Suspension System containing a minimum of 15 percent recycled content. Provide data identifying percentage of recycled content for suspension systems.

2.3 HANGERS

Provide hangers and attachment capable of supporting a minimum 300 pound ultimate vertical load without failure of supporting material or attachment.

2.3.1 Wires

Conform wires to ASTM A641/A641M, Class 1, 0.08 inch (12 gauge) in diameter.

2.3.2 Straps

Provide straps of 1 by 3/16 inch galvanized steel conforming to ASTM A653/A653M, with a light commercial zinc coating or ASTM A1008/A1008M with an electrodeposited zinc coating conforming to ASTM B633, Type RS.

2.3.3 Rods

Provide 3/16 inch diameter threaded steel rods, zinc or cadmium coated.

2.3.4 Eyebolts

Provide eyebolts of weldless, forged-carbon-steel, with a straight-shank in accordance with ASTM A489. Provide minimum 1/4 inch, zinc coated eyebolts.

2.4 ACCESS PANELS

Provide access panels that match adjacent acoustical units, designed and equipped with suitable framing and fastenings for removal and replacement without damage. Size panel to be not less than 12 by 12 inch or more than 12 by 24 inch.

a. Attach an identification plate of 0.032 inch thick aluminum, 3/4 inch in diameter, stamped with the letters "AP" and finished the same as the unit, 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. Provide plates or buttons of minimum 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 is 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) Intercommunication system

2.5 ADHESIVE

Use adhesive as recommended by tile manufacturer. Provide non-aerosol adhesive products used on the interior of the building (defined as inside of the weatherproofing system) that meet either emissions requirements of [CDPH SECTION 01350](#) (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of [SCAQMD Rule 1168](#). Provide aerosol adhesives used on the interior of the building that meet either emissions requirements of [CDPH SECTION 01350](#) (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of [GS-36](#). For products located on the interior of the building (inside of the weatherproofing system), provide certification or validation of [indoor air quality for adhesives](#).

2.6 FINISHES

Use manufacturer's standard textures, patterns and finishes as specified for acoustical units and suspension system members. Treat ceiling suspension system components to inhibit corrosion.

2.7 COLORS AND PATTERNS

Use colors and patterns for acoustical units and suspension system components as [encountered](#); colors listed are not intended to limit the selection of equal colors from other manufacturers.

2.8 ACOUSTICAL SEALANT

Conform acoustical sealant to [ASTM C834](#), nonstaining. That meet either emissions requirements of [CDPH SECTION 01350](#) (limit the requirements for either office or classroom spaces regardless of space type) or VOC content requirements of [SCAQMD Rule 1168](#). For products located on the interior of the building (inside of the weatherproofing system), provide certification of [indoor air quality for Sealants](#).

PART 3 EXECUTION

3.1 INSTALLATION

Do not install building construction materials that show visual evidence of biological growth.

Examine surfaces to receive directly attached acoustical units for unevenness, irregularities, and dampness that would affect quality and execution of the work. Rid areas, where acoustical units will be cemented, of oils, form residue, or other materials that reduce bonding capabilities of the adhesive. Complete and dry interior finish work such as plastering, concrete, and terrazzo work before installation. Complete and approve mechanical, electrical, and other work above the ceiling line prior to the start of acoustical ceiling installation. Provide acoustical work complete with necessary fastenings, clips, and other accessories required for a complete installation. Do not expose mechanical fastenings in the finished work. Lay out hangers for each individual room or space. Provide hangers to support framing around beams, ducts, columns, grilles, and other penetrations through ceilings. Keep main runners and carrying channels clear of abutting walls and partitions. Provide at least two main runners for each ceiling span. Wherever required to bypass an object with the hanger wires, install a subsuspension system so that all hanger

wires will be plumb.

3.1.1 Suspension System

Install suspension system in accordance with **ASTM C636/C636M** and as specified herein. Do not suspend hanger wires or other loads from underside of steel decking.

3.1.1.1 Plumb Hangers

Install hangers plumb and not pressing against insulation covering ducts and pipes. Where lighting fixtures are supported from the suspended ceiling system, provide hangers at a minimum of four hangers per fixture and located not more than **6 inch** from each corner of each fixture.

3.1.1.2 Splayed Hangers

Splay (slope or slant) hangers around obstructions, offsetting the resulting horizontal force by bracing, countersplaying, or other acceptable means.

3.1.2 Wall Molding

Provide wall molding where ceilings abut vertical surfaces. Miter corners where wall moldings intersect or install corner caps. Secure wall molding not more than **3 inch** from ends of each length and not more than **16 inch** on centers between end fastenings. Provide wall molding springs at each acoustical unit in semi-exposed or concealed systems.

3.1.3 Acoustical Units

Install acoustical units in accordance with the approved installation instructions of the manufacturer. Ensure that edges of acoustical units are in close contact with metal supports, with each other, and in true alignment. Arrange acoustical units so that units less than one-half width are minimized. Hold units in exposed-grid system in place with manufacturer's standard hold-down clips, if units weigh less than **1 psf** or if required for fire resistance rating.

3.1.4 Acoustical Sealant

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.

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. Ensure that contact area of each daub is at least **2 inch** 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

Locate ceiling access panels directly under the items which require access.

3.3 CLEANING

Following installation, clean dirty or discolored surfaces of acoustical units and leave them free from defects. Remove units that are damaged or improperly installed and provide new units as directed.

-- End of Section --

SECTION 09 90 00

PAINTS AND COATINGS

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

1.1.1 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.

1.1.1.1 Exterior Painting

Includes new surfaces of the building and appurtenances. Also included are existing coated surfaces made bare by cleaning and construction operations.

1.1.1.2 Interior Painting

Includes new 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 as a direct result of project construction activities. Paint entire wall/ area when touch up is required.

1.1.2 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, anodized aluminum, brass, and lead except existing coated surfaces.

- e. Hardware, fittings, and other factory finished items.

1.1.3 Mechanical and Electrical Painting

Includes field coating of interior new 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.

1.1.4 Miscellaneous Painting

1.2 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 0100	(2017; Suppl 2020) Documentation of the Threshold Limit Values and Biological Exposure Indices

ASTM INTERNATIONAL (ASTM)

ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D235	(2002; R 2012) Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)
ASTM D523	(2014; R 2018) Standard Test Method for Specular Gloss
ASTM D4263	(1983; R 2018) Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D4444	(2013; R 2018) Standard Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters
ASTM D6386	(2016a) Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting
ASTM F1869	(2016a) Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

CENTERS FOR DISEASE CONTROL AND PREVENTION (CDC)

Intelligence Bulletin 65 (2013) Occupational Exposure to Carbon
Nanotubes and Nanofibers

MASTER PAINTERS INSTITUTE (MPI)

MPI 4	(2016) Interior/Exterior Latex Block Filler
MPI 8	(2016) Alkyd, Exterior Flat (MPI Gloss Level I)
MPI 11	(2016) Latex, Exterior Semi-Gloss, MPI Gloss Level 5
MPI 76	(2016) Primer, Alkyd, Quick Dry, for Metal
MPI 77	(2015) Epoxy, Gloss
MPI 79	(2016) Primer, Alkyd, Anti-Corrosive for Metal
MPI 95	(2015) Primer, Quick Dry, for Aluminum
MPI 101	(2016) Primer, Epoxy, Anti-Corrosive, for Metal
MPI 107	(2016) Primer, Rust-Inhibitive, Water Based
MPI 108	(2015) Epoxy, High Build, Low Gloss
MPI 138	(2016) Latex, Interior, High Performance Architectural, (MPI Gloss Level 2)
MPI 139	(2016) Latex, Interior, High Performance Architectural, (MPI Gloss Level 3)
MPI 145	(2016) Latex, Interior, Institutional Low Odor/VOC, (MPI Gloss Level 3)
MPI 146	(2016) Latex, Interior, Institutional Low Odor/VOC, (MPI Gloss Level 4)
MPI 149	(2016) Primer Sealer, Interior, Institutional Low Odor/VOC
MPI 163	(2016) Light Industrial Coating, Exterior, Water Based, Semi-Gloss (MPI Gloss Level 5)
MPI ASM	(2019) Architectural Painting Specification Manual
MPI GPS-1-14	(2014) Green Performance Standard GPS-1-14
MPI GPS-2-14	(2014) Green Performance Standard GPS-2-14
MPI MRM	(2015) Maintenance Repainting Manual

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC 7/NACE No.4	(2007) Brush-Off Blast Cleaning
SSPC Glossary	(2011) SSPC Protective Coatings Glossary
SSPC PA 1	(2016) Shop, Field, and Maintenance Coating of Metals
SSPC QP 1	(2019) Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors (Field Application to Complex Industrial Steel Structures and Other Metal Components)
SSPC SP 1	(2015) Solvent Cleaning
SSPC SP 2	(2018) Hand Tool Cleaning
SSPC SP 3	(2018) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning
SSPC SP 10/NACE No. 2	(2015) Near-White Blast Cleaning
SSPC VIS 1	(2002; E 2004) Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning
SSPC VIS 3	(2004) Guide and Reference Photographs for Steel Surfaces Prepared by Hand and Power Tool Cleaning
SSPC VIS 4/NACE VIS 7	(1998; E 2000; E 2004) Guide and Reference Photographs for Steel Surfaces Prepared by Waterjetting
SSPC-SP WJ-1/NACE WJ-1	(2012) Clean to Bare Substrate, Waterjet Cleaning of Metals
SSPC-SP WJ-2/NACE WJ-2	(2012) Very Thorough Cleaning, Waterjet Cleaning of Metals
SSPC-SP WJ-3/NACE WJ-3	(2012) Thorough Cleaning, Waterjet Cleaning of Metals
SSPC-SP WJ-4/NACE WJ-4	(2012) Light Cleaning, Waterjet Cleaning of Metals

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA Method 24

(2000) Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids of Surface Coatings

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-313

(2018) Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.1000

Air Contaminants

1.3 DEFINITIONS

1.3.1 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.

1.3.2 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 must be accomplished by an MPI testing lab.

1.3.3 Coating

SSPC Glossary; (1) A liquid, liquefiable, or mastic composition that is converted to a solid protective, decorative, or functional adherent film after application as a thin layer; (2) Generic term for paint, lacquer, enamel.

1.3.4 DFT or dft

Dry film thickness, the film thickness of the fully cured, dry paint or coating.

1.3.5 DSD

Degree of Surface Degradation, the MPI system of defining degree of surface degradation. Five levels are generically defined under the Assessment sections in the **MPI MRM**, MPI Maintenance Repainting Manual.

1.3.6 EXT

MPI short term designation for an exterior coating system.

1.3.7 INT

MPI short term designation for an interior coating system.

1.3.8 Loose Paint

Paint or coating that can be removed with a dull putty knife.

1.3.9 mil / mils

The English measurement for 0.001 in or one one-thousandth of an inch.

1.3.10 MPI Gloss Levels

MPI system of defining gloss. Seven 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 at 60 degree angle	Units at 80 degree angle
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 D523](#). Historically, the Government has used Flat (G1 / G2), Eggshell (G3), Semi-Gloss (G5), and Gloss (G6).

1.3.11 MPI System Number

The MPI coating system number in each MPI 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).

1.3.12 Paint

[SSPC Glossary](#); (1) Any pigmented liquid, liquefiable, or mastic composition designed for application to a substrate in a thin layer that is converted to an opaque solid film after application. Used for protection, decoration, identification, or to serve some other functional purposes; (2) Application of a coating material.

1.3.13 REX

MPI short term designation for an exterior coating system used in repainting projects or over existing coating systems.

1.3.14 RIN

MPI short term designation for an interior coating system used in repainting projects or over existing coating systems.

1.4 SCHEDULING

Allow paint, polyurethane, varnish, and wood stain installations to cure prior to the installation of materials that adsorb VOCs, including carpets, unprimed gypsum wallboard, acoustical ceiling panels.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

Samples of specified materials may be taken and tested for compliance with specification requirements.

SD-02 Shop Drawings

Piping Identification

SD-03 Product Data

Coating; G

Product Data Sheets

Sealant

SD-04 Samples

Color; G

SD-07 Certificates

Qualification Testing laboratory for coatings; G

SD-08 Manufacturer's Instructions

Mixing

Manufacturer's Safety Data Sheets

SD-10 Operation and Maintenance Data

Coatings, Data Package 1; G

1.6 QUALITY ASSURANCE

1.6.1 Regulatory Requirements

1.6.1.1 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.

1.6.1.2 Lead Content

Do not use coatings having a lead content over 0.06 percent by weight of nonvolatile content.

1.6.1.3 Chromate Content

Do not use coatings containing zinc-chromate or strontium-chromate.

1.6.1.4 Asbestos Content

Provide asbestos-free materials.

1.6.1.5 Mercury Content

Provide materials free of mercury or mercury compounds.

1.6.1.6 Silica

Provide abrasive blast media containing no free crystalline silica.

1.6.1.7 Human Carcinogens

Provide materials that do not contain ACGIH 0100 confirmed human carcinogens (A1) or suspected human carcinogens (A2).

1.6.1.8 Carbon Based Fibers / Tubes

Materials must not contain carbon based fibers such as carbon nanotubes or carbon nanofibers. Intelligence Bulletin 65 ranks toxicity of carbon nanotubes on a par with asbestos.

1.6.2 Coating Contractor's Qualification

Submit the name, address, telephone number, and e-mail address of the Contractor that will be performing all surface preparation and coating application. Submit evidence that key personnel have successfully performed surface preparation and application of coatings on a minimum of three similar projects within the past three years. List information by individual and include the following:

a. Name of individual and proposed position for this work.

b. Information about each previous assignment including:

Position or responsibility

Employer (if other than the Contractor)

Name of facility owner

Mailing address and telephone number of facility owner

Name of individual in facility owner's organization who can be contacted as a reference

Location, size and description of structure

Dates work was carried out

Description of work carried out on structure

1.6.3 SSPC QP 1 Certification

Contractors that perform surface preparation or coating application on steel substrates must be certified by the Society for Protective Coatings (formerly Steel Structures Painting Council) (SSPC) to the requirements of **SSPC QP 1** prior to Contract award, and must remain certified while accomplishing any surface preparation or coating application. If a Contractor's certification expires, the firm will not be allowed to perform any work until the certification is reissued. Requests for extension of time for any delay to the completion of the project due to an inactive certification will not be considered. Notify the Contracting Officer of any change in Contractor certification status. Notify the Contracting Officer of all scheduled and unannounced on-site audits from SSPC and furnish a copy of all audit reports.

1.6.4 Approved Products List

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. Provide all coats on a particular substrate from a single manufacturer. No variation from the MPI Approved Products List is acceptable.

1.6.5 Paints and Coatings Indoor Air Quality Certifications

Provide paint and coating products certified to meet indoor air quality requirements by **MPI GPS-1-14**, **MPI GPS-2-14** or provide certification by other third-party programs. Provide current product certification documentation from certification body.

Provide certification of **Indoor Air Quality for Paints and Primers**. Submit required indoor air quality certifications in one submittal package.

1.6.6 Field Samples and Tests

The Contracting Officer may choose up to two coatings that have been delivered to the site to be tested at no cost to the Government. Take samples of each chosen product as specified in the paragraph SAMPLING PROCEDURE. Test each chosen product as specified in the paragraph TESTING PROCEDURE. Remove products from the job site which do not conform, and

replace with new products that conform to the referenced specification. Test replacement products that failed initial testing as specified in the paragraph TESTING PROCEDURE at no cost to the Government.

1.6.6.1 Sampling Procedure

Select paint at random from the products that have been delivered to the job site for sample testing. The Contractor must provide **one quart** samples of the selected paint materials. Take samples in the presence of the Contracting Officer, and label, and identify each sample. Provide labels in accordance with the paragraph PACKAGING, LABELING, AND STORAGE.

1.6.6.2 Testing Procedure

Provide Batch Quality Conformance Testing for specified products, as defined by and performed by MPI. As an alternative to Batch Quality Conformance Testing, the Contractor may provide **Qualification Testing** for specified products above to the appropriate MPI product specification, using the third-party laboratory approved under the paragraph QUALIFICATION TESTING laboratory for coatings. Include the backup data and summary of the test results within the qualification testing lab report. Provide a summary listing of all the reference specification requirements and the result of each test. Clearly indicate in the summary whether the tested paint meets each test requirement. Note that Qualification Testing may take 4 to 6 weeks to perform, due to the extent of testing required.

Submit name, address, telephone number, FAX number, and e-mail address of the independent third party laboratory selected to perform testing of coating samples for compliance with specification requirements. Submit documentation that laboratory is regularly engaged in testing of paint samples for conformance with specifications, and that employees performing testing are qualified. If MPI is chosen to perform the Batch Quality Conformance testing, the above submittal information is not required, only a letter is required from the Contractor stating that MPI will perform the testing.

1.7 PACKAGING, LABELING, AND STORAGE

Provide paints 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. Furnish pigmented paints in containers not larger than **5 gallons**. Store paints and thinners 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 **40 to 95 degrees F**. **Do not store paint, polyurethane, varnish, or wood stain products with materials that have a high capacity to absorb VOC emissions. Do not store paint, polyurethane, varnish, or wood stain products in occupied spaces.**

1.8 SAFETY AND HEALTH

Comply with applicable Federal, State, and local laws and regulations, and with the ACCIDENT PREVENTION PLAN, including the Activity Hazard Analysis and in Appendix A of **EM 385-1-1**. Include in the Activity Hazard Analysis

the potential impact of painting operations on painting personnel and on others involved in and adjacent to the work zone.

1.8.1 Toxic Materials

To protect personnel from overexposure to toxic materials, conform to the most stringent guidance of:

- a. The applicable [manufacturer's Safety Data Sheets](#) (SDS) or local regulation.
- b. [29 CFR 1910.1000](#).
- c. [ACGIH 0100](#), threshold limit values.

Submit manufacturer's Safety Data Sheets for coatings, solvents, and other potentially hazardous materials, as defined in [FED-STD-313](#).

1.9 ENVIRONMENTAL REQUIREMENTS

Comply, at minimum, with manufacturer recommendations for space ventilation during and after installation. Isolate area of application from rest of building when applying high-emission paints or coatings.

1.9.1 Coatings

Do not apply coating when air or substrate conditions are:

- a. Less than [5 degrees F](#) above dew point;
- b. Below [50 degrees F](#) or over [95 degrees F](#), unless specifically pre-approved by the Contracting Officer and the product manufacturer. Do not, under any circumstances, violate the manufacturer's application recommendations.

1.9.2 Post-Application

Vacate space for as long as possible after application. Wait a minimum of 48 hours before occupying freshly painted rooms. Maintain one of the following ventilation conditions during the curing period, or for 72 hours after application:

- a. Supply 100 percent outside air 24 hours a day.
- b. Supply airflow at a rate of 6 air changes per hour, when outside temperatures are between [55 degrees F](#) and [85 degrees F](#) and humidity is between 30 percent and 60 percent.
- c. Supply airflow at a rate of 1.5 air changes per hour, when outside air conditions are not within the range stipulated above.

PART 2 PRODUCTS

2.1 MATERIALS

Conform to the [coating](#) specifications and standards referenced in PART 3. Submit [Product Data Sheets](#) for specified [coatings](#) and solvents. Provide preprinted cleaning and maintenance instructions for all coating systems. Submit Manufacturer's Instructions on [Mixing](#): Detailed mixing

instructions, minimum and maximum application temperature and humidity, pot life, and curing and drying times between coats.

2.2 COLOR SELECTION OF FINISH COATS

Provide colors of finish coats as indicated or specified or to match existing. Allow Contracting Officer to select colors not indicated or specified. 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 are approximately the colors indicated and the product conforms to specified requirements.

Provide color, texture, and pattern of wall coating systems. Submit manufacturer's samples of paint colors. Cross reference color samples to color scheme as indicated. Submit color stencil codes. Tint each coat progressively darker to enable confirmation of the number of coats.

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, reinstall removed items by workmen skilled in the trades. Restore surfaces contaminated by coating materials, to original condition and repair damaged items.

3.2 RESEALING OF EXISTING EXTERIOR JOINTS

3.2.1 Backstops

In joints more than 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. Provide backstop material compatible with sealant. Do not use oakum and other types of absorptive materials as backstops.

3.2.2 Primer and Bond Breaker

Install the type recommended by the sealant manufacturer.

3.2.3 Ambient Temperature

Between 38 degrees F and 95 degrees F when applying sealant.

3.2.4 Exterior Sealant

For joints in vertical surfaces, provide ASTM C920, Type S or M, Grade NS, Class 25, Use NT. For joints in horizontal surfaces, provide ASTM C920, Type S or M, Grade P, Class 25, Use T. Color(s) will 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. Apply sealant uniformly smooth and free of wrinkles.

3.2.5 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.

3.3 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. Remove oil and grease prior to mechanical cleaning. Schedule cleaning so that dust and other contaminants will not fall on wet, newly painted surfaces. Spot-prime exposed ferrous metals such as nail heads on or in contact with surfaces to be painted with water-thinned paints, with a suitable corrosion-inhibitive primer capable of preventing flash rusting and compatible with the coating specified for the adjacent areas. Refer to [MPI ASM](#) and [MPI MRM](#) for additional more specific substrate preparation requirements.

3.3.1 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.

3.4 PREPARATION OF METAL SURFACES

3.4.1 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/NACE No.3](#), or [SSPC SP 10/NACE No. 2](#). Brush-off blast remaining surface in accordance with [SSPC 7/NACE No.4](#). Protect shop-coated ferrous surfaces 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/NACE No.3](#) / [SSPC-SP WJ-3/NACE WJ-3](#) [SSPC SP 10/NACE No. 2](#) / [SSPC-SP WJ-2/NACE WJ-2](#).

3.4.2 Final Ferrous Surface Condition:

3.4.2.1 Tool Cleaned Surfaces

Comply with [SSPC SP 2](#) and [SSPC SP 3](#). Use as a visual reference, photographs in [SSPC VIS 3](#) for the appearance of cleaned surfaces.

3.4.2.2 Abrasive Blast Cleaned Surfaces

Comply with SSPC 7/NACE No.4, SSPC SP 6/NACE No.3, and SSPC SP 10/NACE No. 2. Use as a visual reference, photographs in SSPC VIS 1 for the appearance of cleaned surfaces.

3.4.2.3 Waterjet Cleaned Surfaces

Comply with SSPC-SP WJ-1/NACE WJ-1, SSPC-SP WJ-2/NACE WJ-2, SSPC-SP WJ-3/NACE WJ-3 or SSPC-SP WJ-4/NACE WJ-4. Use as a visual reference, photographs in SSPC VIS 4/NACE VIS 7 for the appearance of cleaned surfaces.

3.4.3 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. Completely remove coating by brush-off abrasive blast if the galvanized metal has been passivated or stabilized. Do not "passivate" or "stabilize" new galvanized steel to be coated. If the absence of hexavalent stain inhibitors is not documented, test as described in ASTM D6386, 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 WJ-3/NACE WJ-3 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: Water jet to SSPC-SP WJ-3/NACE WJ-3 degree of cleanliness.

3.4.4 Non-Ferrous Metallic Surfaces

Aluminum and aluminum-alloy, lead, copper, and other nonferrous metal surfaces.

Surface Cleaning: Solvent clean in accordance with SSPC SP 1 and wash with mild non-alkaline detergent to remove dirt and water soluble contaminants.

3.4.5 Terne-Coated Metal Surfaces

Solvent clean surfaces with mineral spirits, ASTM D235. Wipe dry with clean, dry cloths.

3.4.6 Existing Surfaces with a Bituminous or Mastic-Type Coating

Remove chalk, mildew, and other loose material by washing with a solution of 1/2 cup trisodium phosphate, 1/4 cup household detergent, one quart 5 percent sodium hypochlorite solution and 3 quarts of warm water.

3.5 PREPARATION OF CONCRETE AND CEMENTITIOUS SURFACE

3.5.1 Concrete and Masonry

- a. Curing: Allow concrete, stucco and masonry surfaces to cure at least 30 days before painting, and concrete slab on grade to cure at least

90 days before painting.

b. Surface Cleaning: Remove the following deleterious substances.

- (1) Dirt, Chalking, Grease, and Oil: Wash new surfaces with a solution composed of $\frac{1}{2}$ cup trisodium phosphate, $\frac{1}{4}$ cup household detergent, and 4 quarts of warm water. Then rinse thoroughly with fresh water. For large areas, water blasting may be used.
- (2) Fungus and Mold: Wash surfaces with a solution composed of $\frac{1}{2}$ cup trisodium phosphate, $\frac{1}{4}$ cup household detergent, one quart 5 percent sodium hypochlorite solution and 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 4 square feet of surface, per workman, at one time.

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 D4263 or horizontal surfaces that exceed 3 lbs of moisture per 1000 square feet in 24 hours as determined by ASTM F1869. In all cases follow manufacturer's recommendations. Allow surfaces to cure a minimum of 30 days before painting.

3.5.2 Gypsum Board, Plaster, and Stucco

3.5.2.1 Surface Cleaning

Verify that plaster and stucco surfaces are free from loose matter and that gypsum board is 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 is water-based.

3.5.2.2 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.

3.5.2.3 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 D4263. Verify that new plaster to be coated has a maximum moisture content of 8 percent, when measured in accordance with ASTM D4444, 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 APPLICATION

3.6.1 Coating Application

- a. Comply with applicable federal, state and local laws enacted to ensure 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.
- b. At the time of application, paint must show no signs of deterioration. Maintain uniform suspension of pigments during application.
- c. Unless otherwise specified or recommended by the paint manufacturer, paint may be applied by brush, roller, or spray. Use trigger operated spray nozzles for water hoses. Use rollers for applying paints and enamels of a type designed for the coating to be applied and the surface to be coated. Wear protective clothing and respirators when applying oil-based paints or using spray equipment with any paints.
- d. Only apply paints, except water-thinned types, to surfaces that are completely free of moisture as determined by sight or touch.
- e. Thoroughly work coating materials into joints, crevices, and open spaces. Pay special attention to ensure that all edges, corners, crevices, welds, and rivets receive a film thickness equal to that of adjacent painted surfaces.
- f. Apply each coat of paint so that dry film is of uniform thickness and free from runs, drops, ridges, waves, pinholes or other voids, laps, brush marks, and variations in color, texture, and finish. Completely hide all blemishes.
- g. Touch up damaged coatings before applying subsequent coats. Broom clean and clear dust from interior areas before and during the application of coating material.
- h. 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.
- i. 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. Cover each preceding coat or surface completely by ensuring visually perceptible difference in shades of successive coats.
- j. Finished Surfaces: Provide finished surfaces free from runs, drops, ridges, waves, laps, brush marks, and variations in colors.
- k. Thermosetting Paints: Apply topcoats over thermosetting paints (epoxies and urethanes) within the overcoat window recommended by the

manufacturer.

3.6.2 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. Verify that the written permission includes quantities and types of thinners to use.

When thinning is allowed, thin paints immediately prior to application with not more than **one pint** of suitable thinner per **gallon**. The use of thinner does not relieve the Contractor from obtaining complete hiding, full film thickness, or required gloss. Thinning cannot cause the paint to exceed limits on volatile organic compounds. Do not mix paints of different manufacturers.

3.6.3 Two-Component Systems

Mix two-component systems in accordance with manufacturer's instructions. Follow recommendation by the manufacturer for any thinning of the first coat to ensure proper penetration and sealing for each type of substrate.

3.6.4 Coating Systems

- a. Systems by Substrates: Apply coatings that conform to the respective specifications listed in the following Tables:

Table for Exterior Applications	
MPI Division	Substrate Application
MPI Division 3	Exterior Concrete Paint Table
MPI Division 4	Exterior Concrete Masonry Units Paint Table
MPI Division 5	Exterior Metal, Ferrous and Non-Ferrous Paint Table
MPI Division 6	Exterior Wood; Dressed Lumber, Paneling, Decking, Shingles Paint Table
MPI Division 9	Exterior Stucco Paint Table
MPI Division 10	Exterior Cloth Coverings and Bituminous Coated Surfaces Paint Table

Table for Interior Applications	
MPI Division	Substrate Application
MPI Division 3	Interior Concrete Paint Table
MPI Division 4	Interior Concrete Masonry Units Paint Table

Table for Interior Applications	
MPI Division 5	Interior Metal, Ferrous and Non-Ferrous Paint Table
MPI Division 6	Interior Wood Paint Table
MPI 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 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 unspecified surfaces 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.

3.7 COATING SYSTEMS FOR METAL

Apply coatings of Tables in MPI Division 5 for Exterior and Interior.

- a. Apply specified ferrous metal primer to steel surfaces 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, 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. Overcoat these items 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.

3.8 COATING SYSTEMS FOR CONCRETE AND CEMENTITIOUS SUBSTRATES

Apply coatings of Tables in MPI Division 3, 4 and 9 for Exterior and Interior.

3.9 COATING SYSTEMS FOR WOOD AND PLYWOOD

- a. Apply coatings of Tables in MPI Division 6 for Exterior and Interior.
- b. Prior to erection, apply two coats of specified primer to treat and prime wood surfaces which will be inaccessible after erection.
- c. Apply stains in accordance with manufacturer's printed instructions.

3.10 PIPING IDENTIFICATION

Piping Identification, Including Surfaces In Concealed Spaces: Provide in accordance with MIL-STD-101. Place stenciling in clearly visible locations. On piping not covered by MIL-STD-101, stencil approved names or code letters, in letters a minimum of 1/2 inch high for piping and a minimum of 2 inches high elsewhere. Stencil arrow-shaped markings on piping to indicate direction of flow using black stencil paint.

3.11 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.

3.12 WASTE MANAGEMENT

As specified in the Waste Management Plan and as follows. Do not use kerosene or any such organic solvents to clean up water based paints. Properly dispose of paints or solvents in designated containers. Close and seal partially used containers of paint to maintain quality as necessary for reuse. Store in protected, well-ventilated, fire-safe area at moderate temperature. Place materials defined as hazardous or toxic waste in designated containers. Coordinate with manufacturer for take-back program. Set aside scrap to be returned to manufacturer for recycling into new product. When such a service is not available, contact local recyclers to reclaim the materials.

3.13 PAINT TABLES

All DFT's are minimum values. Use only materials with a MPI GPS-1-14 green check mark having a minimum MPI "Environmentally Friendly" E1 rating based on VOC (EPA Method 24) content levels. Acceptable products are listed in the MPI Green Approved Products List, available at <http://www.specifygreen.com/APL/ProductIdxByMPInum.asp>.

3.13.1 Exterior Paint Tables

3.13.1.1 MPI Division 4: Exterior Concrete Masonry Units Paint Table

A. New concrete masonry on uncoated surface

Latex						
New	Existing	Block Filler	Primer	Intermediate	Topcoat	System DFT
MPI EXT 4.2A-G5 (Semigloss)	MPI REX 4.2A-G5 (Semigloss)	MPI 4	N/A	MPI 11	MPI 11	11 mils
Topcoat: Coating to match adjacent surfaces.						

3.13.1.2 MPI Division 5: Exterior Metal, Ferrous and Non-Ferrous Paint Table

(b) Surfaces previously coated with epoxy

Pigmented Polyurethane
Topcoat: Coating to match adjacent surfaces.

(4) New steel blast cleaned to SSPC SP 10/NACE No. 2

Waterborne Light Industrial					
New	Existing	Primer	Intermediate	Topcoat	System DFT
MPI EXT 5.1R-G5 (Semigloss)	MPI EXT 5.1R-G5 (Semigloss)	MPI 101	MPI 108	MPI 163	8.5 mils

(3) Surfaces adjacent to painted surfaces; and miscellaneous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment

Alkyd				
New	Primer	Intermediate	Topcoat	System DFT
MPI EXT 5.1D-G1 (Flat)	MPI 79	MPI 8	MPI 8	5.25 mils

3.13.2 Interior Paint Tables

3.13.2.1 MPI Division 3: Interior Concrete Paint Table

E. New concrete floors in following areas shower rooms, janitor's closet.

Epoxy					
New, uncoated Existing	Existing, previously painted	Primer	Intermediate	Topcoat	System DFT
MPI INT 3.2C-G6 (Gloss)	MPI RIN 3.2C-G6 (Gloss)	MPI 77	MPI 77	MPI 77	5 mils
Note: Primer may be reduced for penetration per manufacturer's instructions.					

3.13.2.2 MPI Division 4: Interior Concrete Masonry Units Paint Table

A. New Concrete Masonry

Institutional Low Odor / Low VOC Latex					
New, uncoated Existing	Filler	Primer	Intermediate	Topcoat	System DFT
MPI INT 4.2E-G4 (Satin)	MPI 4	N/A	MPI 146	MPI 146	4 mils

3.13.2.3 MPI Division 5: Interior Metal, Ferrous and Non-Ferrous Paint Table

A. Interior Steel / Ferrous Surfaces

(1) Metal, Mechanical, Surfaces adjacent to painted surfaces (Match surrounding finish), not otherwise specified except floors, hot metal surfaces, and new prefinished equipment

High Performance Architectural Latex				
New, uncoated Existing	Primer	Intermediate	Topcoat	System DFT
MPI INT 5.1R-G2 (Flat)	MPI 76	MPI 138	MPI 138	5 mils
Topcoat: Coating to match adjacent surfaces.				

(5) Miscellaneous non-ferrous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment. Match surrounding finish

High Performance Architectural Latex				
New, uncoated Existing	Primer	Intermediate	Topcoat	System DFT
MPI INT 5.4F-G3 (Eggshell)	MPI 95	MPI 139	MPI 139	5 mils

(3) New and Existing Surfaces made bare subject to temperatures up to 1100 degrees F

3.13.2.4 MPI Division 9: Interior Plaster, Gypsum Board, Textured Surfaces Paint Table

A. Interior New Wallboard not otherwise specified

Institutional Low Odor / Low VOC Latex, New

Institutional Low Odor / Low VOC Latex				
New	Primer	Intermediate	Topcoat	System DFT
MPI INT 9.2M-G3 (Eggshell)	MPI 149	MPI 145	MPI 145	4 mils
Topcoat: Coating to match adjacent surfaces.				

B. Interior New Wallboard in laundry areas, shower areas, and other high humidity areas not otherwise specified

Waterborne Light Industrial Coating					
New, uncoated Existing	Existing, previously painted	Primer	Intermediate	Topcoat	System DFT
Topcoat: Coating to match adjacent surfaces.					

-- End of Section --

SECTION 10 14 00.20

INTERIOR SIGNAGE

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.

INTERNATIONAL CODE COUNCIL (ICC)

ICC/ANSI A117.1 (2009) Accessible and Usable Buildings and Facilities

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101 (2021) Life Safety Code

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST SP 800-82 (2015; Rev 2) Guide to Industrial Control Systems (ICS) Security

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 8510.01 (2020; Change 1-2020) Risk Management Framework (RMF) for DoD Information Technology (IT)

DODI 8500.01 (2014) Cybersecurity

UFC 4-010-06 (2016; with Change 1, 2017) Cybersecurity of Facility-Related Control Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

36 CFR 1191 Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G

SD-03 Product Data

Room Identification And Directional Signage System; G

Exit Door Tactile Sign; G

SD-04 Samples

Interior Signage; G

Room Identification And Directional Signage System; G

Exit Door Tactile Sign; G

SD-10 Operation and Maintenance Data

Approved Manufacturer's Instructions; G

Protection and Cleaning; G

1.3 QUALITY ASSURANCE

1.3.1 Samples

Submit [interior signage](#) samples of each of the following sign types showing typical quality, workmanship and color: all sign types included in project. Approved samples may be installed in the work, provided each sample is identified and location recorded.

1.3.2 Detail Drawings

Submit detail drawings showing elevations of each type of sign, dimensions, details and methods of mounting or anchoring, mounting height, shape and thickness of materials, and details of construction. Include a schedule showing the location, each sign type, and message.

1.3.3 Sign Fabricator

Sign Fabricator to follow room number strategies created by designer. The room numbering system to be reviewed and approved by the Contracting Officer and command end users during the shop drawing phase, and prior to fabrication.

1.3.4 Cybersecurity

- a. The Risk Management Framework (RMF) is the process by which information systems are accredited for operation by a designated official from the Using Military Department. It is the standard process under which all DoD information systems achieve and maintain their Authority To Operate. The cybersecurity process is documented in [DOD 8510.01](#) and [NIST SP 800-82](#). Refer to [UFC 4-010-06](#) and [DODI 8500.01](#) for additional requirements.
- b. All systems that are IP addressable or interface with the Assured Network required certification to operate. Coordinate with the Government to initiate and complete the accreditation process.
- c. Cybersecurity requires input from the system vendor or provider and support from the local IMD. The local IMD-IA office is the point of

contact for all Cyber Security requirements. The local CMIO is the point of contact for all clinical and functional system requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

Package materials to prevent damage and deterioration during shipment, handling, storage and installation. Deliver products to the jobsite in manufacturer's original packaging and store in a clean, dry area in accordance with manufacturer's instructions.

1.5 WARRANTY

Provide manufacturer's warranty to repair or replace defective interior signage materials and workmanship for a period of 2 years from date of final acceptance of the work.

PART 2 PRODUCTS

2.1 ROOM IDENTIFICATION AND DIRECTIONAL SIGNAGE SYSTEM

Provide signs, plaques, directories, and dimensional building letters that are standard products of manufacturers regularly engaged in the manufacture of such products that essentially duplicate signs that have been in satisfactory use at least 2 years prior to bid opening. Obtain signage from a single manufacturer with edges and corners of finished letter forms and graphics true and clean.

2.1.1 Standard Room Signs

Provide signs that include tactile letters, symbols and Braille for interior rooms or spaces where the sign is not likely to change over time. Tactile text descriptions are required for pictograms that are provided to identify a permanent room. Examples include interior signs that label restrooms, stairs, room numbers or letters, and room names. These permanent room signs can include paper inserts for updatable information, but are to match the existing signage of the facility.

2.1.1.1 Tactile Letters, Symbols and Braille

Provide ADA compliant material per 36 CFR 1191 which is raised 1/32 inch from the first surface, has a minimum 5/8 inch in height and is an ADA acceptable font. The color of the tactile letters is required to contrast with the sign face color per ADA standards. The ADA required Braille has a minimum durometer reading of 90. All raised letters, numbers and symbols are to comply.

2.1.2 Message Inserts

Provide updatable message inserts covered with a clear matte 0.015 inch vinyl protective overlay. The insert is large format color print on white photo paper. Manufacturer is required to offer online ordering capabilities to facilitate and expedite ordering packages of replacement, color-coated paper inserts.

2.1.3 Type of Mounting for Signs

Provide surface mounted signs mounted with concealed mechanical fastening through the holders. Secure inserts in holders with flexible plastic clips. Provide signs with aluminum ceiling/projecting mount attachment extrusion

to secure to ceiling or wall surface, along with matting ceiling/projecting mount track extrusion for hanging, projecting, and double-sided signs. Provide mounting for ceiling/projecting mount attachment extrusion by mechanical fasteners, selected based on wall or ceiling conditions. Mount track extrusion hinges over width of mount attachment and secured with 3.5 by 0.06 mm (6-32 inch) by 6 mm (1/4 inch) cone point stainless steel set screws.

2.1.4 Character Proportions and Heights

Letters and numbers on signs conform to 36 CFR 1191.

2.2 EXIT DOOR TACTILE SIGN

Provide tactile sign with the message EXIT at each exit door that requires an exit sign to conform with NFPA 101. Sign tactile message is to comply with ICC/ANSI A117.1.

2.3 GRAPHICS

Provide signage graphics for modular signs to the following:

2.3.1 Subsurface Copy

Copy is transferred to the back face of clear acrylic sheeting forming the panel face to produce precisely formed opaque image. This method bonds all sign elements (color, graphics, lettering, Braille and substrate) into a single unit.

2.4 COLOR, FINISH, AND CONTRAST

Provide color as indicated; colors listed are not intended to limit the selection of equal colors from other manufacturers. Finish of eggshell, matte, or other non-glare finish for all signs as required in handicapped-accessible buildings.

PART 3 EXECUTION

3.1 INSTALLATION

Install signs plumb and true and in accordance with approved manufacturer's instructions at locations shown on the detail drawings. Submit operating instructions outlining the step-by-step procedures required for system operation. The instructions include simplified diagrams for the system as installed, the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Provide each set permanently bound with a hard cover. The following identification must be inscribed on the covers: "OPERATING AND MAINTENANCE INSTRUCTIONS", name and location of the facility, name of the Contractor, and contract number. Submit in accordance with Section 01 78 23 OPERATING AND MAINTENANCE DATA. Mounting height and mounting location complies with 36 CFR 1191. Install required blocking. Do not install signs on doors or other surfaces until finishes on such surfaces have been installed. Signs installed on glass surfaces are installed with matching blank back-up plates in accordance with manufacturer's instructions.

Do not install items that show visual evidence of biological growth.

3.1.1 Anchorage

Provide anchorage in accordance with approved manufacturer's instructions. Anchorage not otherwise specified or shown includes 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. Provide exposed anchor and fastener materials compatible with metal to which applied with matching color and finish.

- a. Signs mounted to painted gypsum board surfaces must be removable for painting maintenance.
- b. Mount signs to lay-in ceiling grids with clip connections to ceiling tees.
- c. Install signs mounted on metal surfaces with magnetic tape.
- d. Install signs mounted on fabric surfaces with hook and loop tape or pin mount.
- e. Install signs to workstation panels with panel clips.

3.1.2 Protection and Cleaning

Protect the work against damage during construction. Adjust hardware and electrical equipment for proper operation. Clean glass, frames, and other sign surfaces at completion of signage installation in accordance with the manufacturer's written instructions.

-- End of Section --

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SECTION 10 44 16

FIRE EXTINGUISHERS

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.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 1 (2021) Fire Code

NFPA 10 (2022; ERTA 1 2021) Standard for Portable Fire Extinguishers

NFPA 101 (2021) Life Safety Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.157 (2003) Portable Fire Extinguishers

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fire Extinguishers; G

Accessories; G

Schedule; G

SD-03 Product Data

Fire Extinguishers; G

Accessories; G

Replacement Parts List; G

SD-07 Certificates

Fire Extinguishers Certifications; G

Manufacturer's Warranty with Inspection Tag; G

1.3 DELIVERY, STORAGE, AND HANDLING

Protect materials from weather, soil, and damage during delivery, storage, and construction.

Deliver materials in their original packages, containers, or bundles bearing the brand name and the name and type of the material.

1.4 WARRANTY

Guarantee that Fire Extinguishers are free of defects in materials, fabrication, finish, and installation and that they will remain so for a period of not less than 5 years after completion.

Submit the manufacturer's warranty with inspection tag.

1.5 PROJECT SCHEDULE

For fire extinguishers. Coordinate final fire extinguisher schedule with fire protection cabinet schedule to ensure proper fit and function. Use same designations indicated on Drawings.

PART 2 PRODUCTS

Submit fabrication drawings consisting of fabrication and assembly details performed in the factory and product data for the following items: Fire Extinguishers; Accessories, Wall Brackets.

2.1 SYSTEM DESCRIPTION

2.1.1 Types

Submit fire extinguishers certifications showing compliance with local codes and regulations.

Provide fire extinguishers conforming to NFPA 10. Provide quantity and placement in compliance with the applicable sections of NFPA 1, NFPA 101 and 29 CFR 1910.157.

Water type fire extinguishers.

2.1.2 Material

Provide enameled steel extinguisher shell.

2.1.3 Size

10 pounds extinguishers.

PART 3 EXECUTION

3.1 INSTALLATION

Install Fire Extinguishers where indicated on the drawings. Verify exact locations prior to installation.

Provide extinguishers which are fully charged and ready for operation upon installation. Provide extinguishers complete with Manufacturer's Warranty with Inspection Tag attached.

Install fire extinguishers in locations indicated and in compliance with requirements of authorities having jurisdiction.

Comply with the manufacturer's recommendations for all installations.

3.2 PROTECTION

3.2.1 Repairing

Remove and replace damaged and unacceptable portions of completed work with new work at no additional cost to the Government.

Submit [replacement parts list](#) indicating specified items replacement part, replacement cost, and name, address and contact for replacement parts distributor.

3.2.2 Cleaning

Clean all surfaces of the work, and adjacent surfaces which are soiled as a result of the work. Remove from the site all construction equipment, tools, surplus materials and rubbish resulting from the work.

-- End of Section --

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SECTION 21 13 13

WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION

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 OF MECHANICAL ENGINEERS (ASME)

- ASME B16.1 (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
- ASME B16.3 (2021) Malleable Iron Threaded Fittings, Classes 150 and 300
- ASME B16.4 (2021) Gray Iron Threaded Fittings; Classes 125 and 250
- ASME B16.21 (2021) Nonmetallic Flat Gaskets for Pipe Flanges

ASTM INTERNATIONAL (ASTM)

- ASTM A47/A47M (1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
- ASTM A53/A53M (2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- ASTM A135/A135M (2021) Standard Specification for Electric-Resistance-Welded Steel Pipe
- ASTM A153/A153M (2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- ASTM A183 (2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
- ASTM A536 (1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings

FM GLOBAL (FM)

- FM APP GUIDE (updated on-line) Approval Guide
<http://www.approvalguide.com/>

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 13 (2022; ERTA 1 2021) Standard for the

Installation of Sprinkler Systems

NFPA 291

(2022) Recommended Practice for Fire Flow Testing and Marking of Hydrants

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES
(NICET)

NICET 1014-7

(2012) 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 199

(2020) UL Standard for Safety Automatic Sprinklers for Fire-Protection Service

UL Fire Prot Dir

(2012) Fire Protection Equipment Directory

1.2 SYSTEM DESCRIPTION

Provide wet pipe sprinkler system(s) in areas indicated on the drawings. Except as modified herein, the system must meet the requirements of NFPA 13. Pipe sizes which are not indicated on the Contract drawings must be determined by hydraulic calculations.

1.2.1 Hydraulic Design

1.2.1.1 Basis for Calculations

Perform a fire hydrant flow test prior to shop drawing submittal in accordance with NFPA 291. Results must include hydrant elevations relative to the building and hydrant number/identifiers for the tested hydrants, including which were flowed, which had a gauge. This information must be presented in a tabular form if multiple hydrants were flowed. The results must be included with the hydraulic calculations. Hydraulic calculations must be based on flow test noted in this paragraph, unless approved by Contracting Officer. Hydraulic calculations must be based upon the Hazen-Williams formula with a "C" value noted in NFPA 13 for piping. The minimum residual pressure in a service lateral (lead-in) at the design flow rate must be 20 psi at the inlet to the backflow preventer.

1.2.1.2 Hydraulic Calculations

- a. Water supply curves and system requirements must be plotted on semi-logarithmic graph ($N^{1.85}$) paper so as to present a summary of the complete hydraulic calculation.
- b. Provide a summary sheet listing sprinklers in the design area and their respective hydraulic reference points, elevations, minimum discharge pressures and minimum flows. Elevations of hydraulic reference points (nodes) must be indicated.
- c. Documentation must identify each pipe individually and the nodes connected thereto. Indicate the diameter, length, flow, velocity, friction loss, number and type fittings, total friction loss in the

pipe, equivalent pipe length and Hazen-Williams coefficient for each pipe.

- d. Where the sprinkler system is supplied by interconnected risers, the sprinkler system must be hydraulically calculated using the hydraulically most demanding single riser. The calculations must not assume the simultaneous use of more than one riser.
- e. All calculations must include the backflow preventer manufacturer's stated friction loss at the design flow or 8 psi for double check backflow preventer, whichever is greater.
- f. All calculations must be performed back to the actual location of the flow test, taking into account the direction of flow in the service main at the test location.
- g. For gridded systems, calculations must show peaking of demand area friction loss to verify that the hydraulically most demanding area is being used. A flow diagram indicating the quantity and direction of flows must be included.

1.2.1.3 Design Criteria

Hydraulically design the system to discharge a minimum density as indicated on the drawings. Hydraulic calculations must be in accordance with the Area/Density Method of NFPA 13. Add an allowance for exterior hose streams of 250 gpm to the sprinkler system demand at the fire hydrant shown on the drawings closest to the point where the water service enters the building.

1.2.2 Sprinkler Coverage

Provide coverage throughout 100 percent of the area noted on the Contract drawings. Coverage per sprinkler must be in accordance with NFPA 13. Provide sprinklers below all obstructions in accordance with NFPA 13.

1.2.3 Qualified Fire Protection Engineer (QFPE)

An individual who is a licensed professional engineer (P.E.) who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and has relevant fire protection engineering experience. Services of the QFPE must include:

- a. Reviewing SD-02, SD-03, and SD-05 submittal packages for completeness and compliance with the provisions of this specification. Working (shop) drawings and calculations must be prepared by, or prepared under the immediate supervision of, the QFPE. The QFPE must affix their professional engineering stamp with signature to the shop drawings, calculations, and material data sheets, indicating approval prior to submitting the shop drawings to the DFPE.
- b. Provide a letter documenting that the SD-02, SD-03, and SD-05 submittal package has been reviewed and noting all outstanding comments.
- c. Performing in-progress construction surveillance prior to installation of ceilings (rough-in inspection).

- d. Witnessing pre-Government and final Government functional performance testing and performing a final installation review.
- e. Signing applicable certificates under SD-07.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Partial submittals and submittals not fully complying with NFPA 13 and this specification section must be returned disapproved without review. SD-02, SD-03 and SD-05 must be submitted simultaneously.

Shop drawings (SD-02), product data (SD-03) and calculations (SD-05) must be prepared by the designer and combined and submitted as one complete package. The QFPE must review the SD-02/SD-03/SD-05 submittal package for completeness and compliance with the Contract provisions prior to submission to the Government. The QFPE must provide a Letter of Confirmation that they have reviewed the submittal package for compliance with the contract provisions. This letter must include their professional engineer stamp and signature. Partial submittals and submittals not reviewed by the QFPE must be returned disapproved without review.

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualified Fire Protection Engineer (QFPE); G
Sprinkler System Designer; G
Sprinkler System Installer; G

SD-02 Shop Drawings

Shop Drawing; G

SD-03 Product Data

Pipe; G
Fittings; G
Sprinklers ; G
Pipe Hangers and Supports ; G
Seismic Bracing; G

SD-05 Design Data

Seismic Bracing; G
Load calculations for sizing of seismic bracing
Hydraulic Calculations; G

SD-06 Test Reports

Test Procedures; G

SD-07 Certificates

Verification of Compliant Installation; G

Request for Government Final Test; G

SD-10 Operation and Maintenance Data

Operating and Maintenance (O&M) Instructions; G

Spare Parts Data; G

SD-11 Closeout Submittals

As-built drawings

1.4 QUALITY ASSURANCE

1.4.1 Preconstruction Submittals

Within 36 days of contract award but no less than 14 days prior to commencing work on site, the prime Contractor must submit the following for review and approval. SD-02, SD-03 and SD-05 submittals received prior to the review and approval of the qualifications will be returned Disapproved Without Review.

1.4.1.1 Shop Drawing

Two copies of the shop drawings, no later than 28 days prior to the start of system installation. Working drawings conforming to the requirements prescribed in NFPA 13 and must be no smaller than the Contract Drawings. Each set of drawings must include the following:

- a. A descriptive index with drawings listed in sequence by number. A legend sheet identifying device symbols, nomenclature, and conventions used in the package.
- b. Floor plans drawn to a scale not less than 1/8-inch equals 1-foot clearly showing locations of devices, equipment, risers, and other details required to clearly describe the proposed arrangement.
- 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 must 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, elevation of each typical sprinkler above finished floor and elevation of "cloud" or false ceilings in relation to the building ceilings.
- e. Plan and elevation views which establish that the equipment will fit

the allotted spaces with clearance for installation and maintenance.

- f. Riser layout drawings drawn to a scale of not less than **1/2-inch equals 1-foot** to show details of each system component, clearances between each other and from other equipment and construction in the room.
- g. Details of each type of riser assembly, pipe hanger, sway bracing for earthquake protection, and restraint of underground water main at point-of-entry into the building, and electrical devices and interconnecting wiring. The dimension from the edge of vertical piping to the nearest adjacent wall(s) must be indicated on the drawings when vertical piping is located in stairs or other portions of the means of egress.
- h. Details of each type of pipe hanger, seismic bracing/restraint and related components.

1.4.1.2 Product Data

Two copies of annotated catalog data to show the specific model, type, and size of each item. Catalog cuts must also indicate the NRTL listing. The data must be highlighted to show model, size, options, and other pertinent information, that are intended for consideration. Data must be adequate to demonstrate compliance with all contract requirements. Product data for all equipment must be combined into a single submittal.

1.4.1.3 Hydraulic Calculations

Calculations must be as outlined in **NFPA 13** except that calculations must be performed by computer using software intended specifically for fire protection system design using the design data shown on the drawings. Calculations must include isometric diagram indicating hydraulic nodes and pipe segments.

1.4.1.4 Operating and Maintenance (O&M) Instructions

Provide six manuals and one pdf version on electronic media. The manuals must 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, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted must be capable of providing 4-hour on-site response to a service call on an emergency basis.

Submit spare parts data for each different item of material and equipment specified. The data must include a complete list of parts and supplies, and a list of parts recommended by the manufacturer to be replaced after 1-year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied.

1.4.2 Qualifications

1.4.2.1 Sprinkler System Designer

The sprinkler system designer must be certified as a Level III Technician by National Institute for Certification in Engineering Technologies (NICET) in the Water-Based Systems Layout subfield of Fire Protection Engineering Technology in accordance with **NICET 1014-7**.

1.4.2.2 Sprinkler System Installer

The sprinkler system installer must be regularly engaged in the installation of the type and complexity of system specified in the contract documents, and must 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.

1.4.3 Regulatory Requirements

Equipment and material must be listed or approved. Listed or approved, as used in this Section, means listed, labeled or approved by a Nationally Recognized Testing Laboratory (NRTL) such as [UL Fire Prot Dir](#) or [FM APP GUIDE](#). The omission of these terms under the description of an item or equipment described must not be construed as waiving this requirement. All listings or approvals by testing laboratories must be from an existing ANSI or UL published standard. The recommended practices stated in the manufacturer's literature or documentation are mandatory requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity and temperature variations, dirt and dust, or other contaminants. All pipes must be either capped or plugged until installed.

1.6 EXTRA MATERIALS

Spare sprinklers and wrench(es) must be provided as [spare parts](#) in accordance with [NFPA 13](#).

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials, equipment, and devices listed for fire protection service when so required by [NFPA 13](#) or this specification. Select material from one manufacturer, where possible, and not a combination of manufacturers, for a classification of material. Material and equipment must be standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid.

2.1.2 Identification and Marking

Pipe and fitting markings must include name or identifying symbol of manufacturer and nominal size. Pipe must be marked with ASTM designation. Valves and equipment markings must have name or identifying symbol of manufacturer, specific model number, nominal size, name of device, arrow indicating direction of flow, and position of installation (horizontal or vertical), except if valve can be installed in either position. Markings must be included on the body casting or on an etched or stamped metal nameplate permanently on the valve or cover plate.

2.1.3 Pressure Ratings

Valves, fittings, couplings, alarm switches, and similar devices must be

rated for the maximum working pressures that can be experienced in the system, but in no case less than 175 psi.

2.2 ABOVEGROUND PIPING COMPONENTS

2.2.1 Steel Piping Components

2.2.1.1 Steel Pipe

Except as modified herein, steel pipe must be black as permitted by NFPA 13 and conform to the applicable provisions of ASTM A53/A53M, ASTM A135/A135M or ASTM A153/A153M.

Steel pipe must be minimum Schedule 40 for sizes 2 inches and less; and minimum Schedule 10 for sizes larger than 2 inches. Steel piping with wall thickness less than Schedule 40 must not be threaded.

2.2.1.2 Fittings

Fittings must be welded, threaded, or grooved-end type. Threaded fittings must be cast-iron conforming to ASME B16.4, malleable-iron conforming to ASME B16.3 or ductile-iron conforming to ASTM A536. Plain-end fittings with mechanical couplings, fittings that use steel gripping devices to bite into the pipe, steel press fittings and field welded fittings are not permitted. Fittings, mechanical couplings, and rubber gaskets must be supplied by the same manufacturer. Threaded fittings must use Teflon tape or manufacturer's approved joint compound. Reducing couplings are not permitted except as allowed by NFPA 13.

2.2.1.3 Grooved Mechanical Joints and Fittings

Joints and fittings must be designed for not less than 175 psi service and the product of the same manufacturer. Field welded fittings must not be used. Fitting and coupling housing must be malleable-iron conforming to ASTM A47/A47M, Grade 32510; ductile-iron conforming to ASTM A536, Grade 65-45-12. Rubber gasketed grooved-end pipe and fittings with mechanical couplings are permitted in pipe sizes 2 inches and larger. Gasket must be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts must be heat-treated steel conforming to ASTM A183 and must be cadmium-plated or zinc-electroplated.

2.2.1.4 Flanges

Flanges must conform to NFPA 13 and ASME B16.1. Gaskets must be non-asbestos compressed material in accordance with ASME B16.21, 1/16-inch thick, and full face or self-centering flat ring type.

2.2.2 Flexible Sprinkler Hose

2.2.3 Pipe Hangers and Supports

Provide galvanized pipe hangers, supports and seismic bracing in accordance with NFPA 13. Design and install seismic protection in accordance with the requirements of NFPA 13 section titled "Protection of Piping Against Damage Where Subject to Earthquakes for Seismic Design Category "D".

2.3 SPRINKLERS

Sprinklers must comply with UL 199 and NFPA 13. Sprinklers with internal

O-rings are not acceptable. Sprinklers in high heat areas including attic spaces or in close proximity to unit heaters must have temperature classification in accordance with NFPA 13. Extended coverage sprinklers are permitted for loading docks, residential occupancies and high-piled storage applications only.

2.3.1 Pendent Sprinkler

Pendent sprinkler must be quick-response type with nominal K-factor of 8.0. Assembly must include an integral escutcheon.

2.3.2 Dry Sprinkler Assembly

Dry sprinkler assembly must be of the pendent type as indicated. Assembly must include an integral escutcheon. Maximum length must not exceed maximum indicated in its listing.

2.4 ACCESSORIES

2.4.1 Sprinkler Cabinet

Provide spare sprinklers in accordance with NFPA 13 and must be placed in a suitable metal or plastic cabinet of sufficient size to accommodate all the spare sprinklers and wrenches in designated locations. Spare sprinklers must be representative of, and in proportion to, the number of each type and temperature rating of the sprinklers installed as required by NFPA 13. At least one wrench of each type required must be provided.

2.4.2 Pendent Sprinkler Escutcheon

Escutcheon must be one-piece metallic type with a depth of less than 3/4-inch and suitable for installation on pendent sprinklers. The escutcheon must have a factory finish that matches the pendent sprinkler.

2.4.3 Pipe Escutcheon

Provide split hinge metal plates for piping entering walls, floors, and ceilings in exposed spaces. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.4.4 Sprinkler Guard

Listed guard must be a steel wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards must be provided on sprinklers located within 7 feet of the floor.

PART 3 EXECUTION

3.1 VERIFYING ACTUAL FIELD CONDITIONS

Before commencing work, examine all adjoining work on which the contractor's work that is dependent for perfect workmanship according to the intent of this specification section, and report to the Contracting Officer's Representative a condition that prevents performance of first class work. No "waiver of responsibility" for incomplete, inadequate or defective adjoining work will be considered unless notice has been filed before submittal of a proposal.

3.2 INSTALLATION

The installation must be in accordance with the applicable provisions of **NFPA 13** and publications referenced therein. Locate sprinklers in a consistent pattern with ceiling grid, lights, and air supply diffusers. Install sprinkler system over and under ducts, piping and platforms when such equipment can negatively affect or disrupt the sprinkler discharge pattern and coverage.

- a. Piping offsets, fittings, and other accessories required must be furnished to provide a complete installation and to eliminate interference with other construction.
- b. Wherever the contractor's work interconnects with work of other trades the Contractor must coordinate with other Contractors to insure all Contractors have the information necessary so that they may properly install all necessary connections and equipment. Identify all work items needing access (dampers and similar equipment) that are concealed above hung ceilings by permanent color coded pins/tabs in the ceiling directly below the item.
- c. Provide required supports and hangers for piping, conduit, and equipment so that loading will not exceed allowable loadings of structure. Submittal of a bid must be a deemed representation that the contractor submitting such bid has ascertained allowable loadings and has included in his estimates the costs associated in furnishing required supports.

3.2.1 Waste Removal

At the conclusion of each day's work, clean up and stockpile on site all waste, debris, and trash which may have accumulated during the day as a result of work by the contractor and of his presence on the job. Sidewalks and streets adjoining the property must be kept broom clean and free of waste, debris, trash and obstructions caused by work of the contractor, which will affect the condition and safety of streets, walks, utilities, and property.

3.3 ABOVEGROUND PIPING INSTALLATION

The methods of fabrication and installation of the aboveground piping must fully comply with the requirements and recommended practices of **NFPA 13** and this specification section.

3.3.1 Protection of Piping Against Earthquake Damage

Seismic restraint is required.

3.3.2 Piping in Exposed Areas

Install exposed piping without diminishing exit access widths, corridors or equipment access. Exposed horizontal piping, including drain piping, must be installed to provide maximum headroom.

3.3.3 Piping in Finished Areas

In areas with suspended or dropped ceilings and in areas with concealed spaces above the ceiling, piping must be concealed above ceilings. Piping must be inspected, hydrostatically tested and approved before being

concealed. Risers and similar vertical runs of piping in finished areas must be concealed.

3.3.4 Pendent Sprinklers

- a. Drop nipples to pendent sprinklers must consist of minimum 1-inch pipe with a reducing coupling into which the sprinkler must be threaded.
- b. Where sprinklers are installed below suspended or dropped ceilings, drop nipples must be cut such that sprinkler ceiling plates or escutcheons are of a uniform depth throughout the finished space. The outlet of the reducing coupling must not extend below the underside of the ceiling.
- c. Recessed pendent sprinklers must be installed such that the distance from the sprinkler deflector to the underside of the ceiling must not exceed the manufacturer's listed range and must be of uniform depth throughout the finished area.
- d. Pendent sprinklers in suspended ceilings must be located in the center of the tile (plus or minus 2 inches).
- e. Dry pendent sprinkler assemblies must be such that sprinkler ceiling plates or escutcheons are of the uniform depth throughout the finished space.
- f. Dry pendent sprinklers must be of the required length to permit the sprinkler to be threaded directly into a branch line tee.
- g. Where the maximum static or flowing pressure, whichever is greater at the sprinkler, applied other than through the fire department connection, exceeds 100 psi and a branch line above the ceiling supplies sprinklers in a pendent position below the ceiling, the cumulative horizontal length of an unsupported armover to a sprinkler or sprinkler drop must not exceed 12 inches for steel pipe and 6 inches for copper tube.

3.3.5 Upright Sprinklers

Riser nipples or "sprigs" to upright sprinklers must contain no fittings between the branch line tee and the reducing coupling at the sprinkler.

3.3.6 Pipe Joints

Pipe joints must conform to NFPA 13, except as modified herein. Not more than four threads must 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 must be provided where indicated or required by NFPA 13. Grooved pipe and fittings must be prepared in accordance with the manufacturer's latest published specification according to pipe material, wall thickness and size. Grooved couplings, fittings and grooving tools must be products of the same manufacturer. For copper tubing, pipe and groove dimensions must comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field must be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe must be measured and recorded for

each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances.

3.3.7 Reducers

Reductions in pipe sizes must be made with one-piece tapered reducing fittings. When standard fittings of the required size are not manufactured, single bushings of the face or hex type will be permitted. Where used, face bushings must be installed with the outer face flush with the face of the fitting opening being reduced. Bushings cannot 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 $1/2$ -inch.

3.3.8 Pipe Penetrations

- a. 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 must be core-drilled and provided with pipe sleeves. Each sleeve must be Schedule 40 galvanized steel, ductile-iron or cast-iron pipe and extend through its respective wall or floor and be cut flush with each wall surface. Sleeves must provide required clearance between the pipe and the sleeve per NFPA 13. The space between the sleeve and the pipe must be firmly packed with mineral wool insulation.
- b. Where pipes and sleeves penetrate fire walls, fire partitions, or floors, pipes/sleeves must be firestopped.
- c. In penetrations that are not fire-rated or not a floor penetration, the space between the sleeve and the pipe must 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.

3.3.9 Escutcheons

Escutcheons must be provided for pipe penetration in finished areas of ceilings, floors and walls. Escutcheons must be securely fastened to the pipe at surfaces through which piping passes.

3.4 PAINTING

Color code mark piping as specified in Section 09 90 00 PAINTS AND COATINGS.

3.5 FIELD QUALITY CONTROL

3.5.1 Test Procedures

Submit detailed test procedures, prepared and signed by the NICET Level III or IV Fire Sprinkler Technician, and the representative of the installing company, and reviewed by the QFPE 60 days prior to performing system tests. Detailed test procedures must list all components of the installed system. Test procedures must include sequence of testing, time estimate for each test, and sample test data forms. The test data forms must be in a check-off format (pass/fail with space to add applicable test data; similar to the forms in NFPA 13). The test procedures and accompanying test data forms must be used for the pre-Government testing and the Government final testing.

- a. Provide space to identify the date and time of each test. Provide

space to identify the names and signatures of the individuals conducting and witnessing each test.

3.5.2 Pre-Government Testing

3.5.2.1 Verification of Compliant Installation

Conduct inspections and tests to ensure that equipment is functioning properly. Tests must meet the requirements of paragraph entitled "Minimum System Tests" and "System Acceptance" as noted in NFPA 13. The Contractor and QFPE must be in attendance at the pre-Government testing to make necessary adjustments. After inspection and testing is complete, provide a signed Verification of Compliant Installation letter by the QFPE that the installation is complete, compliant with the specification and fully operable. The letter must include the names and titles of the witnesses to the pre-Government tests. Provide all completion documentation as required by NFPA 13 and the test reports noted below.

- a. NFPA 13 Aboveground Material and Test Certificate

3.5.2.2 Request for Government Final Test

When the verification of compliant installation has been completed, submit a formal request for Government final test to the and Designated Fire Protection Engineer (DFPE) Contracting Officers Designated Representative (COR). Government final testing will not be scheduled until the DFPE has received copies of the request for Government final testing and Verification of Compliant Installation letter with all required reports. Submit request for test at least 15 calendar days prior to the requested test date.

3.5.3 Correction of Deficiencies

If equipment was found to be defective or non-compliant with contract requirements, perform corrective actions and repeat the tests. Tests must be conducted and repeated if necessary until the system has been demonstrated to comply with all contract requirements.

3.5.4 Government Final Tests

The tests must be performed in accordance with the approved test procedures in the presence of the DFPE. Furnish instruments and personnel required for the tests. The following must be provided at the job site for Government Final Testing:

- a. The manufacturer's technical representative.
- b. The contractor's Qualified Fire Protection Engineer (QFPE).
- c. Marked-up red line drawings of the system as actually installed.

Government Final Tests will be witnessed by the and Designated Fire Protection Engineer, Contracting Officer, and Qualified Fire Protection Engineer (QFPE). At this time, all required tests noted in the paragraph "Minimum System Tests" must be repeated at their discretion.

3.6 MINIMUM SYSTEM TESTS

The system, including the underground water mains, and the aboveground

pipng and system components, must be tested to ensure that equipment and components function as intended. The underground and aboveground interior piping systems and attached appurtenances subjected to system working pressure must be tested in accordance with NFPA 13.

3.7 SYSTEM ACCEPTANCE

Following acceptance of the system, as-built drawings and O&M manuals must be delivered to the Contracting Officer for review and acceptance. Submit six sets of detailed as-built drawings. The drawings must show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final acceptance test of the system. At least one set of as-built (marked-up) drawings must be provided at the time of, or prior to the final acceptance test.

- a. Provide one set of full size paper as-built drawings and schematics. The drawings must be prepared electronically and sized no less than the contract drawings. Furnish one set of CDs or DVDs containing software back-up and CAD based drawings in latest version of AutoCAD, DXF and portable document formats of as-built drawings and schematics.
- b. Provide operating and maintenance (O&M) instructions.

3.8 ONSITE TRAINING

Conduct a training course for the responding fire department and operating and maintenance personnel as designated by the Contracting Officer. Training must be performed on two separate days (to accommodate different shifts of Fire Department personnel) for a period of 4 hours of normal working time and must start after the system is functionally complete and after the final acceptance test. The on-site training must cover all of the items contained in the approved Operating and Maintenance Instructions.

-- End of Section --

SECTION 22 00 00

PLUMBING, GENERAL PURPOSE

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 OF MECHANICAL ENGINEERS (ASME)

ASME A112.6.3	(2019) Standard for Floor and Trench Drains
ASME A112.6.4	(2003; R 2012) Roof, Deck and Balcony Drains
ASME A112.36.2M	(1991; R 2017) Cleanouts
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.4	(2021) Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.12	(2019) Cast Iron Threaded Drainage Fittings
ASME B31.1	(2022) Power Piping

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA B300	(2018) Hypochlorites
AWWA C606	(2022) Grooved and Shouldered Joints

ASTM INTERNATIONAL (ASTM)

ASTM A74	(2021) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2023) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A515/A515M	(2017; R2022) Standard Specification for

Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service

ASTM A516/A516M

(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service

ASTM A888

(2021a) Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

ASTM B370

(2022) Standard Specification for Copper Sheet and Strip for Building Construction

ASTM C564

(2020a) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings

ASTM C920

(2018) Standard Specification for Elastomeric Joint Sealants

ASTM D2000

(2018) Standard Classification System for Rubber Products in Automotive Applications

ASTM D2235

(2004; R 2016) Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings

ASTM D2564

(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems

ASTM D2665

(2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings

ASTM D2822/D2822M

(2005; R 2011; E 2011) Standard Specification for Asphalt Roof Cement, Asbestos-Containing

ASTM D2855

(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings

ASTM D3138

(2004; R 2016) Standard Specification for Solvent Cements for Transition Joints Between Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Non-Pressure Piping Components

ASTM D3139

(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

ASTM D3212

(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F493	(2022) Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
ASTM F891	(2016) Standard Specification for Coextruded Poly (Vinyl Chloride) (PVC) Plastic Pipe with a Cellular Core
ASTM F1760	(2016; R 2020) Standard Specification for Coextruded Poly(Vinyl Chloride) (PVC) Non-Pressure Plastic Pipe Having Reprocessed-Recycled Content
ASTM F2389	(2023) Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

CAST IRON SOIL PIPE INSTITUTE (CISPI)

CISPI 301	(2018) Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
CISPI 310	(2012) Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

INTERNATIONAL CODE COUNCIL (ICC)

ICC IPC	(2021) International Plumbing Code

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2024) Standard for the Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF 372	(2016) Drinking Water System Components - Lead Content
NSF/ANSI 14	(2022) Plastics Piping System Components and Related Materials

NSF/ANSI 61 (2022) Drinking Water System Components -
Health Effects

PLASTIC PIPE AND FITTINGS ASSOCIATION (PPFA)

PPFA Fire Man (2016) Firestopping: Plastic Pipe in Fire
Resistive Construction

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J1508 (2023) Hose Clamp Specifications

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

PL 93-523 (1974; A 1999) Safe Drinking Water Act

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Plumbing System; G

Detail drawings consisting of schedules, performance charts, instructions, diagrams, and other information to illustrate the requirements and operations of systems that are not covered by the Plumbing Code. 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.

SD-03 Product Data

Recycled Content for Cast Iron Pipe; S

SD-06 Test Reports

Tests

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. SD-07 Certificates

Materials and Equipment

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.

SD-10 Operation and Maintenance Data

Plumbing System; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

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. 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 product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.3.1 Alternative Qualifications

Products having less than a two-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 or laboratory tests, can be shown.

1.3.2 Service Support

The equipment items shall be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3.3 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.

1.3.4 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.

1.3.4.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.3.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.5 REGULATORY REQUIREMENTS

Unless otherwise required herein, plumbing work shall be in accordance with **ICC IPC**.

1.6 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.

1.7 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. 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. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.8 ACCESSIBILITY OF EQUIPMENT

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

2.1 MATERIALS

Materials for various services shall be in accordance with TABLE I .
Cement pipe shall contain recycled content as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Pipe schedules shall be selected based on service requirements. Pipe fittings shall be compatible with the applicable pipe materials. Plastic pipe, fittings, and solvent cement shall meet NSF/ANSI 14 and shall be NSF listed for the service intended. Plastic pipe, fittings, and solvent cement used for potable hot and cold water service shall bear the NSF seal "NSF-PW." Polypropylene pipe and fittings shall conform to dimensional requirements of Schedule 40, Iron Pipe size and shall comply with NSF/ANSI 14, NSF/ANSI 61 and ASTM F2389. Polypropylene piping that will be exposed to UV light shall be provided with a Factory applied UV resistant coating. Pipe threads (except dry seal) shall conform to ASME B1.20.1. Grooved pipe couplings and fittings shall be from the same manufacturer. Material or equipment containing a weighted average of greater than 0.25 percent lead shall not be used in any potable water system intended for human consumption, and shall be certified in accordance with NSF/ANSI 61, Annex G or NSF 372. 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/ANSI 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/ANSI 61, Section 9. Hubless cast-iron soil pipe shall not be installed underground, under concrete floor slabs, or in crawl spaces below kitchen floors. Cast-iron pipe shall contain a minimum of 95 percent recycled content. Provide data identifying percentage of recycled content for cast iron pipe. Plastic pipe shall not be installed in air plenums. Plastic pipe shall not be installed in a pressure piping system in buildings greater than three stories including any basement levels.

2.1.1 Pipe Joint Materials

Grooved pipe and hubless cast-iron soil pipe shall not be used underground. Solder containing lead shall not be used with copper pipe. Cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Institute. Joints and gasket materials shall conform to the following:

- a. Coupling for Cast-Iron Pipe: for hub and spigot type ASTM A74, AWWA C606. For hubless type: CISPI 310
- b. PTFE Tape: PTFE Tape, for use with Threaded Metal or Plastic Pipe.

- c. Rubber Gaskets for Cast-Iron Soil-Pipe and Fittings (hub and spigot type and hubless type): [ASTM C564](#).
- d. Rubber Gaskets for Grooved Pipe: [ASTM D2000](#), maximum temperature 230 degrees F.
- e. Flexible Elastomeric Seals: [ASTM D3139](#), [ASTM D3212](#) or [ASTM F477](#).
- f. Bolts and Nuts for Grooved Pipe Couplings: Heat-treated carbon steel, [ASTM A183](#).
- g. Solvent Cement for Transition Joints between ABS and PVC Nonpressure Piping Components: [ASTM D3138](#).
- h. Plastic Solvent Cement for ABS Plastic Pipe: [ASTM D2235](#).
- i. Plastic Solvent Cement for PVC Plastic Pipe: [ASTM D2564](#) and [ASTM D2855](#).
- j. Plastic Solvent Cement for CPVC Plastic Pipe: [ASTM F493](#).
- r. Flanged fittings including, but not limited to, flanges, bolts, nuts and bolt patterns shall be in accordance with [ASME B16.5](#) class 150 and shall have the manufacturer's trademark affixed in accordance with [MSS SP-25](#). Flange material shall conform to [ASTM A105/A105M](#). Blind flange material shall conform to [ASTM A516/A516M](#) cold service and [ASTM A515/A515M](#) for hot service. Bolts shall be high strength or intermediate strength with material conforming to [ASTM A193/A193M](#).
- k. Heat-fusion joints for polypropylene piping: [ASTM F2389](#).

2.1.2 Miscellaneous Materials

Miscellaneous materials shall conform to the following:

- a. Copper, Sheet and Strip for Building Construction: [ASTM B370](#).
- b. Asphalt Roof Cement: [ASTM D2822/D2822M](#).
- c. Hose Clamps: [SAE J1508](#).
- d. Metallic Cleanouts: [ASME A112.36.2M](#).
- e. Hypochlorites: [AWWA B300](#).

2.1.3 Pipe Insulation Material

Insulation shall be as specified in Section [23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS](#).

2.2 PIPE HANGERS, INSERTS, AND SUPPORTS

Pipe hangers, inserts, and supports shall conform to [MSS SP-58](#).

2.3 DRAINS

2.3.1 Floor and Shower Drains

Floor 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 conforming to ASTM C564 may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Floor drains shall conform to ASME A112.6.3.

2.3.2 Roof Drains and Expansion Joints

Roof drains shall conform to ASME A112.6.4, 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 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.

2.4 MISCELLANEOUS PIPING ITEMS

2.4.1 Escutcheon Plates

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Provide chromium-plated on copper alloy plates or polished stainless steel finish in finished spaces. Provide paint finish on plates in unfinished spaces.

2.4.2 Pipe Sleeves

Provide where piping passes entirely through walls, ceilings, roofs, and floors. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade, except where penetrating a membrane waterproof floor.

2.4.2.1 Sleeves in Masonry and Concrete

Provide steel pipe sleeves or schedule 40 PVC plastic pipe sleeves. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the

core-drilled hole are completely grouted smooth.

2.4.2.2 Sleeves Not in Masonry and Concrete

Provide 26 gage galvanized steel sheet or PVC plastic pipe sleeves.

2.4.3 Pipe Hangers (Supports)

Provide **MSS SP-58** Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor. Provide Type 40 insulation protection shield for insulated piping.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Piping located in air plenums shall conform to **NFPA 90A** requirements. 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 Fire Man**. The plumbing system shall be installed complete with necessary fixtures, fittings, traps, valves, and accessories.

Drainage piping shall be extended **5 feet** outside the building, unless otherwise indicated. 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 **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.

3.1.1 Water Pipe, Fittings, and Connections

3.1.1.1 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.

3.1.1.2 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 **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 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.

3.1.2 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.

3.1.2.1 Threaded

Threaded joints shall have American Standard taper pipe threads conforming to ASME B1.20.1. 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.

3.1.2.2 Mechanical Couplings

Mechanical couplings may be used in conjunction with grooved pipe for aboveground, ferrous or non-ferrous, domestic hot and cold water systems, in lieu of unions, brazed, soldered, welded, flanged, or threaded joints.

Mechanical couplings are permitted in accessible locations including behind access plates. Flexible grooved joints will not be permitted, except as vibration isolators adjacent to mechanical equipment. Rigid grooved joints shall incorporate an angle bolt pad design which maintains metal-to-metal contact with equal amount of pad offset of housings upon installation to ensure positive rigid clamping of the pipe.

Designs which can only clamp on the bottom of the groove or which utilize gripping teeth or jaws, or which use misaligned housing bolt holes, or which require a torque wrench or torque specifications will not be permitted.

Grooved fittings and couplings, and grooving tools shall be provided from the same manufacturer. Segmentally welded elbows shall not be used. Grooves shall be prepared in accordance with the coupling manufacturer's latest published standards. Grooving shall be performed by qualified grooving operators having demonstrated proper grooving procedures in accordance with the tool manufacturer's recommendations.

The Contracting Officer shall be notified 24 hours in advance of test to demonstrate operator's capability, and the test shall be performed at the work site, if practical, or at a site agreed upon. The operator shall demonstrate the ability to properly adjust the grooving tool, groove the pipe, and to verify the groove dimensions in accordance with the coupling

manufacturer's specifications.

3.1.2.3 Plastic Pipe

Acrylonitrile-Butadiene-Styrene (ABS) pipe shall have joints made with solvent cement. PVC and CPVC 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.

3.1.3 Pipe Sleeves and Flashing

Pipe sleeves shall be furnished and set in their proper and permanent location.

3.1.3.1 Sleeve Requirements

Unless indicated otherwise, provide pipe sleeves meeting the following requirements:

- a. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors.
- b. 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.
- c. 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 4 inches above the finished floor.
- d. Unless otherwise indicated, sleeves shall be of a size to provide a minimum of 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.
- e. 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 C920 and with a primer, backstop material and surface preparation as specified in Section

07 92 00 JOINT SEALANTS. 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.

- f. Sleeves through below-grade walls in contact with earth shall be recessed 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 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 07 84 00 FIRESTOPPING.

3.1.3.2 Flashing Requirements

Pipes passing through roof shall be installed through a 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 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 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 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 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.

3.1.3.3 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 6 inches in diameter.
- b. A tack-welded or banded-metal rain shield around the pipe.

3.1.3.4 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 1/4 to 1/2 inch wide by 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 07 92 00 JOINT SEALANTS.

3.1.3.5 Pipe Penetrations

Provide sealants for all pipe penetrations. All pipe penetrations shall be sealed to prevent infiltration of air, insects, and vermin.

3.1.4 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 07 84 00 FIRESTOPPING.

3.1.5 Supports

3.1.5.1 General

Hangers used to support piping 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.

3.1.5.2 Pipe Hangers, Inserts, and Supports

Installation of pipe hangers, inserts and supports shall conform to MSS SP-58 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-58 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 4 inches and larger when the temperature of the medium is 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 4 inches.

- (2) Be used on insulated pipe 4 inches and larger when the temperature of the medium is 60 degrees F or less.
- (3) Have a high density insert for all pipe sizes. High density inserts shall have a density of 8 pcf or greater.
- i. Horizontal pipe supports shall be spaced as specified in MSS SP-58 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves. Operating temperatures in determining hanger spacing for PVC or CPVC pipe shall be 120 degrees F for PVC and 180 degrees F for CPVC. 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 15 feet nor more than 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 4 inches and larger when the temperature of the medium is 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 4 inches a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.
 - (3) On pipe 4 inches and larger carrying medium less than 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 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.

3.1.5.3 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. Supports shall not be attached to the underside of concrete filled floor or concrete roof decks

unless approved by the Contracting Officer. Masonry anchors for overhead applications shall be constructed of ferrous materials only.

3.1.6 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.

3.1.7 Pipe Cleanouts

Pipe cleanouts shall be the same size as the pipe except that cleanout plugs larger than [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 [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 [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 or plastic.

3.2 IDENTIFICATION SYSTEMS

3.2.1 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 [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.

3.3 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.

3.4 PAINTING

Painting of pipes, hangers, supports, and other iron work, either in concealed spaces or exposed spaces, is specified in Section 09 90 00 PAINTS AND COATINGS.

3.5 TESTS

3.5.1 Plumbing System

The following tests shall be performed on the plumbing system in accordance with ICC IPC, except that the drainage and vent system final test shall include the smoke test. The Contractor has the option to perform a peppermint test in lieu of the smoke test. If a peppermint test is chosen, the Contractor must submit a testing procedure and reasons for choosing this option in lieu of the smoke test to the Contracting Officer for approval.

- a. Drainage and Vent Systems Test. The final test shall include a smoke test.
- b. Building Sewers Tests.

3.5.2 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.

3.6 TABLES

TABLE I						
PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS						
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E
1	Cast iron soil pipe and fittings, hub and spigot, ASTM A74 with compression gaskets. Pipe and fittings shall be marked with the CISPI trademark.	X	X	X	X	X
2	Cast iron soil pipe and fittings hubless, CISPI 301 and ASTM A888 . Pipe and fittings shall be marked with the CISPI trademark.		X	X	X	X
3	Cast iron drainage fittings, threaded, ASME B16.12 for use with Item 10	X		X	X	
4	Cast iron screwed fittings (threaded) ASME B16.4 for use with Item 10				X	X
5	Polyvinyl Chloride plastic drain, waste and vent pipe and fittings, ASTM D2665 , ASTM F891 , (Sch 40) ASTM F1760	X	X	X	X	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 * - Hard Temper						

SECTION 23 05 15

COMMON PIPING FOR HVAC

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 INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325 (2017) Steel Construction Manual

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A112.19.2/CSA B45.1 (2018; ERTA 2018) Standard for Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals

ASME B16.1 (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

ASME B16.3 (2021) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.5 (2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B16.9 (2018) Factory-Made Wrought Buttwelding Fittings

ASME B16.22 (2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASME B16.25 (2017) Buttwelding Ends

ASME B16.34 (2021) Valves - Flanged, Threaded and Welding End

ASME B31.3 (2020) Process Piping

ASME B40.100 (2013) Pressure Gauges and Gauge Attachments

ASME BPVC SEC IX (2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN WELDING SOCIETY (AWS)

AWS WHB-2.9 (2004) Welding Handbook; Volume 2, Welding Processes, Part 1

ASTM INTERNATIONAL (ASTM)

ASTM A6/A6M	(2021) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A126	(2004; R 2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A197/A197M	(2000; R 2019) Standard Specification for Cupola Malleable Iron
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A276/A276M	(2017) Standard Specification for Stainless Steel Bars and Shapes
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B370	(2012; R 2019) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM B749	(2020) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products
ASTM C67/C67M	(2021) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM C109/C109M	(2021) Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or (50-mm) Cube Specimens)
ASTM C404	(2018) Standard Specification for Aggregates for Masonry Grout

ASTM C476	(2020) Standard Specification for Grout for Masonry
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM E814	(2013a; R 2017) Standard Test Method for Fire Tests of Penetration Firestop Systems
ASTM F104	(2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials
ASTM F2389	(2021) Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

FLUID SEALING ASSOCIATION (FSA)

FSA-0017	(1995e6) Standard for Non-Metallic Expansion Joints and Flexible Pipe Connectors Technical Handbook

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 515	(2017) Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-67	(2017; Errata 1 2017) Butterfly Valves
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
MSS SP-125	(2010) Gray Iron and Ductile Iron In-Line,

Spring-Loaded, Center-Guided Check Valves

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-C-18480	(1982; Rev B; Notice 2 2009) Coating Compound, Bituminous, Solvent, Coal-Tar Base
MIL-DTL-17813	(2009; Rev H; Supp 1 2009; Notice 1 2013) Expansion Joints, Pipe, Metallic Bellows, General Specification for

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1922	(Rev A; Notice 3) Shield, Expansion (Caulking Anchors, Single Lead)
CID A-A-1923	(Rev A; Notice 3) Shield, Expansion (Lag, Machine and Externally Threaded Wedge Bolt Anchors)
CID A-A-1924	(Rev A; Notice 3) Shield, Expansion (Self Drilling Tubular Expansion Shell Bolt Anchors)
CID A-A-1925	(Rev A; Notice 3) Shield Expansion (Nail Anchors)
CID A-A-55614	(Basic; Notice 2) Shield, Expansion (Non-Drilling Expansion Anchors)
CID A-A-55615	(Basic; Notice 3) Shield, Expansion (Wood Screw and Lag Bolt Self-Threading Anchors)

UNDERWRITERS LABORATORIES (UL)

UL 1479	(2015; Reprint May 2021) Fire Tests of Through-Penetration Firestops

1.2 GENERAL REQUIREMENTS

Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section

Submit [Records of Existing Conditions](#) consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work constitutes acceptance of the existing conditions.

Include with [Equipment Foundation Data](#) for piping systems all plan dimensions of foundations and relative elevations, equipment weight and operating loads, horizontal and vertical loads, horizontal and vertical clearances for installation, and size and location of anchor bolts.

Submit [Fabrication Drawings](#) for pipes, valves and specialties consisting of fabrication and assembly details to be performed in the factory.

Submit [Material, Equipment, and Fixture Lists](#) for pipes, valves and specialties including manufacturer's style or catalog numbers,

specification and drawing reference numbers, warranty information, and fabrication site information. Provide a complete list of construction equipment to be used.

Submit [Manufacturer's Standard Color Charts](#) for pipes, valves and specialties showing the manufacturer's recommended color and finish selections.

Include with [Listing of Product Installations](#) for piping systems identification of at least 5 units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. Include in the list purchaser, address of installation, service organization, and date of installation.

Submit [Record Drawings](#) for pipes, valves and accessories providing current factual information including deviations and amendments to the drawings, and concealed and visible changes in the work.

Submit [Connection Diagrams](#) for pipes, valves and specialties indicating the relations and connections of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Submit [Coordination Drawings](#) for pipes, valves and specialties showing coordination of work between different trades and with the structural and architectural elements of work. Detail all drawings sufficiently to show overall dimensions of related items, clearances, and relative locations of work in allotted spaces. Indicate on drawings where conflicts or clearance problems exist between various trades.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section [01 33 00](#) SUBMITTAL PROCEDURES:

[SD-01 Preconstruction Submittals](#)

[Material, Equipment, and Fixture Lists](#)

[SD-02 Shop Drawings](#)

[Record Drawings](#)

[Connection Diagrams](#)

[Coordination Drawings](#)

[Fabrication Drawings](#)

[Installation Drawings](#)

[SD-03 Product Data](#)

[Pipe and Fittings](#)

Piping Specialties

Valves

Miscellaneous Materials

Supporting Elements

Equipment Foundation Data

SD-04 Samples

Manufacturer's Standard Color Charts

SD-05 Design Data

Pipe and Fittings

Piping Specialties

Valves

SD-06 Test Reports

Hydrostatic Tests

Air Tests

Valve-Operating Tests

Drainage Tests

Pneumatic Tests

Non-Destructive Electric Tests

System Operation Tests

SD-07 Certificates

Record of Satisfactory Field Operation

List of Qualified Permanent Service Organizations

Listing of Product Installations

Records of Existing Conditions

Surface Resistance

Shear and Tensile Strengths

Temperature Ratings

Bending Tests

Flattening Tests

Transverse Guided Weld Bend Tests

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.4 QUALITY ASSURANCE

1.4.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Provide standard products in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.4.2 Alternative Qualifications

Products having less than a two-year field service record are acceptable if a certified [record of satisfactory field operation](#) for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.4.3 Service Support

Ensure the equipment items are supported by service organizations. Submit a certified [list of qualified permanent service organizations](#) for support of the equipment which includes their addresses and qualifications. Select service organizations that are reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.4.4 Manufacturer's Nameplate

Provide a nameplate on each item of equipment bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable.

1.4.5 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.

1.4.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions are considered mandatory, the word "should" is interpreted as "shall." Reference to the "code official" is interpreted to mean the "Contracting Officer." For Navy owned property, interpret references to the "owner" to mean the "Contracting Officer." For leased facilities, references to the "owner" is interpreted to mean

the "lessor." References to the "permit holder" are interpreted to mean the "Contractor."

1.4.5.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, are applied as appropriate by the Contracting Officer and as authorized by his administrative cognizance and the FAR.

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6 ELECTRICAL REQUIREMENTS

Furnish motors, controllers, disconnects and contactors with their respective pieces of equipment. Ensure motors, controllers, disconnects and contactors conform to and have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Furnish internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors is not permitted. Provide controllers and contactors with a maximum of 120 volt control circuits, and auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, include the cost of additional electrical service and related work under the section that specified that motor or equipment. Provide power wiring and conduit for field installed equipment under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.7 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Provide instructors thoroughly familiar with all parts of the installation and trained in operating theory as well as practical operation and maintenance work.

Give instruction 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 is as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.8 ACCESSIBILITY

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

2.1 PIPE AND FITTINGS

Submit equipment and performance data for [pipe and fittings](#) consisting of corrosion resistance, life expectancy, gage tolerances, and grade line analysis. Submit design analysis and calculations consisting of surface resistance, rates of flow, head losses, inlet and outlet design, required radius of bend, and pressure calculations. Also include in data pipe size, shape, and dimensions, as well as temperature ratings, vibration and thrust limitations minimum burst pressures, shut-off and non-shock pressures and weld characteristics.

2.1.1 Type BCS, Black Carbon Steel

Ensure pipe [1/8 through 12 inches](#) is Schedule 40 black carbon steel, conforming to [ASTM A53/A53M](#).

Ensure fittings [2 inches and under](#) are [150-pounds per square inch, gage \(psig\)](#) working steam pressure (wsp) banded black malleable iron screwed, conforming to [ASTM A197/A197M](#) and [ASME B16.3](#).

Ensure fittings [2-1/2 inches and over](#) are Steel butt weld, conforming to [ASTM A234/A234M](#) and [ASME B16.9](#) to match pipe wall thickness.

Ensure flanges [2-1/2 inches and over](#) are [150-pound](#) forged-steel conforming to [ASME B16.5](#), welding neck to match pipe wall thickness.

2.1.2 Type CPR, Copper

2.1.2.1 Type CPR-A, Copper Above Ground

Ensure tubing [2 inches and under](#) is seamless copper tubing, conforming to [ASTM B88](#), Type L (hard-drawn for all horizontal and all exposed vertical lines, annealed for concealed vertical lines).

Ensure fittings [2 inches and under](#) are [150-psig](#) wsp wrought-copper solder joint fittings conforming to [ASME B16.22](#).

Ensure unions [2 inches and under](#) are [150-psig](#) wsp wrought-copper solder joint, conforming to [ASME B16.22](#).

2.2 PIPING SPECIALTIES

Submit equipment and performance data for [piping specialties](#) consisting of corrosion resistance, life expectancy, gage tolerances, and grade line analysis. Submit design analysis and calculations consisting of surface resistance, rates of flow, head losses, inlet and outlet design, required radius of bend, and pressure calculations. Also include in data pipe size, shape, and dimensions, as well as temperature ratings, vibration and thrust limitations minimum burst pressures, shut-off and non-shock

pressures and weld characteristics.

2.2.1 Air Vents

Provide manual air vents using 3/8-inch globe valves.

Provide automatic air vents on pumps, mains, and where indicated using ball-float construction. Ensure the vent inlet is not less than 3/4-inch ips and the outlet not less than 1/4-inch ips. Orifice size is 1/8 inch. Provide corrosion-resistant steel trim conforming to ASTM A276/A276M. Fit vent with try-cock. Ensure vent discharges air at any pressure up to 150 psi. Ensure outlet is copper tube routed.

2.2.2 Dielectric Connections

Electrically isolate dissimilar pipe metals from each other by couplings, unions, or flanges commercially manufactured for that purpose and rated for the service pressure and temperature.

2.2.3 Expansion Vibration Isolation Joints

Construct single or multiple arch-flanged expansion vibration isolation joints of steel-ring reinforced chloroprene-impregnated cloth materials. Design joint to absorb the movement of the pipe sections in which installed with no detrimental effect on the pipe or connected equipment. Back flanges with ferrous-metal backing rings. Provide control rod assemblies to restrict joint movement. Coat all nonmetallic exterior surfaces of the joint with chlorosulphonated polyethylene. Provide grommets in limit bolt hole to absorb noise transmitted through the bolts.

Ensure joints are suitable for continuous-duty working temperature of at least 250 degrees F.

Ensure joint, single-arch, movement limitations and size-related, pressure characteristics conform to FSA-0017.

2.2.4 Flexible Pipe

Construct flexible pipe vibration and pipe-noise eliminators of wire-reinforced, rubber-impregnated cloth and cord materials and be flanged. Back the flanges with ferrous-metal backing rings. Ensure service pressure-rating is a minimum 1.5 times actual service, with surge pressure at 180 degrees F.

Construct flexible pipe vibration and pipe noise eliminators of wire-reinforced chloroprene-impregnated cloth and cord materials. Ensure the pipe is flanged. Provide all flanges backed with ferrous-metal backing rings. Coat nonmetallic exterior surfaces of the flexible pipe with an acid- and oxidation-resistant chlorosulphonated polyethylene. Rate the flexible pipe for continuous duty at 130 psi and 250 degrees F.

Ensure unit pipe lengths, face-to-face, are not less than the following:

<u>INSIDE DIAMETER</u>	<u>UNIT PIPE LENGTH</u>
To 2-1/2 inches, inclusive	12 inches
3 to 4 inches, inclusive	18 inches

INSIDE DIAMETER
5 to 12 inches, inclusive

UNIT PIPE LENGTH
24 inches

2.2.5 Flexible Metallic Pipe

Ensure flexible pipe is the bellows-type with wire braid cover and designed, constructed, and rated in accordance with the applicable requirements of [ASME B31.3](#).

Ensure flanged end connection rating and materials conform to specifications for system primary-pressure rating.

2.2.6 Metallic Expansion Joints

Provide metallic-bellows expansion joints conforming to [MIL-DTL-17813](#).

Design and construct joints to absorb all of the movements of the pipe sections in which installed, with no detrimental effect on pipe or supporting structure.

Rate, design, and construct joints for pressures to [125 psig](#) and temperatures to [500 degrees F](#).

Ensure joints have a designed bursting strength in excess of four times their rated pressure.

Ensure joints are capable of withstanding a hydrostatic test of 1.5 times their rated pressure while held at their uncompressed length without leakage or distortion that may adversely affect their life cycle.

Ensure life expectancy is not less than 10,000 cycles.

Ensure movement capability of each joint exceeds calculated movement of piping by 100 percent.

Provide bellows and internal sleeve material of AISI Type 304, 304L, or 321 corrosion-resistant steel.

End connections require no field preparation other than cleaning.

Butt weld end preparation of expansion joints conform to the same codes and standards requirements as applicable to the piping system materials at the indicated joint location.

Flanges of flanged-end expansion joints conforms to the same codes and standard requirements as are applicable to companion flanges specified for the given piping system at the indicated joint location.

Provide joints, [2-1/2 inches](#) and smaller, with internal guides and limit stops.

Provide joints, [3 inches](#) and larger, with removable external covers, internal sleeves, and purging connection. Size sleeves to accommodate lateral clearance required, with minimum reduction of flow area, and with oversized bellows where necessary. When a sleeve requires a gasket as part of a locking arrangement, provide the gasket used by the manufacturer. Joints without purging connection may be provided; however,

remove these from the line prior to, or not installed until, cleaning operations are complete.

Ensure each expansion joint has adjustable clamps or yokes provided at quarter points, straddling the bellows. Overall joint length is set by the manufacturer to maintain joints in manufacturer's recommended position during installation.

Permanently and legibly mark each joint with the manufacturer's name or trademark and serial number; the size, series, or catalog number; bellows material; and directional-flow arrow.

2.2.7 Pressure Gages

Ensure pressure gages conform to ASME B40.100 and to requirements specified herein. Pressure-gage size is 3-1/2 inches nominal diameter. Ensure case is corrosion-resistant steel, conforming to any of the AISI 300 series of ASTM A6/A6M, with an ASM No. 4 standard commercial polish or better. Equip gages with adjustable red marking pointer and damper-screw adjustment in inlet connection. Align service-pressure reading at midpoint of gage range. Ensure all gages are Grade B or better and be equipped with gage isolators.

2.2.8 Sight-Flow Indicators

Construct sight-flow indicators for pressure service on 3-inch ips and smaller of bronze with specially treated single- or double-glass sight windows and have a bronze, nylon, or tetrafluoroethylene rotating flow indicator mounted on an AISI corrosion-resistant steel shaft. Body may have screwed or flanged end. Provide pressure- and temperature-rated assembly for the applied service. Flapper flow-type indicators are not acceptable.

2.2.9 Sleeve Couplings

Sleeve couplings for plain-end pipe consist of one steel middle ring, two steel followers, two chloroprene or Buna-N elastomer gaskets, and the necessary steel bolts and nuts.

2.2.10 Thermometers

Ensure thermometers conform to ASTM E1, except for being filled with a red organic liquid. Provide an industrial pattern armored glass thermometer, (well-threaded and seal-welded). Ensure thermometers installed 6 feet or higher above the floor have an adjustable angle body. Ensure scale is not less than 7 inches long and the case face is manufactured from manufacturer's standard polished aluminum or AISI 300 series polished corrosion-resistant steel. Provide thermometers with nonferrous separable wells. Provide lagging extension to accommodate insulation thickness.

2.2.11 Pump Suction Strainers

Provide a cast iron strainer body, rated for not less than 25 psig at 100 degrees F, with flanges conforming to ASME B16.1, Class 125. Strainer construction is such that there is a machined surface joint between body and basket that is normal to the centerline of the basket.

Ensure minimum ratio of open area of each basket to pipe area is 3 to 1. Provide a basket with AISI 300 series corrosion-resistant steel wire mesh

with perforated backing.

Ensure mesh is capable of retaining all particles larger than 1,000 micrometer, with a pressure drop across the strainer body of not more than 0.5 psi when the basket is two-thirds dirty at maximum system flow rate. Provide reducing fittings from strainer-flange size to pipe size.

Provide a differential-pressure gage fitted with a two-way brass cock across the strainer.

Provide manual air vent cocks in cap of each strainer.

2.2.12 Line Strainers, Water Service

Provide Y-type strainers with removable basket. Ensure strainers in sizes 2-inch ips and smaller have screwed ends; in sizes 2-1/2-inch ips and larger, strainers have flanged ends. Ensure body working-pressure rating exceeds maximum service pressure of installed system by at least 50 percent. Ensure body has cast-in arrows to indicate direction of flow. Ensure all strainer bodies fitted with screwed screen retainers have straight threads and gasketed with nonferrous metal. For strainer bodies 2-1/2-inches and larger, fitted with bolted-on screen retainers, provide offset blowdown holes. Fit all strainers larger than 2-1/2-inches with manufacturer's standard ball-type blowdown valve. Ensure body material is cast bronze conforming to ASTM B62. Where system material is nonferrous, use nonferrous metal for the metal strainer body material.

Ensure minimum free-hole area of strainer element is equal to not less than 3.4 times the internal area of connecting piping. Strainer screens perforation size is not to exceed 0.045-inch. Ensure strainer screens have finished ends fitted to machined screen chamber surfaces to preclude bypass flow. Strainer element material is AISI Type 316 corrosion-resistant steel.

2.3 VALVES

Submit equipment and performance data for valves consisting of corrosion resistance and life expectancy. Submit design analysis and calculations consisting of rates of flow, head losses, inlet and outlet design, and pressure calculations. Also include in data, pipe dimensions, as well as temperature ratings, vibration and thrust limitations, minimum burst pressures, shut-off and non-shock pressures and weld characteristics.

Polypropylene valves will comply with the performance requirements of ASTM F2389. Valves shall conform to ASME B16.34.

2.3.1 Ball and Butterfly Valves

Ensure ball valves conform to MSS SP-72 for flanged valves and MSS SP-110 for screwed-end valves for Figure 1A 1 piece body, 1B vertically split body, 1C top entry 1D three piece body and are rated for service at not less than 175 psig at 200 degrees F. For valve bodies in sizes 2 inches and smaller, use screwed-end connection-type constructed of Class A copper alloy. For valve bodies in sizes 2-1/2 inches and larger, use flanged-end connection type, constructed of Class D material. Balls and stems of valves 2 inches and smaller are manufacturer's standard with hard chrome plating finish. Balls and stems of valves 2-1/2 inches and larger are manufacturer's standard Class C corrosion-resistant steel alloy with hard chrome plating. Balls of valves 6 inches and larger may be Class D with

900 Brinell hard chrome plating. Ensure valves are suitable for flow from either direction and seal equally tight in either direction. Valves with ball seals held in place by spring washers are not acceptable. Ensure all valves have adjustable packing glands. Seats and seals are fabricated from tetrafluoroethylene.

Ensure butterfly valves conform to [MSS SP-67](#) and are the wafer type for mounting between specified flanges. Ensure valves are rated for [150-psig](#) shutoff and nonshock working pressure. Select bodies of cast ferrous metal conforming to [ASTM A126](#), Class B, and to [ASME B16.1](#) for body wall thickness. Seats and seals are fabricated from resilient elastomer designed for field removal and replacement.

2.3.2 Drain, Vent, and Gage Cocks

Provide lever handle drain, vent, and gage cocks, ground key type, with washer and screw, constructed of polished [ASTM B62](#) bronze, and rated [125-psi](#) wsp. Ensure end connections are rated for specified service pressure.

Ensure pump vent cocks, and where spray control is required, are UL umbrella-hood type, constructed of manufacturer's standard polished brass. Ensure cocks are [1/2-inch ips](#) male, end threaded, and rated at not less than [125 psi at 225 degrees F](#).

2.3.3 Gate Valves (GAV)

Ensure gate valves [2 inches](#) and smaller conform to [MSS SP-80](#). For valves located in tunnels, equipment rooms, factory-assembled equipment, and where indicated use union-ring bonnet, screwed-end type. Make packing of non-asbestos type materials. Use rising stem type valves.

Ensure gate valves [2-1/2 inches](#) and larger, are Type I, (solid wedge disc, tapered seats, steam rated); Class 125 ([125-psig](#) steam-working pressure at [353 degrees F](#) saturation); and [200-psig](#), wog (nonshock), conforming to [MSS SP-70](#) and to requirements specified herein. Select flanged valves, with bronze trim and outside screw and yoke (OS&Y) construction. Make packing of non-asbestos type materials.

2.3.4 Globe and Angle Valves (GLV-ANV)

Ensure globe and angle valves [2 inches](#) and smaller, are [125-pound, 125-psi](#) conforming to [MSS SP-80](#) and to requirements specified herein. For valves located in tunnels, equipment rooms, factory-assembled equipment, and where indicated, use union-ring bonnet, screwed-end type. Ensure disc is free to swivel on the stem in all valve sizes. Composition seating-surface disc construction may be substituted for all metal-disc construction. Make packing of non-asbestos type materials. Ensure disk and packing are suitable for pipe service installed.

Ensure globe and angle valves, [2-1/2 inches](#) and larger, are cast iron with bronze trim. Ensure valve bodies are cast iron conforming to [ASTM A126](#), Class A, as specified for Class 1 valves under [MSS SP-80](#). Select flanged valves in conformance with [ASME B16.1](#). Valve construction is outside screw and yoke (OS&Y) type. Make packing of non-asbestos type materials.

2.3.5 Standard Check Valves (SCV)

Ensure standard check valves in sizes [2 inches](#) and smaller are [125-psi](#)

swing check valves except as otherwise specified. Provide lift checks where indicated. Ensure swing-check pins are nonferrous and suitably hard for the service. Select composition type discs. Ensure the swing-check angle of closure is manufacturer's standard unless a specific angle is needed.

Use cast iron, bronze trim, swing type check valves in sizes 2-1/2 inches and larger. Ensure valve bodies are cast iron, conforming to ASTM A126, Class A and valve ends are flanged in conformance with ASME B16.1. Swing-check pin is AISI Type or approved equal corrosion-resistant steel. Angle of closure is manufacturer's standard unless a specific angle is needed. Ensure valves have bolted and gasketed covers.

Provide check valves with external spring-loaded, positive-closure devices and valve ends are mechanical joint.

2.3.6 Nonslam Check Valves (NSV)

Provide check valves at pump discharges in sizes 2 inches and larger with nonslam or silent-check operation conforming to MSS SP-125. Select a valve disc or plate that closes before line flow can reverse to eliminate slam and water-hammer due to check-valve closure. Ensure valve is Class 125 rated for 200-psi maximum, nonshock pressure at 150 degrees F in sizes to 12 inches. Use valves that are wafer type to fit between flanges conforming to ASME B16.1. Valve body may be cast iron, or equivalent strength ductile iron. Select disks using manufacturer's standard bronze, aluminum bronze, or corrosion-resistant steel. Ensure pins, springs, and miscellaneous trim are manufacturer's standard corrosion-resistant steel. Disk and shaft seals are Buna-N elastomer tetrafluoroethylene.

2.4 MISCELLANEOUS MATERIALS

Submit equipment and performance data for miscellaneous materials consisting of corrosion resistance, life expectancy, gage tolerances, and grade line analysis.

2.4.1 Bituminous Coating

Ensure the bituminous coating is a solvent cutback, heavy-bodied material to produce not less than a 12-mil dry-film thickness in one coat, and is recommended by the manufacturer to be compatible with factory-applied coating and rubber joints.

For previously coal-tar coated and uncoated ferrous surfaces underground, use bituminous coating solvent cutback coal-tar type, conforming to MIL-C-18480.

2.4.2 Bolting

Ensure flange and general purpose bolting is hex-head and conforms to ASTM A307, Grade B (bolts, for flanged joints in piping systems where one or both flanges are cast iron). Heavy hex-nuts conform to ASTM A563. Square-head bolts and nuts are not acceptable. Ensure threads are coarse-thread series.

2.4.3 Elastomer Caulk

Use two-component polysulfide- or polyurethane-base elastomer caulking material, conforming to ASTM C920.

2.4.4 Escutcheons

Manufacture escutcheons from nonferrous metals and chrome-plated except when AISI 300 series corrosion-resistant steel is provided. Ensure metals and finish conforms to [ASME A112.19.2/CSA B45.1](#).

Use one-piece escutcheons where mounted on chrome-plated pipe or tubing, and one-piece of split-pattern type elsewhere. Ensure all escutcheons have provisions consisting of internal spring-tension devices for maintaining a fixed position against a surface.

2.4.5 Flashing

Ensure sheetlead conforms to [ASTM B749](#), .

Ensure sheet copper conforms to [ASTM B370](#) and be not less than 16 ounces per square foot weight.

2.4.6 Flange Gaskets

Provide compressed non-asbestos sheets, conforming to [ASTM F104](#), coated on both sides with graphite or similar lubricant, with nitrile composition, binder rated to 750 degrees F.

2.4.7 Grout

Provide shrink-resistant grout as a premixed and packaged metallic-aggregate, mortar-grouting compound conforming to [ASTM C404](#) and [ASTM C476](#).

Ensure shrink-resistant grout is a combination of pre-measured and packaged epoxy polyamide or amine resins and selected aggregate mortar grouting compound conforming to the following requirements:

Tensile strength		1,900 psi, minimum
Compressive strength	ASTM C109/C109M	14,000 psi, minimum
Shrinkage, linear		0.00012 inch per inch, maximum
Water absorption	ASTM C67/C67M	0.1 percent, maximum
Bond strength to		1,000 psi, minimum steel in shear minimum

2.4.8 Pipe Thread Compounds

Use polytetrafluoroethylene tape not less than 2 to 3 mils thick in potable and process water and in chemical systems for pipe sizes to and including 1-inch ips. Use polytetrafluoroethylene dispersions and other suitable compounds for all other applications upon approval by the Contracting Officer; however, do not use lead-containing compounds in potable water systems.

2.5 SUPPORTING ELEMENTS

Submit equipment and performance data for the [supporting elements](#) consisting of corrosion resistance, life expectancy, gage tolerances, and

grade line analysis.

Provide all necessary piping systems and equipment supporting elements, including but not limited to: building structure attachments; supplementary steel; hanger rods, stanchions, and fixtures; vertical pipe attachments; horizontal pipe attachments; anchors; guides; and spring-cushion, variable, or constant supports. Ensure supporting elements are suitable for stresses imposed by systems pressures and temperatures and natural and other external forces normal to this facility without damage to supporting element system or to work being supported.

Ensure supporting elements conform to requirements of [ASME B31.3](#), and [MSS SP-58](#), except as noted.

Ensure attachments welded to pipe are made of materials identical to that of pipe or materials accepted as permissible raw materials by referenced code or standard specification.

Ensure supporting elements exposed to weather are hot-dip galvanized or stainless steel. Select materials of such a nature that their apparent and latent-strength characteristics are not reduced due to galvanizing process. Electroplate supporting elements in contact with copper tubing with copper.

Type designations specified herein are based on [MSS SP-58](#). Ensure masonry anchor group-, type-, and style-combination designations are in accordance with [CID A-A-1922](#), [CID A-A-1923](#), [CID A-A-1924](#), [CID A-A-1925](#), [CID A-A-55614](#), and [CID A-A-55615](#). Provide support elements, except for supplementary steel, that are cataloged, load rated, commercially manufactured products.

2.5.1 Building Structure Attachments

2.5.1.1 Anchor Devices, Concrete and Masonry

Ensure anchor devices conform to [CID A-A-1922](#), [CID A-A-1923](#), [CID A-A-1924](#), [CID A-A-1925](#), [CID A-A-55614](#), and [CID A-A-55615](#)

For cast-in, floor mounted, equipment anchor devices, provide adjustable positions.

Do not use powder-actuated anchoring devices to support any mechanical systems components.

2.5.1.2 Beam Clamps

Ensure beam clamps are center-loading [MSS SP-58](#) Type 20 .

2.5.1.3 C-Clamps

Do not use C-clamps.

2.5.1.4 Inserts, Concrete

Use concrete [MSS SP-58](#) Type 18 inserts. When applied to piping in sizes [2 inches](#) and larger and where otherwise required by imposed loads, insert and wire a [1-foot](#) length of [1/2-inch](#) reinforcing rod through wing slots. Submit proprietary-type continuous inserts for approval.

2.5.2 Horizontal Pipe Attachments

2.5.2.1 Single Pipes

Support piping in sizes to and including 2-inch ips by MSS SP-58 Type 6 solid malleable iron pipe rings, except that, use split-band-type rings in sizes up to 1-inch ips.

Support piping in sizes through 8-inch ips inclusive by MSS SP-58 Type 1 attachments.

Use MSS SP-58 Type 1 and Type 6 assemblies on vapor-sealed insulated piping and have an inside diameter larger than pipe being supported to provide adequate clearance during pipe movement.

Where thermal movement of a point in a piping system 4 inches and larger would cause a hanger rod to deflect more than 4 degrees from the vertical or where a horizontal point movement exceeds 1/2 inch, use MSS SP-58 Type 44 through 46 pipe rolls.

Support piping in sizes larger than 8-inch ips with MSS SP-58 Type 44 through 46 pipe rolls.

Use MSS SP-58 Type 40 shields on all insulated piping. Ensure area of the supporting surface is such that compression deformation of insulated surfaces does not occur. Roll away longitudinal and transverse shield edges from the insulation.

Provide insulated piping without vapor barrier on roll supports with MSS SP-58 Type 39 saddles.

Provide spring supports as indicated.

2.5.2.2 Parallel Pipes

Use trapeze hangers fabricated from structural steel shapes, with U-bolts, in congested areas and where multiple pipe runs occur. Ensure structural steel shapes conform to supplementary steel requirements .

2.5.3 Vertical Pipe Attachments

Ensure vertical pipe attachments are MSS SP-58 Type 8.

Include complete fabrication and attachment details of any spring supports in shop drawings.

2.5.4 Hanger Rods and Fixtures

Use only circular cross section rod hangers to connect building structure attachments to pipe support devices. Use pipe, straps, or bars of equivalent strength for hangers only where approved by the Contracting Officer.

Provide turnbuckles, swing eyes, and clevises as required by support system to accommodate temperature change, pipe accessibility, and adjustment for load and pitch. Rod couplings are not acceptable.

2.5.5 Supplementary Steel

Where it is necessary to frame structural members between existing members or where structural members are used in lieu of commercially rated supports, design and fabricate such supplementary steel in accordance with [AISC 325](#).

PART 3 EXECUTION

3.1 PIPE INSTALLATION

Submit certificates for pipes, valves and specialties showing conformance with test requirements as contained in the reference standards contained in this section. Provide certificates verifying [Surface Resistance](#), [Shear and Tensile Strengths](#), [Temperature Ratings](#), [Bending Tests](#), [Flattening Tests](#) and [Transverse Guided Weld Bend Tests](#).

Provide test reports for [Hydrostatic Tests](#), [Air Tests](#), [Valve-Operating Tests](#), [Drainage Tests](#), [Pneumatic Tests](#), [Non-Destructive Electric Tests](#) and [System Operation Tests](#), in compliance with referenced standards contained within this section.

Fabricate and install piping systems in accordance with [ASME B31.3](#), [MSS SP-58](#), and [AWS WHB-2.9](#).

Submit [Installation Drawings](#) for pipes, valves and specialties. Drawings include the manufacturer's design and construction calculations, forces required to obtain rated axial, lateral, or angular movements, installation criteria, anchor and guide requirements for equipment, and equipment room layout and design. Ensure drawings specifically advise on procedures to be followed and provisions required to protect expansion joints during specified hydrostatic testing operations.

Ensure connections between steel piping and copper piping are electrically isolated from each other. Dielectric pipe unions shall be installed 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.

Make final connections to equipment with unions installed every [100 feet](#) of straight run. Install unions in the line downstream of screwed- and welded-end valves.

Ream all pipe ends before joint connections are made.

Make screwed joints with specified joint compound with not more than three threads showing after joint is made up.

Apply joint compounds to the male thread only and exercise care to prevent compound from reaching the unthreaded interior of the pipe.

Install screwed unions, welded unions, or bolted flanges wherever required to permit convenient removal of equipment, valves, and piping accessories from the piping system for maintenance.

Securely support piping systems with due allowance for thrust forces, thermal expansion and contraction. Do not subject the system to mechanical, chemical, vibrational or other damage as specified in [ASME B31.3](#).

Ensure field welded joints conform to the requirements of the [AWS WHB-2.9](#), [ASME B31.3](#), and [ASME BPVC SEC IX](#).

Make piping systems butt weld joints with backing rings. Use compatible backing ring materials with materials being joined. Ensure joint configuration conforms to [ASME B16.25](#).

For polypropylene pipe, make fusion-weld joints in accordance with the pipe and fitting manufacturer's specifications and product standards. Use fusion-weld tooling, welding machines, and electrofusion devices specified by the pipe and fittings manufacturer. Prior to joining, prepare the pipe and fittings in accordance with [ASTM F2389](#) and the manufacturer's specifications. Ensure joint preparation, setting and alignment, fusion process, cooling times and working pressure are in accordance with the pipe and fitting manufacturer's specifications.

3.2 VALVES

Install valves in piping mains and all branches and at equipment where indicated and as specified.

Install valves to permit isolation of branch piping and each equipment item from the balance of the system.

Install riser and downcomer drains above piping shutoff valves in piping [2-1/2 inches](#) and larger. Tap and fit shutoff valve body with a [1/2-inch](#) plugged globe valve.

Install valves unavoidably located in furred or other normally inaccessible places with access panels adequately sized for the location and located so that concealed items may be serviced, maintained, or replaced.

3.3 SUPPORTING ELEMENTS INSTALLATION

Install supporting elements in accordance with the referenced codes and standards.

Support piping from building structure. Do not support piping from roof deck or from other pipe.

Run piping parallel with the lines of the building. Space and install piping and components so that a threaded pipe fitting may be removed between adjacent pipes and so that there is no less than [1/2 inch](#) of clear space between the finished surface and other work and between the finished surface of parallel adjacent piping. Arrange hangers on different adjacent service lines running parallel with each other in line with each other and parallel to the lines of the building.

Install piping support elements at intervals specified hereinafter, at locations not more than [3 feet](#) from the ends of each runout, and not over [1 foot](#) from each change in direction of piping.

Base load rating for all pipe-hanger supports on insulated weight of lines

filled with water and forces imposed. Deflection per span is not exceed slope gradient of pipe. Ensure supports are in accordance with the following minimum rod size and maximum allowable hanger spacing for specified pipe. For concentrated loads such as valves, reduce the allowable span proportionately:

<u>PIPE SIZE</u> <u>INCHES</u>	<u>ROD SIZE</u> <u>INCHES</u>	<u>STEEL PIPE</u> <u>FEET</u>	<u>COPPER PIPE</u> <u>FEET</u>
1 and smaller	3/8	8	6
1-1/4 to 1-1/2	3/8	10	8
2	3/8	10	8
2-1/2 to 3-1/2	1/2	12	12
4 to 5	5/8	16	14
6	3/4	16	16
8 to 12	7/8	20	20
14 to 18	1	20	20
20 and over	1-1/4	20	20

Install vibration isolation supports where needed.

Support vertical risers independently of connected horizontal piping, whenever practicable, with fixed or spring supports at the base and at intervals to accommodate system range of thermal conditions. Ensure risers have guides for lateral stability. For risers subject to expansion, install only one rigid support at a point approximately one-third down from the top. Place clamps under fittings unless otherwise specified. Support carbon-steel pipe at each floor and at not more than 15-foot intervals for pipe 2 inches and smaller and at not more than 20-foot intervals for pipe 2-1/2 inches and larger.

3.4 PENETRATIONS

Install effective sound stopping and adequate operating clearance to prevent structure contact where piping penetrates walls, floors, or ceilings into occupied spaces adjacent to equipment rooms; where similar penetrations occur between occupied spaces; and where penetrations occur from pipe chases into occupied spaces. Occupied spaces include space above ceilings where no special acoustic treatment of ceiling is provided. Finish penetrations to be compatible with surface being penetrated.

3.5 SLEEVES

Install sleeves where piping passes through roofs, masonry, concrete walls and floors.

Continuously braze sleeves passing through steel decks to the deck.

Ensure sleeves that extend through floors, roofs, load bearing walls, and fire barriers are continuous and fabricated from Schedule 40 steel pipe, with welded anchor lugs. Form all other sleeves by molded linear

polyethylene liners or similar materials that are removable. Ensure diameter of sleeves is large enough to accommodate pipe, insulation, and jacketing without touching the sleeve and provides a minimum **3/8-inch** clearance. Install a sleeve size to accommodate mechanical and thermal motion of pipe precluding transmission of vibration to walls and the generation of noise.

Pack the space between a pipe, bare or insulated, and the inside of a pipe sleeve or a construction surface penetration solid with a mineral fiber conforming to **ASTM C553** Type V (flexible blanket), **to 1,000 degrees F**. Install this packing wherever the piping passes through firewalls, equipment room walls, floors, and ceilings connected to occupied spaces, and other locations where sleeves or construction-surface penetrations occur between occupied spaces. Where sleeves or construction surface penetrations occur between conditioned and unconditioned spaces, fill the space between a pipe, bare or insulated, and the inside of a pipe sleeve or construction surface penetration with an elastomer caulk to a depth of **1/2 inch**. Ensure all caulked surfaces are oil- and grease-free.

Ensure through-penetration fire stop materials and methods are in accordance with **ASTM E814** and **UL 1479**.

Caulk exterior wall sleeves watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed metal components.

3.6 ESCUTCHEONS

Install escutcheons at all penetrations of piping into finished areas. Where finished areas are separated by partitions through which piping passes, install escutcheons on both sides of the partition. Where suspended ceilings are installed, install plates at the underside only of such ceilings. For insulated pipes, select plates large enough to fit around the insulation. Use chrome-plated escutcheons in all occupied spaces and of size sufficient to effectively conceal openings in building construction. Firmly attach escutcheons with setscrews.

3.7 FLASHINGS

Install flashings at penetrations of building boundaries by mechanical systems and related work.

3.8 UNDERGROUND PIPING INSTALLATION

Prior to being lowered into a trench, clean all piping, visually inspected for apparent defects, and tapped with a hammer to audibly detect hidden defects.

Further inspect suspect cast-ferrous piping by painting with kerosene on external surfaces to reveal cracks.

Distinctly mark defective materials found using a road-traffic quality yellow paint; promptly remove defective material from the site.

After conduit has been inspected, and not less than 48 hours prior to being lowered into a trench, coat all external surfaces of cast ferrous conduit with a compatible bituminous coating for protection against brackish ground water. Apply a single coat, in accordance with the manufacturer's instructions, to result in a dry-film thickness of not less than **12 mils**.

Ensure excavations are dry and clear of extraneous materials when pipe is being laid.

Use wheel cutters for cutting of piping or other machines designed specifically for that purpose. Electric-arc and oxyacetylene cutting is not permitted.

Begin laying of pipe at the low point of a system. When in final acceptance position, ensure it is true to the grades and alignment indicated, with unbroken continuity of invert. Blocking and wedging is not permitted.

Make changes in direction with long sweep fittings.

Install necessary socket clamping, piers, bases, anchors, and thrust blocking. Protect rods, clamps, and bolting with a coating of bitumen.

Support underground piping below supported or suspended slabs from the slab with a minimum of two supports per length of pipe. Protect supports with a coating of bitumen.

On excavations that occur near and below building footings, install backfilling material consisting of 2,000-psi cured compressive-strength concrete poured or pressure-grouted up to the level of the footing.

Properly support vertical downspouts; soil, waste, and vent stacks; water risers; and similar work on approved piers at the base and provided with approved structural supports attached to building construction.

Provide cleanout, flushing, and observation risers.

3.9 HEAT TRACE CABLE INSTALLATION

Field apply heater tape and cut to fit as necessary, linearly along the length of pipe after piping has been pressure tested and approved by the Contracting Officer. Secure the heater to piping with cable ties. Label thermal insulation on the outside, "Electrical Heat Trace."

Install power connection, end seals, splice kits and tee kit components in accordance with IEEE 515 to provide a complete workable system. Terminate connection to the thermostat and ends of the heat tape in a junction box. Ensure cable and conduit connections are raintight.

3.10 DISINFECTION

Flush piping with potable water until visible grease, dirt and other contaminants are removed (visual inspection).

3.11 OPERATION AND MAINTENANCE

Provide Operation and Maintenance Manuals consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions. Submit test data that is clear and readily legible.

3.12 PAINTING OF NEW EQUIPMENT

Factory or shop apply new equipment painting, as specified herein, and

provided under each individual section.

3.12.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied withstands 125 hours in a salt-spray fog test, except that equipment located outdoors withstand 500 hours in a salt-spray fog test. Conduct salt-spray fog test is in accordance with [ASTM B117](#), and for that test the acceptance criteria is as follows: immediately after completion of the test, the inspected paint shows no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shows no signs of rust creepage beyond [0.125 inch](#) on either side of the scratch mark.

Ensure the film thickness of the factory painting system applied on the equipment is not less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above [120 degrees F](#), design the factory painting system for the temperature service.

3.12.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except clean to bare metal, surfaces subject to temperatures in excess of [120 degrees F](#).

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Selected color of finish coat is aluminum or light gray.

- a. Temperatures Less Than [120 Degrees F](#): Immediately after cleaning, the metal surfaces subject to temperatures less than [120 degrees F](#) receives one coat of pretreatment primer applied to a minimum dry film thickness of [0.3 mil](#), one coat of primer applied to a minimum dry film thickness of [one mil](#); and two coats of enamel applied to a minimum dry film thickness of [one mil](#) per coat.
- b. Temperatures Between [120 and 400 Degrees F](#): Metal surfaces subject to temperatures between [120 and 400 degrees F](#) Receives two coats of [400 degrees F](#) heat-resisting enamel applied to a total minimum thickness of [2 mils](#).
- c. Temperatures Greater Than [400 Degrees F](#): Metal surfaces subject to temperatures greater than [400 degrees F](#) receives two coats of [600 degrees F](#) heat-resisting paint applied to a total minimum dry film thickness of [2 mils](#).

-- End of Section --

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

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.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.4 (1983; Amendment 1985; R 2006)
Specification for Sound Level Meters (ASA 47)

ASA S1.11 PART 1 (2014) American National Standard
Electroacoustics - Octave-Band and
Fractional-Octave-Band Filters - Part 1:
Specifications

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 203 (1990; R 2011) Field Performance
Measurements of Fan Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING
ENGINEERS (ASHRAE)

ASHRAE 62.1 (2010) Ventilation for Acceptable Indoor
Air Quality

ASHRAE HVAC APP IP HDBK (2016) HVAC Applications Handbook, I-P
Edition

ASSOCIATED AIR BALANCE COUNCIL (AABC)

AABC MN-1 (2002; 6th ed) National Standards for
Total System Balance

AABC MN-4 (1996) Test and Balance Procedures

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB MASV (2006) Procedural Standards for
Measurements and Assessment of Sound and
Vibration

NEBB PROCEDURAL STANDARDS (2015) Procedural Standards for TAB
(Testing, Adjusting and Balancing)
Environmental Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION
(SMACNA)

SMACNA 1780	(2002) HVAC Systems - Testing, Adjusting and Balancing, 3rd Edition
SMACNA 1858	(2004) HVAC Sound And Vibration Manual - First Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

1.2 DEFINITIONS

- a. AABC: Associated Air Balance Council
- b. COTR: Contracting Officer's Technical Representative
- c. DALT: Duct air leakage test
- d. DALT'd: Duct air leakage tested
- e. HVAC: Heating, ventilating, and air conditioning; or heating, ventilating, and cooling
- f. NEBB: National Environmental Balancing Bureau
- g. Out-of-tolerance data: Pertains only to field acceptance testing of Final DALT or TAB report. When applied to DALT work, this phase means "a leakage rate measured during DALT field acceptance testing which exceeds the leakage rate allowed by SMACNA Leak Test Manual for an indicated duct construction and sealant class." When applied to TAB work this phase means "a measurement taken during TAB field acceptance testing which does not fall within the range of plus 5 to minus 5 percent of the original measurement reported on the TAB Report for a specific parameter."
- h. Season of maximum heating load: The time of year when the outdoor temperature at the project site remains within plus or minus 30 degrees Fahrenheit of the project site's winter outdoor design temperature, throughout the period of TAB data recording.
- i. Season of maximum cooling load: The time of year when the outdoor temperature at the project site remains within plus or minus 5 degrees Fahrenheit of the project site's summer outdoor design temperature, throughout the period of TAB data recording.
- j. Season 1, Season 2: Depending upon when the project HVAC is completed and ready for TAB, Season 1 is defined, thereby defining Season 2. Season 1 could be the season of maximum heating load, or the season of maximum cooling load.
- k. Sound measurements terminology: Defined in AABC MN-1, NEBB MASV, or SMACNA 1858 (TABB).
- l. TAB: Testing, adjusting, and balancing (of HVAC systems)
- m. TAB'd: HVAC Testing/Adjusting/Balancing procedures performed

- n. TAB Agency: TAB Firm
- o. TAB team field leader: TAB team field leader
- p. TAB team supervisor: TAB team engineer
- q. TAB team technicians: TAB team assistants
- r. TABB: Testing Adjusting and Balancing Bureau

1.2.1 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, NEBB, or TABB requirements where differences exist.

SIMILAR TERMS			
Contract Term	AABC Term	NEBB Term	TABB Term
TAB Standard	National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems	Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems	International Standards for Environmental Systems Balance
TAB Specialist	TAB Engineer	TAB Supervisor	TAB Supervisor
Systems Readiness Check	Construction Phase Inspection	Field Readiness Check & Preliminary Field Procedures	Field Readiness Check & Prelim. Field Procedures

1.3 WORK DESCRIPTION

The work includes duct air leakage testing (DALT) and testing, adjusting, and balancing (TAB) of new heating, ventilating, and cooling (HVAC) air and water distribution systems including equipment and performance data, ducts, and piping which are located within, on, under, between, and adjacent to buildings, including records of existing conditions.

Perform TAB in accordance with the requirements of the TAB procedural standard recommended by the TAB trade association that approved the TAB Firm's qualifications. Comply with requirements of AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 (TABB) as supplemented and modified by this specification section. All recommendations and suggested practices contained in the TAB procedural standards are considered mandatory.

Conduct DALT and TAB of the indicated existing systems and equipment and

submit the specified DALT and TAB reports for approval. Conduct DALT testing in compliance with the requirements specified in **SMACNA 1972 CD**, except as supplemented and modified by this section. Conduct DALT and TAB work in accordance with the requirements of this section.

1.3.1 Air Distribution Systems

Test, adjust, and balance systems (TAB) in compliance with this section. Obtain Contracting Officer's written approval before applying insulation to exterior of air distribution systems as specified under Section **23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS**.

1.3.2 Water Distribution Systems

TAB systems in compliance with this section. Obtain Contracting Officer's written approval before applying insulation to water distribution systems as specified under Section **23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS**. At Contractor's option and with Contracting Officer's written approval, the piping systems may be insulated before systems are TAB'd.

Terminate piping insulation immediately adjacent to each flow control valve, automatic control valve, or device. Seal the ends of pipe insulation and the space between ends of pipe insulation and piping, with waterproof vapor barrier coating.

After completion of work under this section, insulate the flow control valves and devices as specified under Section **23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS**.

1.3.3 TAB SCHEMATIC DRAWINGS

Show the following information on TAB Schematic Drawings:

1. A unique number or mark for each piece of equipment or terminal.
2. Air quantities at air terminals.
3. Air quantities and temperatures in air handling unit schedules.
4. Water quantities and temperatures in thermal energy transfer equipment schedules.
5. Water quantities and heads in pump schedules.
6. Water flow measurement fittings and balancing fittings.
7. Ductwork Construction and Leakage Testing Table that defines the DALT test requirements, including each applicable HVAC duct system ID or mark, duct pressure class, duct seal class, and duct leakage test pressure. This table is included in the file for Graphics for Unified Facilities Guide Specifications:
<http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-gra>

The Testing, Adjusting, and Balancing (TAB) Specialist must review the Contract Plans and Specifications and advise the Contracting Officer of any deficiencies that would prevent the effective and accurate TAB of the system, including records of existing conditions, and systems readiness check. The TAB Specialist must provide a Design Review Report individually listing each deficiency and the corresponding proposed

corrective action necessary for proper system operation.

Submit three copies of the [TAB Schematic Drawings and Report Forms](#) to the Contracting Officer, no later than 21 days prior to the start of TAB field measurements.

1.3.4 Related Requirements

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section [01 33 00 SUBMITTAL PROCEDURES](#):

[SD-01 Preconstruction Submittals](#)

[Records of Existing Conditions; G](#)

[TAB Firm; G](#)

[Designation of TAB Team Assistants; G](#)

[Designation of TAB Team Engineer; G or TAB Specialist; G](#)

[Designation of TAB Team Field Leader; G](#)

[SD-02 Shop Drawings](#)

[TAB Schematic Drawings and Report Forms; G](#)

[SD-03 Product Data](#)

[Equipment and Performance Data; G](#)

[TAB Related HVAC Submittals; G](#)

A list of the TAB Related HVAC Submittals, no later than 7 days after the approval of the TAB team engineer and assistant.

[TAB Procedures; G](#)

[Proposed procedures for TAB, submitted with the TAB Schematic Drawings and Report Forms.](#)

[Calibration; G](#)

[Systems Readiness Check; G](#)

[TAB Execution; G](#)

[TAB Verification; G](#)

[SD-06 Test Reports](#)

[Completed Pre-Final DALT Report; G](#)

Certified Final DALT Report; G

TAB Design Review Report; G

TAB Report for Season 1; G

TAB Report for Season 2; G

SD-07 Certificates

Independent TAB Agency and Personnel Qualifications; G

DALT and TAB Submittal and Work Schedule; G

TAB Pre-Field Engineering Report; G

TAB Firm; G

Design Review Report; G

Pre-field DALT Preliminary Notification; G

Advanced Notice for Season 1 TAB Field Work; G

Prerequisite HVAC Work Check Out List For Season 1; G

Advanced Notice for Season 2 TAB Field Work; G

Prerequisite HVAC Work Check Out List For Season 2; G

1.5 QUALITY ASSURANCE

1.5.1 Independent TAB Agency and Personnel Qualifications

To secure approval for the proposed agency, submit information certifying that the TAB agency is a first tier subcontractor who is not affiliated with any other company participating in work on this contract, including design, furnishing equipment, or construction. Further, submit the following, for the agency, to Contracting Officer for approval:

a. Independent AABC or NEBB or TABB TAB agency:

TAB agency: AABC registration number and expiration date of current certification; or NEBB certification number and expiration date of current certification; or TABB certification number and expiration date of current certification.

TAB team supervisor: Name and copy of AABC or NEBB or TABB TAB supervisor certificate and expiration date of current certification.

TAB team field leader: Name and documented evidence that the team field leader has satisfactorily performed full-time supervision of TAB work in the field for not less than 3 years immediately preceding this contract's bid opening date.

TAB team field technicians: Names and documented evidence that each field technician has satisfactorily assisted a TAB team field

leader in performance of TAB work in the field for not less than one year immediately preceding this contract's bid opening date.

Current certificates: Registrations and certifications are current, and valid for the duration of this contract. Renew Certifications which expire prior to completion of the TAB work, in a timely manner so that there is no lapse in registration or certification. TAB agency or TAB team personnel without a current registration or current certification are not to perform TAB work on this contract.

- b. TAB Team Members: TAB team approved to accomplish work on this contract are full-time employees of the TAB agency. No other personnel is allowed to do TAB work on this contract.
- c. Replacement of TAB team members: Replacement of members may occur if each new member complies with the applicable personnel qualifications and each is approved by the Contracting Officer.

1.5.2 TAB Standard

Perform TAB in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved, i.e., AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 unless otherwise specified herein. All recommendations and suggested practices contained in the TAB Standard are considered mandatory. Use the provisions of the TAB Standard, including checklists, report forms, etc., as nearly as practical, to satisfy the Contract requirements. Use the TAB Standard 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, adhere to the manufacturer's recommendations.

All quality assurance provisions of the TAB Standard such as performance guarantees are part of this contract. For systems or system components not covered in the TAB Standard, TAB procedures must 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, NEBB, or TABB), the requirements and recommendations contained in these procedures and requirements are considered mandatory, including the latest requirements of ASHRAE 62.1.

1.5.3 Qualifications

1.5.3.1 TAB Firm

The TAB Firm must be either a member of AABC or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications, including TAB of environmental systems and the measuring of sound and vibration in environmental systems.

Certification must be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor must 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, the NEBB, or the TABB within the five years preceding Contract Award is

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 will 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 must be a prime subcontractor of the Contractor and be financially and corporately independent of the mechanical subcontractor, reporting directly to and paid by the Contractor.

1.5.3.2 TAB Specialist

The TAB Specialist must be either a member of AABC, an experienced technician of the Firm certified by the NEBB, or a Supervisor certified by the TABB. The certification must be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, 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, the NEBB, or the TABB within the five years preceding Contract Award is not 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 will be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by the approved successor.

1.5.3.3 TAB Specialist Responsibilities

TAB Specialist responsibilities include all TAB work specified herein and in related sections under his direct guidance. The TAB specialist is required to be onsite on a daily basis to direct TAB efforts. The TAB Specialist must participate in the commissioning process.

1.5.3.4 TAB Related HVAC Submittals

The TAB Specialist must prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all HVAC TAB. Accompany the submittals identified on this list with a letter of approval signed and dated by the TAB Specialist when submitted to the Government. Ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.

1.5.4 Responsibilities

The Contractor is responsible for ensuring compliance with the requirements of this section. The following delineation of specific work responsibilities is specified to facilitate TAB execution of the various work efforts by personnel from separate organizations. This breakdown of specific duties is specified to facilitate adherence to the schedule listed in the paragraph TAB SUBMITTAL AND WORK SCHEDULE.

1.5.4.1 Contractor

- a. TAB personnel: Ensure that the DALT work and the TAB work is accomplished by a group meeting the requirements specified in the paragraph TAB PERSONNEL QUALIFICATION REQUIREMENTS.

- b. Pre-DALT/TAB meeting: Attend the meeting with the TAB Supervisor, and ensure that a representative is present for the sheetmetal contractor, mechanical contractor, electrical contractor, and automatic temperature controls contractor.
- c. HVAC documentation: Furnish one complete set of the following HVAC-related documentation to the TAB agency:
 - (1) Contract drawings and specifications
 - (2) Approved submittal data for equipment
 - (3) Construction work schedule
 - (4) Up-to-date revisions and change orders for the previously listed items
- d. Submittal and work schedules: Ensure that the schedule for submittals and work required by this section and specified in the paragraph TAB SUBMITTAL AND WORK SCHEDULE is met.
- e. Coordination of supporting personnel:

Provide the technical personnel, such as factory representatives or HVAC controls installer required by the TAB field team to support the DALT and the TAB field measurement work.

Provide equipment mechanics to operate HVAC equipment and ductwork mechanics to provide the field designated test ports to enable TAB field team to accomplish the DALT and the TAB field measurement work. Ensure these support personnel are present at the times required by the TAB team, and cause no delay in the DALT and the TAB field work.

Conversely, ensure that the HVAC controls installer has required support from the TAB team field leader to complete the controls check out.
- f. Deficiencies: Ensure that the TAB Agency supervisor submits all Design/Construction deficiency notifications directly to the Contracting officer within 3 days after the deficiency is encountered. Further, ensure that all such notification submittals are complete with explanation, including documentation, detailing deficiencies.
- g. Prerequisite HVAC work: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as prerequisite work items, the deficiencies pointed out by the TAB team supervisor in the design review report.
- h. Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's pre-field engineering report. Do not allow the TAB team to commence TAB field work until all of the following are completed.
 - (1) HVAC system installations are fully complete.

- (2) HVAC prerequisite checkout work lists specified in the paragraph PRE-FIELD TAB ENGINEERING REPORT are completed, submitted, and approved. Ensure that the TAB Agency gets a copy of the approved prerequisite HVAC work checklist.
- (3) DALT field checks for all systems are completed.
- (4) HVAC system filters are clean for both Season 1 and Season 2 TAB field work.
- i. Advance notice: Furnish to the Contracting Officer with advance written notice for the commencement of the DALT field work and for the commencement of the TAB field work.
- j. Insulation work: For required DALT work, ensure that insulation is not installed on ducts to be DALT'd until DALT work on the subject ducts is complete. Later, ensure that openings in duct and machinery insulation coverings for TAB test ports are marked, closed and sealed.

1.5.4.2 TAB Agency

Provide the services of a TAB team which complies with the requirements of the paragraph INDEPENDENT TAB AGENCY PERSONNEL QUALIFICATIONS. The work to be performed by the TAB agency is limited to testing, adjusting, and balancing of HVAC air and water systems to satisfy the requirements of this specification section.

1.5.4.3 TAB Team Supervisor

- a. Overall management: Supervise and manage the overall TAB team work effort, including preliminary and technical DALT and TAB procedures and TAB team field work.
- b. Pre-DALT/TAB meeting: Attend meeting with Contractor.
- c. Design review report: Review project specifications and accompanying drawings to verify that the air systems and water systems are designed in such a way that the TAB engineer can accomplish the work in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.
- d. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency; such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the pre-field engineering report, the during the DALT or TAB field work.
- e. Pre-field DALT preliminary notification: Monitor the completion of the duct installation of each system and provide the necessary written notification to the Contracting Officer.
- f. Pre-field engineering report: Utilizing the following HVAC-related documentation; contract drawings and specifications, approved submittal data for equipment, up-to-date revisions and change orders;

prepare this report.

- g. Prerequisite HVAC work checklist: Ensure the Contractor gets a copy of this checklist at the same time as the pre-field engineering report is submitted.
- h. Technical assistance for DALT work.
 - (1) Technical assistance: Provide immediate technical assistance to TAB field team.
 - (2) DALT field visit: Near the end of the DALT field work effort, visit the contract site to inspect the HVAC installation and the progress of the DALT field work. Conduct a site visit to the extent necessary to verify correct procedures are being implemented and to confirm the accuracy of the Pre-final DALT Report data which has been reported. Also, perform sufficient evaluation to allow the TAB supervisor to issue certification of the final report. Conduct the site visit full-time for a minimum of one 8 hour workday duration.
- i. Final DALT report: Certify the DALT report. This certification includes the following work:
 - (1) Review: Review the Pre-final DALT report data. From these field reports, prepare the Certified Final DALT report.
 - (2) **TAB Verification**: Verify adherence, by the TAB field team, to the procedures specified in this section.
- j. Technical Assistance for TAB Work: Provide immediate technical assistance to the TAB field team for the TAB work.
 - (1) TAB field visit: At the midpoint of the Season 1 and Season 2 TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work. Conduct site visit full-time for a minimum of one 8 hour workday duration.
 - (2) TAB field visit: Near the end of the TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work. Conduct site visit full-time for a minimum of one 8 hour workday duration. Review the TAB final report data and certify the TAB final report.
- k. Certified TAB report: Certify the TAB report. This certification includes the following work:
 - (1) Review: Review the TAB field data report. From this field report, prepare the certified TAB report.
 - (2) Verification: Verify adherence, by the TAB field team, to the TAB plan prescribed by the pre-field engineering report and verify adherence to the procedures specified in this section.
- l. Design/Construction deficiencies: Within 3 working days after the TAB Agency has encountered any design or construction deficiencies, the TAB Supervisor must submit written notification directly to the Contracting Officer, with a separate copy to the Contractor, of all such deficiencies. Provide in this submittal a complete explanation,

including supporting documentation, detailing deficiencies. Where deficiencies are encountered that are believed to adversely impact successful completion of TAB, the TAB Agency must issue notice and request direction in the notification submittal.

- m. TAB Field Check: The TAB team supervisor must attend and supervise Season 1 and Season 2 TAB field check.

1.5.4.4 TAB Team Field Leader

- a. Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, EXECUTION.
- b. Full time: Be present at the contract site when DALT field work or TAB field work is being performed by the TAB team; ensure day-to-day TAB team work accomplishments are in compliance with this section.
- c. Prerequisite HVAC work: Do not bring the TAB team to the contract site until a copy of the prerequisite HVAC Checklist, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

1.5.5 Test Reports

1.5.5.1 Data from DALT Field Work

Report the data for the Pre-final DALT Report and Certified Final DALT Report in compliance the following requirements:

- a. Report format: Submit report data on Air Duct Leakage Test Summary Report Forms as shown on Page 6-2 of **SMACNA 1972 CD**. In addition, submit in the report, a marked duct shop drawing which identifies each section of duct tested with assigned node numbers for each section. Include node numbers in the completed report forms to identify each duct section. The TAB supervisor must review and certify the report.
- b. The TAB supervisor must include a copy of all calculations prepared in determining the duct surface area of each duct test section. In addition, provide the ductwork air leak testing (DALT) reports with a copy(s) of the calibration curve for each of the DALT test orifices used for testing.
- c. Instruments: List the types of instruments actually used to measure the data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date. Instruments must have been calibrated within one year of the date of use in the field. Instrument calibration must be traceable to the measuring standards of the National Institute of Standards and Technology.
- d. Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

1.5.5.2 Certified TAB Reports

Submit: **TAB Report for Season 1** and **TAB Report for Season 2** in the following manner:

- a. Report format: Submit the completed pre-field data forms approved in

the pre-field TAB Engineering Report completed by TAB field team, reviewed and certified by the TAB supervisor. Bind the report with a waterproof front and back cover. Include a table of contents identifying by page number the location of each report. Report forms and report data must be typewritten. Handwritten report forms or report data are not acceptable.

- b. Temperatures: On each TAB report form reporting TAB work accomplished on HVAC thermal energy transfer equipment, include the indoor and outdoor dry bulb temperature range and indoor and outdoor wet bulb temperature range within which the TAB data was recorded. Include in the TAB report continuous time versus temperature recording data of wet and dry bulb temperatures for each thermal zone.
 - (1) . Measure and compile data on a continuous basis for the period in which TAB work affecting those rooms is being done.
 - (2) Measure and record data only after the HVAC systems installations are complete, the systems fully balanced and the HVAC systems controls operating in fully automatic mode.
 - (3) Data may be compiled using direct digital controls trend logging where available. Otherwise, temporarily install calibrated time versus temperature/humidity recorders for this purpose. The HVAC systems and controls must be fully operational a minimum of 24 hours in advance of commencing data compilation. Include the specified data in the Season 1 and Season 2 TAB Report.
- c. System Diagrams: Provide updated diagrams with final installed locations of all terminals and devices, any numbering changes, and actual test locations. Use a key numbering system on the diagram which identifies each outlet contained in the outlet airflow report sheets.
- d. Static Pressure Profiles: Report static pressure profiles for air duct systems including: Supply, return, exhaust, and outside air. Report static pressure data for all supply, return, relief, exhaust and outside air ducts for the systems listed. Include the following in the static pressure report data, in addition to AABC/NEBB/TABB required data:
 - (1) Report supply fan, return fan, relief fan, and exhaust fan inlet and discharge static pressures.
 - (2) Report static pressure drop across chilled water coils, DX coils, hot water coils, steam coils, electric resistance heating coils and heat reclaim devices installed in unit cabinetry or the system ductwork.
 - (3) Report static pressure drop across outside air, return air, and supply air automatic control dampers, both proportional and two-position, installed in unit cabinetry.
 - (4) Report static pressure drop across air filters, acoustic silencers, moisture eliminators, air flow straighteners, air flow measuring stations or other pressure drop producing specialty items installed in unit cabinetry, or in the system ductwork. Examples of these specialty items are smoke detectors, white sound generators, RF shielding, wave guides, security bars, blast

valves, small pipes passing through ductwork, and duct mounted humidifiers.

Do not report static pressure drop across duct fittings provided for the sole purpose of conveying air, such as elbows, transitions, offsets, plenums, manual dampers, and branch takes-offs.

- (5) Report static pressure drop across outside air and relief/exhaust air louvers.
- (6) Report static pressure readings of supply air, return air, exhaust/relief air, and outside air in duct at the point where these ducts connect to each air moving unit and also at the following locations:

Main Duct: Take readings at four locations along the full length of the main duct, 25 percent, 50 percent, 75 percent, and 100 percent of the total duct length.

Floor Branch Mains: Take readings at floor branch mains served by a main duct vertical riser.

Branch Main Ducts: Take readings at branch main ducts.

VAV Terminals: Take readings at inlet static pressure at VAV terminal box primary air branch ducts.

- e. **Duct Traverses:** Report duct traverses for main and branch main supply, return, exhaust, relief and outside air ducts. This includes all ducts, including those which lack 7 1/2 duct diameters upstream and 2 1/2 duct diameters downstream of straight duct unobstructed by duct fittings/offsets/elbows. The TAB Agency must evaluate and report findings on the duct traverses taken. Evaluate the suitability of the duct traverse measurement based on satisfying the qualifications for a pilot traverse plane as defined by **AMCA 203**, "Field Measurements", Section 8, paragraph 8.3, "Location of Traverse Plane."

- f. **Instruments:** List the types of instruments actually used to measure the tab data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.

Instrumentation, used for taking wet bulb temperature readings must provide accuracy of plus or minus 5 percent at the measured face velocities. Submit instrument manufacturer's literature to document instrument accuracy performance is in compliance with that specified.

- g. **Certification:** Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.
- h. **Performance Curves:** The TAB Supervisor must include, in the TAB Reports, factory pump curves and fan curves for pumps and fans TAB'd on the job.
- i. **Calibration Curves:** The TAB Supervisor must include, in the TAB Reports, a factory calibration curve for installed flow control

balancing valves, flow venturi's and flow orifices TAB'd on the job.

1.6 SEQUENCING AND SCHEDULING

1.6.1 Projects with Phased Construction

This specification section is structured as though the HVAC construction, and thereby the TAB work, will be completed in a single phase. When the construction is completed in phases, the DALT work and TAB work must be planned, completed, and accepted for each construction phase.

1.6.1.1 Phasing of Work

This specification section is structured as though the HVAC construction, and thereby the TAB work, is going to be completed in a single phase. All elements of the TAB work are addressed on this premise. When a contract is to be completed in construction phases, including the TAB work, and the DALT work, the TAB work and DALT work must be planned for, completed and approved by the Contracting Officer with each phase. An example of this case would be one contract that requires the rehabilitation of the HVAC in each of several separated buildings. At the completion of the final phase, compile all approved reports and submit as one document.

1.6.2 DALT and TAB Submittal and Work Schedule

Submit this schedule, and TAB Schematic Drawings, adapted for this particular contract, to the Contracting Officer (CO) for review and approval. Include with the submittal the planned calendar dates for each submittal or work item. Resubmit an updated version for CO approval every 90 calendar days. Compliance with the following schedule is the Contractor's responsibility.

Qualify TAB Personnel: Within 45 calendar days after date of contract award, submit TAB agency and personnel qualifications.

Pre-DALT/TAB Meeting: Within 30 calendar days after the date of approval of the TAB agency and personnel, meet with the COTR.

Design Review Report: Within 60 calendar days after the date of the TAB agency personnel qualifications approval, submit design review report.

Pre-Field DALT Preliminary Notification: On completion of the duct installation for each system, notify the Contracting Officer in writing within 5 days after completion.

Ductwork Selected for DALT: Within 7 calendar days of Pre-Field DALT Preliminary Notification, the COTR will select which of the project ductwork must be DALT'd.

DALT Field Work: Within 48 hours of COTR's selection, complete DALT field work on selected.

Submit Pre-final DALT Report: Within one working day after completion of DALT field work, submit Pre-final DALT Report. Separate Pre-final DALT reports may be submitted to allow phased testing from system to system.

DALT Work Field Check: Upon approval of the Pre-final DALT Report, schedule the COTR's DALT field check work with the Contracting Officer.

Submit Final DALT Report: Within 15 calendar days after completion of successful DALT Work Field Check, submit Season 1 TAB report.

Pre-Field TAB Engineering Report: Within 21 calendar days after approval of the TAB agency Personnel Qualifications, submit the Pre-Field TAB Engineering Report.

Prerequisite HVAC Work Check Out List For Season 1 and Advanced Notice For Season 1 TAB Field Work: At a minimum of 115 calendar days prior to CCD, submit Season 1 prerequisite HVAC work check out list certified as complete, and submit advance notice of commencement of Season 1 TAB field work.

Season 1 TAB Field Work: At a minimum of 90 calendar days prior to CCD, and when the ambient temperature is within Season 1 limits, accomplish Season 1 TAB field work.

Submit Season 1 TAB Report: Within 15 calendar days after completion of Season 1 TAB field work, submit Season 1 TAB report.

Season 1 TAB Field Check: 30 calendar days after Season 1 TAB report is approved by the Contracting Officer, conduct Season 1 field check.

Complete Season 1 TAB Work: Prior to CCD, complete all TAB work except Season 2 TAB work.

Prerequisite HVAC Work Check Out List For Season 2 and Advanced Notice For Season 2 TAB Field Work: Within 150 calendar days after date of the commencement of the Season 1 TAB field work, submit the Season 2 prerequisite HVAC work check out list certified as complete and submit advance notice of commencement of Season 2 TAB field work.

Season 2 TAB Field Work: Within 180 calendar days after date of commencement of the Season 1 TAB field work and when the ambient temperature is within Season 2 limits, accomplish Season 2 TAB field work.

Submit Season 2 TAB Report: Within 15 calendar days after completion of Season 2 TAB field work, submit Season 2 TAB report.

Season 2 TAB Field Check: 30 calendar days after the Season 2 TAB report is approved by the Contracting Officer, conduct Season 2 field check.

Complete Season 2 TAB Work: Within 15 calendar days after the completion of Season 2 TAB field data check, complete all TAB work.

Season 2 TAB Field Work: Within 180 calendar days after date of commencement of the Season 1 TAB field work and when the ambient temperature is within Season 2 limits, accomplish Season 2 TAB field work; submit Season 2 TAB report; and conduct Season 2 field check.

Complete Season 2 TAB Work: Within 15 calendar days after the completion of Season 2 field data check, complete TAB work.

1.6.2.1 TAB Design Review Report

Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.

1.6.2.2 Pre-Field DALT Preliminary Notification

Notification: On completion of the installation of each duct system indicated to be DALT'd, notify the Contracting Officer in writing within 7 calendar days after completion.

1.6.2.3 TAB Pre-Field Engineering Report

Submit report containing the following information:

a. Step-by-step TAB procedure:

- (1) Strategy: Describe the method of approach to the TAB field work from start to finish. Include in this description a complete methodology for accomplishing each seasonal TAB field work session.
- (2) Air System Diagrams: Use the contract drawings and duct fabrication drawings if available to provide air system diagrams in the report showing the location of all terminal outlet supply, return, exhaust and transfer registers, grilles and diffusers. Use a key numbering system on the diagrams which identifies each outlet contained in the outlet airflow report sheets. Show intended locations of all traverses and static pressure readings.
- (3) Procedural steps: Delineate fully the intended procedural steps to be taken by the TAB field team to accomplish the required TAB work of each air distribution system and each water distribution system. Include intended procedural steps for TAB work for subsystems and system components.

b. Pre-field data: Submit AABC or NEBB or **SMACNA 1780** data report forms with the following pre-field information filled in:

- (1) Design data obtained from system drawings, specifications, and approved submittals.
- (2) Notations detailing additional data to be obtained from the contract site by the TAB field team.
- (3) Designate the actual data to be measured in the TAB field work.
- (4) Provide a list of the types of instruments, and the measuring range of each, which are anticipated to be used for measuring in the TAB field work. By means of a keying scheme, specify on each TAB data report form submitted, which instruments will be used for measuring each item of TAB data. If the selection of which instrument to use, is to be made in the field, specify from which instruments the choice will be made. Place the instrument key number in the blank space where the measured data would be entered.

- c. Prerequisite HVAC work checkout list: Provide a list of inspections and work items which are to be completed by the Contractor. This list must be acted upon and completed by the Contractor and then submitted and approved by the Contracting Officer prior to the TAB team coming to the contract site.

At a minimum, a list of the applicable inspections and work items listed in the **NEBB PROCEDURAL STANDARDS**, Section III, "Preliminary TAB Procedures" under paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" must be provided for each separate system to be TAB'd.

1.7 WARRANTY

Furnish workmanship and performance warranty for the DALT and TAB system work performed for a period not less than 2 years from the date of Government acceptance of the work; issued directly to the Government. Include provisions that if within the warranty period the system shows evidence of major performance deterioration, or is significantly out of tolerance, resulting from defective TAB or DALT workmanship, the corrective repair or replacement of the defective materials and correction of the defective workmanship is the responsibility of the TAB firm. Perform corrective action that becomes necessary because of defective materials and workmanship while system TAB and DALT is under warranty 7 days after notification, unless additional time is approved by the Contracting Officer. Failure to perform repairs within the specified period of time constitutes grounds for having the corrective action and repairs performed by others and the cost billed to the TAB firm. The Contractor must also provide a 2 year contractor installation warranty.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 WORK DESCRIPTIONS OF PARTICIPANTS

Comply with requirements of this section.

3.2 PRE-DALT/TAB MEETING

Meet with the Contracting Officer's technical representative (COTR) to develop a mutual understanding relative to the details of the DALT work and TAB work requirements. Ensure that the TAB supervisor is present at this meeting. Requirements to be discussed include required submittals, work schedule, and field quality control.

3.3 DALT PROCEDURES

3.3.1 Instruments, Consumables and Personnel

Provide instruments, consumables and personnel required to accomplish the DALT field work. Follow the same basic procedure specified below for TAB Field Work, including maintenance and calibration of instruments, accuracy of measurements, preliminary procedures, field work, workmanship and treatment of deficiencies. Calibrate and maintain instruments in accordance with manufacturer's written procedures.

3.3.2 Advance Notice of Pre-Final DALT Field Work

On completion of the installation of each duct system indicated to be DALT'd, notify the Contracting Officer in writing prior to the COTR's duct selection field visit.

3.3.3 Ductwork To Be DALT'd

From each duct system indicated as subject to DALT, the COTR will randomly select sections of each completed duct system for testing by the Contractor's TAB Firm. The sections selected will not exceed 20 percent of the total measured linear footage of duct systems indicated as subject to DALT. Sections of duct systems subject to DALT will include 20 percent of main ducts, branch main ducts, branch ducts and plenums for supply, return, exhaust, and plenum ductwork.

3.3.4 DALT Testing

Perform DALT on the HVAC duct sections of each system as selected by the COTR. Use the duct class, seal class, leakage class and the leak test pressure data indicated on the drawings, to comply with the procedures specified in [SMACNA 1972 CD](#).

In spite of specifications of [SMACNA 1972 CD](#) to the contrary, DALT ductwork of construction class of [3-inch](#) water gauge static pressure and below if indicated to be DALT'd. Complete DALT work on the COTR selected ductwork within 48 hours after the particular ductwork was selected for DALT. Separately conduct DALT work for large duct systems to enable the DALT work to be completed in 48 hours.

3.3.5 Completed Pre-Final DALT Report

After completion of the DALT work, prepare a Pre-final DALT Report using the reporting forms specified. TAB team to furnish data required by those data report forms. Prepare the report neatly and legibly; the Pre-final DALT report is the basis for the Final DALT Report. TAB supervisor must review and certify the Pre-final DALT Report and submit this report within one day of completion of DALT field work. Verbally notify the COTR that the field check of the Pre-final DALT Report data can commence.

3.3.6 Quality Assurance - COTR DALT Field Acceptance Testing

In the presence of the COTR and TAB team field leader, verify for accuracy Pre-final DALT Report data selected by the COTR. For each duct system, this acceptance testing shall be conducted on a maximum of 50 percent of the duct sections DALT'd.

Further, if any data on the Pre-final DALT report form for a given duct section is out-of-tolerance, then field acceptance testing shall be conducted on data for one additional duct section, preferably in the same duct system, in the presence of the COTR.

3.3.7 Additional COTR Field Acceptance Testing

If any of the duct sections checked for a given system are determined to have a leakage rate measured that exceeds the leakage rate allowed by SMACNA Leak Test Manual for an indicated duct construction class and sealant class, terminate data checking for that section. The associated Pre-final DALT Report data for the given duct system will be disapproved.

Make the necessary corrections and prepare a revised Pre-final DALT Report. Reschedule a field check of the revised report data with the COTR.

3.3.8 Certified Final DALT Report

On successful completion of all field checks of the Pre-final DALT Report data for all systems, the TAB Supervisor is to assemble, review, certify and submit the Final DALT Report to the Contracting Officer for approval.

3.3.9 Prerequisite for TAB Field Work

Do not commence TAB field work prior to the completion and approval, for all systems, of the Final DALT Report.

3.4 TAB PROCEDURES

3.4.1 TAB Field Work

Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents.

That is, comply with the the requirements of AABC MN-1 or SMACNA 1780 (TABB) and SMACNA 1858 (TABB), except as supplemented and modified by this section.

Provide instruments and consumables required to accomplish the TAB work. Calibrate and maintain instruments in accordance with manufacturer's written procedures.

Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. Conduct TAB work, including measurement accuracy, and sound measurement work in conformance with the AABC MN-1 and AABC MN-4, or NEBB TABES and NEBB MASV, or SMACNA 1780 (used by TABB) and SMACNA 1858 sound measurement procedures, except as supplemented and modified by this section. The only water flow and air flow reporting which can be deferred until the Season 2 is that data which would be affected in terms of accuracy due to outside ambient conditions.

3.4.2 Preliminary Procedures

Use the approved pre-field engineering report as instructions and procedures for accomplishing TAB field work. TAB engineer is to locate, in the field, test ports required for testing. It is the responsibility of the sheet metal contractor to provide and install test ports as required by the TAB engineer.

3.4.3 TAB Air Distribution Systems

3.4.3.1 Units With Coils

Report heating and cooling performance capacity tests for hot water, chilled water, DX and steam coils for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

- a. For air handlers with capacities greater than 7.5 tons (90,000 Btu)

cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing."

Do not determine entering and leaving wet and dry bulb temperatures by single point measurement, but by the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of AABC MN-4, Procedure 3.5, "Coil Capacity Testing."

Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with AABC MN-4, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

- b. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.4.3.2 Air Handling Units

Air handling unit systems including fans (air handling unit fans, exhaust fans and winter ventilation fans), coils, ducts, plenums, mixing boxes, terminal units, variable air volume boxes, and air distribution devices for supply air, return air, outside air, mixed air relief air, and makeup air.

3.4.4 TAB Water Distribution Systems

3.4.4.1 Chilled Water

Chilled water systems including chillers, condensers, cooling towers, pumps, coils, system balance valves and flow measuring devices.

For water chillers, report data as required by AABC, NEBB and TABB standard procedures, including refrigeration operational data.

3.4.4.2 Heating Hot Water

Heating hot water systems including boilers, hot water converters (e.g., heat exchangers), pumps, coils, system balancing valves and flow measuring devices.

3.4.5 Sound Measurement Work

3.4.5.1 Areas To Be Sound Measured

In the following spaces, measure and record the sound power level for each octave band listed in ASHRAE HVAC APP IP HDBK Noise Criteria:

- a. All HVAC mechanical rooms, including machinery spaces and other spaces containing HVAC power drivers and power driven equipment.
- b. All spaces sharing a common barrier with each mechanical room,

including rooms overhead, rooms on the other side of side walls, and rooms beneath the mechanical room floor.

3.4.5.2 Procedure

Measure sound levels in each room, when unoccupied except for the TAB team, with all HVAC systems that would cause sound readings in the room operating in their noisiest mode. Record the sound level in each octave band. Attempt to mitigate the sound level and bring the level to within the specified **ASHRAE HVAC APP IP HDBK** noise criteria goals, if such mitigation is within the TAB team's control. State in the report the **ASHRAE HVAC APP IP HDBK** noise criteria goals. If sound level cannot be brought into compliance, provide written notice of the deficiency to the Contractor for resolution or correction.

3.4.5.3 Timing

Measure sound levels at times prescribed by AABC or NEBB or TABB.

3.4.5.4 Meters

Measure sound levels with a sound meter complying with **ASA S1.4**, Type 1 or 2, and an octave band filter set complying with **ASA S1.11 PART 1**. Use measurement methods for overall sound levels and for octave band sound levels as prescribed by NEBB.

3.4.5.5 Calibration

Calibrate sound levels as prescribed by AABC or NEBB or TABB, except that calibrators emitting a sound pressure level tone of 94 dB at 1000 hertz (Hz) are also acceptable.

3.4.5.6 Background Noise Correction

Determine background noise component of room sound (noise) levels for each (of eight) octave bands as prescribed by AABC or NEBB or TABB.

3.4.6 TAB Work on Performance Tests Without Seasonal Limitations

3.4.6.1 Performance Tests

In addition to the TAB proportionate balancing work on the air distribution systems and the water distribution systems, accomplish TAB work on the HVAC systems which directly transfer thermal energy. TAB the operational performance of the heating systems and cooling systems.

3.4.6.2 Ambient Temperatures

On each tab report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. Record these temperatures at beginning and at the end of data taking.

3.4.6.3 Sound Measurements

Comply with the paragraph SOUND MEASUREMENT WORK, specifically, the requirement that a room must be operating in its noisiest mode at the time of sound measurements in the room. The maximum noise level measurements

could depend on seasonally related heat or cooling transfer equipment.

3.4.6.4 Water Chillers

For water chillers, report data as required by NEBB Form TAB 15-83, **NEBB PROCEDURAL STANDARDS**, including refrigeration operational data.

3.4.6.5 Refrigeration Units

For refrigeration compressors/condensers/condensing units, report data as required by NEBB Form TAB 15-83, **NEBB PROCEDURAL STANDARDS**, including refrigeration operational data.

3.4.6.6 Coils

Report heating and cooling performance capacity tests for hot water and chilled water for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

- a. For Central station air handlers with capacities greater than 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests in accordance with **AABC MN-4**, procedure 3.5, "Coil Capacity Testing".

Entering and leaving wet and dry bulb temperatures are not determined by single point measurement, but the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of **AABC MN-4**, Procedure 3.5, "Coil Capacity Testing."

Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with **AABC MN-4**, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

- b. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.4.7 TAB Work on Performance Tests With Seasonal Limitations

3.4.7.1 Performance Tests

Accomplish proportionate balancing TAB work on the air distribution systems and water distribution systems, in other words, accomplish adjusting and balancing of the air flows and water flows, any time during the duration of this contract, subject to the limitations specified elsewhere in this section. However, accomplish, within the following seasonal limitations, TAB work on HVAC systems which directly transfer thermal energy.

3.4.7.2 Season Of Maximum Load

Visit the contract site for at least two TAB work sessions for TAB field measurements. Visit the contract site during the season of maximum heating load and visit the contract site during the season of maximum cooling load, the goal being to TAB the operational performance of the heating systems and cooling systems under their respective maximum outdoor environment-caused loading. During the seasonal limitations, TAB the operational performance of the heating systems and cooling systems.

3.4.7.3 Ambient Temperatures

On each tab report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. Record these temperatures at beginning and at the end of data taking.

3.4.7.4 Sound Measurements

Comply with the paragraph SOUND MEASUREMENT WORK, specifically, the requirement that a room must be operating in its noisiest mode at the time of sound measurements in the room. The maximum noise level measurements could depend on seasonally related heat or cooling transfer equipment.

3.4.7.5 Water Chillers

Water chillers: For water chillers, report data as required by NEBB Form TAB 15-83, **NEBB PROCEDURAL STANDARDS**, including refrigeration operational data.

3.4.7.6 Refrigeration Units

For refrigeration compressors/condensers/condensing units, report data as required by NEBB Form TAB 15-83, **NEBB PROCEDURAL STANDARDS**, including refrigeration operational data.

3.4.7.7 Coils

Report heating and cooling performance capacity tests for , , DX for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

- a. For Central station air handlers with capacities greater than 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests in accordance with **AABC MN-4**, procedure 3.5, "Coil Capacity Testing."

Entering and leaving wet and dry bulb temperatures are not determined by single point measurement, but by the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of **AABC MN-4**, Procedure 3.5, "Coil Capacity Testing."

Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with **AABC MN-4**, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

- b. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.4.8 Workmanship

Conduct TAB work on the HVAC systems until measured flow rates are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. This TAB work includes adjustment of balancing valves, balancing dampers, and sheaves. Further, this TAB work includes changing out fan sheaves and pump impellers if required to obtain air and water flow rates specified or indicated. If, with these adjustments and equipment changes, the specified or indicated design flow rates cannot be attained, contact the Contracting Officer for direction.

3.4.9 Deficiencies

Strive to meet the intent of this section to maximize the performance of the equipment as designed and installed. However, if deficiencies in equipment design or installation prevent TAB work from being accomplished within the range of design values specified in the paragraph WORKMANSHIP, provide written notice as soon as possible to the Contractor and the Contracting Officer describing the deficiency and recommended correction.

Responsibility for correction of installation deficiencies is the Contractor's. If a deficiency is in equipment design, call the TAB team supervisor for technical assistance. Responsibility for reporting design deficiencies to Contractor is the TAB team supervisor's.

3.4.10 TAB Reports

After completion of the TAB field work, prepare the TAB field data for TAB supervisor's review and certification, using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms is to be furnished by the TAB team. Except as approved otherwise in writing by the Contracting Officer, the TAB work and thereby the TAB report is considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph WORKMANSHIP.

3.4.11 Quality Assurance - COTR TAB Field Acceptance Testing

3.4.11.1 TAB Field Acceptance Testing

During the field acceptance testing, verify, in the presence of the COTR, random selections of data (water, air quantities, air motion, sound level readings) recorded in the TAB Report. Points and areas for field acceptance testing are to be selected by the COTR. Measurement and test procedures are the same as approved for TAB work for the TAB Report.

Field acceptance testing includes verification of TAB Report data recorded for the following equipment groups:

Group 1: All chillers, boilers, return fans, computer room units, and

air handling units (rooftop and central stations).

Group 2: 25 percent of the VAV terminal boxes and associated diffusers and registers.

Group 3: 25 percent of the supply diffusers, registers, grilles associated with constant volume air handling units.

Group 4: 25 percent of the return grilles, return registers, exhaust grilles and exhaust registers.

Group 5: 25 percent of the supply fans, exhaust fans, and pumps.

Further, if any data on the TAB Report for Groups 2 through 5 is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, additional group data verification is required in the presence of the COTR. Verify TAB Report data for one additional piece of equipment in that group. Continue this additional group data verification until out-of-tolerance data ceases to be found.

3.4.11.2 Additional COTR TAB Field Acceptance Testing

If any of the acceptance testing measurements for a given equipment group is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, terminate data verification for all affected data for that group. The affected data for the given group will be disapproved. Make the necessary corrections and prepare a revised TAB Report. Reschedule acceptance testing of the revised report data with the COTR.

Further, if any data on the TAB Report for a given field acceptance test group is out-of-tolerance, then field test data for one additional field test group as specified herein. Continue this increase field test work until out-of-tolerance data ceases to be found. This additional field testing is up and above the original 25 percent of the of reported data entries to be field tested.

If there are no more similar field test groups from which to choose, additional field testing from another, but different, type of field testing group must be tested.

3.4.11.3 Prerequisite for Approval

Compliance with the field acceptance testing requirements of this section is a prerequisite for the final Contracting Officer approval of the TAB Report submitted.

3.5 MARKING OF SETTINGS

Upon the final TAB work approval, permanently mark the settings of HVAC adjustment devices including valves, gauges, splitters, and dampers so that adjustment can be restored if disturbed at any time. Provide permanent markings clearly indicating the settings on the adjustment devices which result in the data reported on the submitted TAB report.

3.6 MARKING OF TEST PORTS

The TAB team is to permanently and legibly mark and identify the location points of the duct test ports. If the ducts have exterior insulation, make these markings on the exterior side of the duct insulation. Show the

location of test ports on the as-built mechanical drawings with dimensions given where the test port is covered by exterior insulation.

-- End of Section --

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SECTION 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS

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. 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.

ASTM INTERNATIONAL (ASTM)

ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A580/A580M	(2018) Standard Specification for Stainless Steel Wire
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM C195	(2007; R 2013) Standard Specification for Mineral Fiber Thermal Insulating Cement
ASTM C450	(2008) Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
ASTM C533	(2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C534/C534M	(2020a) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C547	(2019) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2021a) Standard Specification for Cellular Glass Thermal Insulation
ASTM C591	(2021) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation

ASTM C610	(2015) Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation
ASTM C647	(2008; R 2013) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM C755	(2019b) Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation
ASTM C795	(2008; R 2018) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C916	(2020) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C921	(2010; R 2015) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM C1126	(2018) Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
ASTM C1136	(2021) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C1710	(2011) Standard Guide for Installation of Flexible Closed Cell Preformed Insulation in Tube and Sheet Form
ASTM D882	(2012) Tensile Properties of Thin Plastic Sheeting
ASTM D2863	(2019) Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
ASTM D5590	(2000; R 2010; E 2012) Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96/E96M	(2021) Standard Test Methods for Gravimetric Determination of Water Vapor

Transmission Rate of Materials

ASTM E2231

(2021) Standard Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350

(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

FM GLOBAL (FM)

FM APP GUIDE

(updated on-line) Approval Guide
<http://www.approvalguide.com/>

GREEN SEAL (GS)

GS-36

(2013) Adhesives for Commercial Use

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 2758

(2014) Paper - Determination of Bursting Strength

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58

(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MIDWEST INSULATION CONTRACTORS ASSOCIATION (MICA)

MICA Insulation Stds

(8th Ed) National Commercial & Industrial Insulation Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A

(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

NFPA 90B

(2021) Standard for the Installation of Warm Air Heating and Air Conditioning Systems

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS

SCS Global Services (SCS) Indoor Advantage

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168

(2017) Adhesive and Sealant Applications

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
MIL-A-24179	(1969; Rev A; Am 2 1980; Notice 1 1987; Notice 2 2020) Adhesive, Flexible Unicellular-Plastic Thermal Insulation
MIL-PRF-19565	(1988; Rev C) Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

UNDERWRITERS LABORATORIES (UL)

UL 94	(2013; Reprint Mar 2022) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 2818	(2013) GREENGUARD Certification Program For Chemical Emissions For Building Materials, Finishes And Furnishings

1.2 SYSTEM DESCRIPTION

1.2.1 General

Provide field-applied insulation and accessories on mechanical systems as specified herein; factory-applied insulation is specified under the piping, duct or equipment to be insulated. 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 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

Submit the three SD types, SD-02 Shop Drawings, SD-03 Product Data, and SD-08 Manufacturer's Instructions at the same time for each system.

SD-02 Shop Drawings

MICA Plates; G

Pipe Insulation Systems and Associated Accessories

Duct Insulation Systems and Associated Accessories

Equipment Insulation Systems and Associated Accessories

Recycled content for insulation materials; S

SD-03 Product Data

Pipe Insulation Systems; G

Duct Insulation Systems; G

Equipment Insulation Systems; G

SD-04 Samples

Thermal Insulation; G

SD-07 Certificates

Indoor air quality for adhesives; S

SD-08 Manufacturer's Instructions

Pipe Insulation Systems; G

Duct Insulation Systems; G

Equipment Insulation Systems; G

1.4 CERTIFICATIONS

1.4.1 Adhesives and Sealants

Provide products certified to meet indoor air quality requirements by **UL 2818** (Greenguard) Gold, **SCS** Global Services Indoor Advantage Gold or provide certification or validation by other third-party programs that products meet the requirements of this Section. Provide current product certification documentation from certification body. When product does not have certification, provide validation that product meets the indoor air quality product requirements cited herein.

1.5 QUALITY ASSURANCE

1.5.1 Installer Qualification

Qualified installers shall have successfully completed three or more similar type jobs within the last 5 years.

1.6 DELIVERY, STORAGE, AND HANDLING

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. The Contracting Officer may reject insulation material and supplies that become dirty, dusty, wet, or contaminated by some other means. 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, date codes, and

approximate shelf life (if applicable). Insulation packages and containers shall be asbestos free.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials which are the standard products of manufacturers regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit 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 including adhesives, sealants and jackets for each mechanical system requiring insulation shall be included. The product data must be copyrighted, have an identifying or publication number, and shall have been published prior to the issuance date of this solicitation. Materials furnished under this section shall be submitted together in a booklet.

2.1.1 Insulation System

Provide insulation systems in accordance with the approved MICA National Insulation Standards plates as supplemented by this specification. Provide field-applied insulation for heating, ventilating, and cooling (HVAC) air distribution systems and piping systems that are located within, on, under, and adjacent to buildings; and for plumbing systems. Provide CFC and HCFC free insulation.

2.1.2 Surface Burning Characteristics

Unless otherwise specified, insulation must have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#). Flame spread, and smoke developed indexes, shall be determined by [ASTM E84](#) or [UL 723](#). Test insulation in the same density and installed thickness as the material to be used in the actual construction. Prepare and mount test specimens according to [ASTM E2231](#).

2.2 MATERIALS

Provide insulation that meets or exceeds the requirements of [ASHRAE 90.1](#). Insulation exterior shall be cleanable, grease resistant, non-flaking and non-peeling. Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either wet or dry state. Materials to be used on stainless steel surfaces shall meet [ASTM C795](#) requirements. Calcium silicate shall not be used on chilled or cold water systems. Materials shall be asbestos free. Provide product recognized under [UL 94](#) (if containing plastic) and listed in [FM APP GUIDE](#).

2.2.1 Adhesives

Provide non-aerosol adhesive products used on the interior of the building (defined as inside of the weatherproofing system) that meet either emissions requirements of [CDPH SECTION 01350](#) (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of [SCAQMD Rule 1168](#) (HVAC duct sealants must meet limit requirements of "Other" category within [SCAQMD Rule 1168](#) sealants table).

Provide aerosol adhesives used on the interior of the building that meet either emissions requirements of [CDPH SECTION 01350](#) (use the office or classroom requirements, regardless of space type) or VOC content requirements of [GS-36](#). Provide certification or validation of [indoor air quality for adhesives](#).

2.2.1.1 Acoustical Lining Insulation Adhesive

Adhesive shall be a nonflammable, fire-resistant adhesive conforming to [ASTM C916](#), Type I.

2.2.1.2 Mineral Fiber Insulation Cement

Cement shall be in accordance with [ASTM C195](#).

2.2.1.3 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. To resist mold/mildew, lagging adhesive shall meet [ASTM D5590](#) with 0 growth rating. Lagging adhesives shall be nonflammable and fire-resistant and shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#). Adhesive shall be [MIL-A-3316](#), Class 1, pigmented white 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 bonding glass tape to joints of fibrous glass board; for bonding lagging cloth to thermal insulation; or Class 2 for attaching fibrous glass insulation to metal surfaces. Lagging adhesives shall be applied in strict accordance with the manufacturer's recommendations for pipe and duct insulation.

2.2.1.4 Contact Adhesive

Adhesives may be any of, but not limited to, the neoprene based, rubber based, or elastomeric type that have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#). 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 [212 degrees F](#). The dried adhesive shall be nonflammable and fire resistant. Flexible Elastomeric Adhesive: Comply with [MIL-A-24179](#), Type II, Class I. Provide product listed in [FM APP GUIDE](#).

2.2.2 Caulking

[ASTM C920](#), Type S, Grade NS, Class 25, Use A.

2.2.3 Corner Angles

Nominal [0.016 inch](#) aluminum [1 by 1 inch](#) with factory applied kraft backing. Aluminum shall be [ASTM B209](#), Alloy 3003, 3105, or 5005.

2.2.4 Fittings

Fabricated Fittings are the prefabricated fittings for flexible elastomeric pipe insulation systems in accordance with [ASTM C1710](#). Together with the flexible elastomeric tubes, they provide complete system integrity for retarding heat gain and controlling condensation drip from chilled-water and refrigeration systems. Flexible elastomeric, fabricated fittings provide thermal protection (0.25 k) and condensation resistance (0.05 Water Vapor Transmission factor). For satisfactory performance, properly installed protective vapor retarder/barriers and vapor stops shall be used on high relative humidity and below ambient temperature applications to reduce movement of moisture through or around the insulation to the colder interior surface.

2.2.5 Finishing Cement

[ASTM C450](#): Mineral fiber hydraulic-setting thermal insulating and finishing cement. All cements that may come in contact with Austenitic stainless steel must comply with [ASTM C795](#).

2.2.6 Fibrous Glass Cloth and Glass Tape

Fibrous glass cloth, with 20X20 maximum mesh size, and glass tape shall have maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#). Tape shall be 4 inch wide rolls. Class 3 tape shall be 4.5 ounces/square yard. Elastomeric Foam Tape: Black vapor-retarder foam tape with acrylic adhesive containing an anti-microbial additive.

2.2.7 Staples

Outward clinching type [ASTM A167](#), Type 304 or 316 stainless steel.

2.2.8 Jackets

2.2.8.1 Aluminum Jackets

Aluminum jackets shall be corrugated, embossed or smooth sheet, 0.016 inch nominal thickness; [ASTM B209](#), Temper H14, Temper H16, Alloy 3003, 5005, or 3105. Corrugated aluminum jacket shall not be used outdoors. Aluminum jacket securing bands shall be Type 304 stainless steel, 0.015 inch thick, 1/2 inch wide for pipe under 12 inch diameter and 3/4 inch wide for pipe over 12 inch and larger diameter. Aluminum jacket circumferential seam bands shall be 2 by 0.016 inch aluminum matching jacket material. Bands for insulation below ground shall be 3/4 by 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 Pittsburgh 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.

2.2.9 Vapor Retarder Required

[ASTM C921](#), Type I, 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, 35 pounds/inch width. [ASTM C921](#), Type II, minimum puncture resistance 25 Beach units, tensile strength minimum 20 pounds/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 that require manufacturer or fabricator applied pipe insulation jackets are cellular glass, when all joints are sealed with a vapor barrier mastic, and mineral fiber. 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 E84](#). Flexible elastomerics require (in addition to vapor barrier skin) vapor retarder jacketing for high relative humidity and below ambient temperature applications.

2.2.9.1 White Vapor Retarder All Service Jacket (ASJ)

ASJ is for use on hot/cold pipes, ducts, or equipment indoors or outdoors if covered by a suitable protective jacket. The product shall meet all physical property and performance requirements of [ASTM C1136](#), Type I, except the burst strength shall be a minimum of 85 psi. [ASTM D2863](#) Limited Oxygen Index (LOI) shall be a minimum of 31.

In addition, neither the outer exposed surface nor the inner-most surface contacting the insulation shall be paper or other moisture-sensitive material. The outer exposed surface shall be white and have an emittance of not less than 0.80. The outer exposed surface shall be paintable.

2.2.9.2 Vapor Retarder/Vapor Barrier Mastic Coatings

2.2.9.2.1 Vapor Barrier

The vapor barrier shall be self adhesive (minimum 2 mils adhesive, 3 mils embossed) greater than 3 plies standard grade, silver, white, black and embossed white jacket for use on hot/cold pipes. Permeability shall be less than 0.02 when tested in accordance with [ASTM E96/E96M](#). Products shall meet [UL 723](#) or [ASTM E84](#) flame and smoke requirements and shall be UV resistant.

2.2.9.2.2 Vapor Retarder

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 in accordance with [ASTM C755](#), Section 7.2.2, Table 2, for insulation type and service conditions. The coating shall be nonflammable, fire resistant type. To resist mold/mildew, coating shall meet [ASTM D5590](#) with 0 growth rating. Coating shall meet [MIL-PRF-19565](#) Type II (if selected for indoor service) and be Qualified Products Database listed. All other application and service properties shall be determined pursuant to [ASTM C647](#).

2.2.9.3 Laminated Film Vapor Retarder

[ASTM C1136](#), 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. Vapor retarder shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#). Flexible Elastomeric exterior foam with factory applied UV Jacket. Construction of laminate designed to provide UV resistance, high puncture, tear resistance and an excellent WVT rate.

2.2.9.4 Polyvinylidene Chloride (PVDC) Film Vapor Retarder

The PVDC film vapor retarder shall have a maximum moisture vapor transmission of 0.02 perms, minimum puncture resistance of 150 Beach units, a minimum tensile strength in any direction of 30 lb/inch when tested in accordance with ASTM D882, and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.2.9.5 Polyvinylidene Chloride Vapor Retarder Adhesive Tape

Requirements must meet the same as specified for Laminated Film Vapor Retarder above.

2.2.9.6 Vapor Barrier/Weather Barrier

The vapor barrier shall be greater than 3 ply self adhesive laminate -white vapor barrier jacket- superior performance (less than 0.0000 permeability when tested in accordance with ASTM E96/E96M). Vapor barrier shall meet UL 723 or ASTM E84 25 flame and 50 smoke requirements; and UV resistant. Minimum burst strength 185 psi in accordance with ISO 2758. Tensile strength 68 lb/inch width (PSTC-1000). Tape shall be as specified for laminated film vapor barrier above.

2.2.10 Vapor Retarder Not Required

ASTM C921, Type II, Class D, 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. Jacket shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.2.11 Wire

Soft annealed ASTM A580/A580M Type 302, 304 or 316 stainless steel, 16 or 18 gauge.

2.2.12 Insulation Bands

Insulation bands shall be 1/2 inch wide; 26 gauge stainless steel.

2.2.13 Sealants

Sealants shall be chosen from the butyl polymer type, the styrene-butadiene rubber type, or the butyl type of sealants. Sealants shall have a maximum permeance of 0.02 perms based on Procedure B for ASTM E96/E96M, and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.3 PIPE INSULATION SYSTEMS

Conform insulation materials to Table 1 and minimum insulation thickness as listed in Table 2 and meet or exceed the requirements of ASHRAE 90.1 - IP. Limit pipe insulation materials to those listed herein and meeting the following requirements:

2.3.1 Recycled Materials

Provide insulation materials containing the following minimum percentage

of recycled material content by weight:

Rock Wool: 75 percent slag of weight
Fiberglass: 20 percent glass cullet
Rigid Foam: 9 percent recovered material
Phenolic Rigid Foam: 9 percent recovered material

Provide data identifying percentage of recycled content for insulation materials.

2.3.2 Aboveground Cold Pipeline (-30 to 60 deg. F)

Insulation for outdoor, indoor, exposed or concealed applications, shall be as follows:

2.3.2.1 Cellular Glass

ASTM C552, Type II, and Type III. Supply the insulation from the fabricator with (paragraph WHITE VAPOR RETARDER ALL SERVICE JACKET (ASJ)) ASJ vapor retarder and installed with all longitudinal overlaps sealed and all circumferential joints ASJ taped or supply the insulation unfaced from the fabricator and install with all longitudinal and circumferential joints sealed with vapor barrier mastic.

2.3.2.2 Flexible Elastomeric Cellular Insulation

Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive, complying with ASTM C534/C534M, Grade 1, Type I or II. Type I, Grade 1 for tubular materials. Type II, Grade 1, for sheet materials. Type I and II shall have vapor retarder/vapor barrier skin on one or both sides of the insulation, and require an additional exterior vapor retarder covering for high relative humidity and below ambient temperature applications.

2.3.2.3 Mineral Fiber Insulation with Integral Wicking Material (MFIWM)

ASTM C547. Install in accordance with manufacturer's instructions. Do not use in applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

2.3.2.4 Polyisocyanurate Insulation

ASTM C591, Type I. Supply the insulation with a factory applied vapor retarder/barrier that complies with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation and all covering must pass the flame spread index of 25 and the smoke developed index of 50 when tested in accordance with ASTM E84.

2.3.3 Aboveground Hot Pipeline (Above 60 deg. F)

Insulation for outdoor, indoor, exposed or concealed applications shall meet the following requirements. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.1 Mineral Fiber

ASTM C547, Types I, II or III, supply the insulation with manufacturer's recommended factory-applied jacket.

2.3.3.2 Calcium Silicate

ASTM C533, Type I indoor only, or outdoors above 250 degrees F pipe temperature. Supply insulation with the manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.3 Cellular Glass

ASTM C552, Type II and Type III. Supply the insulation with manufacturer's recommended factory-applied jacket.

2.3.3.4 Flexible Elastomeric Cellular Insulation

Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive, complying with ASTM C534/C534M, Grade 1, Type I or II to 220 degrees F service. Type I for tubular materials. Type II for sheet materials.

2.3.3.5 Phenolic Insulation

ASTM C1126 Type III to 250 degrees F service shall comply with ASTM C795. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.6 Perlite Insulation

ASTM C610

2.3.3.7 Polyisocyanurate Insulation

ASTM C591, Type I. Supply the insulation with a factory applied vapor retarder/barrier that complies with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation and all covering must pass the flame spread index of 25 and the smoke developed index of 50 when tested in accordance with ASTM E84.

2.3.4 Aboveground Dual Temperature Pipeline

Selection of insulation for use over a dual temperature pipeline system (Outdoor, Indoor - Exposed or Concealed) 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.

2.4 DUCT INSULATION SYSTEMS

2.4.1 Factory Applied Insulation

Provide factory-applied ASTM C534/C534M Grade 1, Type II, flexible elastomeric closed cell insulation according to manufacturer's recommendations for insulation with insulation manufacturer's standard reinforced fire-retardant vapor barrier, with identification of installed thermal resistance (R) value and out-of-package R value.

2.4.1.1 Rigid Insulation

Calculate the minimum thickness in accordance with ASHRAE 90.1.

2.4.1.2 Blanket Insulation

Calculate minimum thickness in accordance with ASHRAE 90.1.

2.4.2 Acoustical Duct Lining

2.4.2.1 General

For ductwork indicated or specified in Section 23 30 00 HVAC AIR DISTRIBUTION to be acoustically lined, provide external insulation in accordance with this specification section and in addition to the acoustical duct lining. Do not use acoustical lining in place of duct wrap or rigid board insulation (insulation on the exterior of the duct).

2.4.2.2 Duct Liner

Flexible Elastomeric Acoustical and Conformable Duct Liner Materials: Flexible Elastomeric Thermal, Acoustical and Conformable Insulation Compliance with ASTM C534/C534M Grade 1, Type II; and NFPA 90A or NFPA 90B as applicable.

2.4.3 Duct Insulation Jackets

2.4.3.1 All-Purpose Jacket

Provide insulation with insulation manufacturer's standard reinforced fire-retardant jacket with or without integral vapor barrier as required by the service. In exposed locations, provide jacket with a white surface suitable for field painting.

2.4.3.2 Metal Jackets

2.4.3.2.1 Aluminum Jackets

ASTM B209, Temper H14, minimum thickness of 27 gauge (0.016 inch), with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide smooth surface jackets for jacket outside dimension 8 inches and larger. Provide corrugated surface jackets for jacket outside dimension 8 inches and larger. Provide stainless steel bands, minimum width of 1/2 inch.

2.4.3.2.2 Stainless Steel Jackets

ASTM A167 or ASTM A240/A240M; Type 304, minimum thickness of 33 gauge (0.010 inch), smooth surface with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide stainless steel bands, minimum width of 1/2 inch.

2.4.3.3 Vapor Barrier/Weatherproofing Jacket

Vapor barrier/weatherproofing jacket shall be laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply (minimum 2.9 mils adhesive), heavy duty white or natural).

2.4.4 Weatherproof Duct Insulation

Provide ASTM C552, cellular glass thermal insulation , and weatherproofing

as specified in manufacturer's instruction. Multi-ply, Polymeric Blend Laminate Jacketing: Construction of laminate designed to provide UV resistance, high puncture, tear resistance and an excellent WVT rate.

2.5 EQUIPMENT INSULATION SYSTEMS

Insulate equipment and accessories as specified in Tables 5 and 6. In outside locations, provide insulation 1/2 inch thicker than specified. Increase the specified insulation thickness for equipment where necessary to equal the thickness of angles or other structural members to make a smooth, exterior surface. Submit a booklet containing manufacturer's published installation instructions for the insulation systems. The instructions must be copyrighted, have an identifying or publication number, and shall have been published prior to the issuance date of this solicitation. A booklet is also required by paragraphs titled: Pipe Insulation Systems and Duct Insulation Systems.

PART 3 EXECUTION

3.1 APPLICATION - GENERAL

Apply insulation to unheated and uncooled piping and equipment. Do not compress flexible elastomeric cellular insulation at joists, studs, columns, ducts, and hangers. The insulation must not pull apart after a one hour period; replace any insulation found to pull apart after one hour.

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 in other sections of this 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 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 07 84 00 FIRESTOPPING. The protection of ducts at point of passage through firewalls must be in accordance with NFPA 90A and/or NFPA 90B. All other penetrations, such as piping, conduit, and wiring, through firewalls must be protected with a material or system of the same hourly rating that is listed by UL, FM, or a NRTL.

3.1.3 Painting and Finishing

Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.4 Installation of Flexible Elastomeric Cellular Insulation

Install flexible elastomeric cellular insulation with seams and joints sealed with rubberized contact adhesive. Flexible elastomeric cellular insulation shall not be used on surfaces greater than 220 degrees F. Stagger seams when applying multiple layers of insulation. Protect insulation exposed to weather and not shown to have vapor barrier weatherproof jacketing with two coats of UV resistant finish or PVC or metal jacketing as recommended by the manufacturer after the adhesive is dry and cured.

3.1.4.1 Adhesive Application

Apply a brush coating of adhesive to both butt ends to be joined and to both slit surfaces to be sealed. Allow the adhesive to set until dry to touch but tacky under slight pressure before joining the surfaces. Insulation seals at seams and joints shall not be capable of being pulled apart one hour after application. Insulation that can be pulled apart one hour after installation shall be replaced.

3.1.4.2 Adhesive Safety Precautions

Use natural cross-ventilation, local (mechanical) pickup, and/or general area (mechanical) ventilation to prevent an accumulation of solvent vapors, keeping in mind the ventilation pattern must remove any heavier-than-air solvent vapors from lower levels of the workspaces. Gloves and spectacle-type safety glasses are recommended in accordance with safe installation practices.

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 That Require Insulation

Insulation is required on all pipes, ducts, or equipment, except for omitted items as specified.

3.2 PIPE INSULATION SYSTEMS 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/barrier, 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.
- e. Adjacent insulation.
- f. ASME stamps.
- g. Access plates of fan housings.
- h. Cleanouts or handholes.

3.2.1.2 Pipes Passing Through Walls, Roofs, and Floors

Pipe insulation shall be continuous through the sleeve.

Provide an aluminum jacket or vapor barrier/weatherproofing self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 ply standard grade, silver, white, black and embossed with factory applied moisture retarder over the insulation wherever penetrations require sealing.

3.2.1.2.1 Penetrate Interior Walls

The aluminum jacket or vapor barrier/weatherproofing - self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 plies standard grade, silver, white, black and embossed shall extend 2 inches beyond either side of the wall and shall be secured on each end with a band.

3.2.1.2.2 Penetrating Floors

Extend the aluminum jacket from a point below the backup material to a point 10 inches above the floor with one band at the floor and one not more than 1 inch from the end of the aluminum jacket.

3.2.1.2.3 Penetrating Waterproofed Floors

Extend the aluminum jacket from below the backup material to a point 2 inches above the flashing with a band 1 inch from the end of the aluminum jacket.

3.2.1.2.4 Penetrating Exterior Walls

Continue the aluminum jacket required for pipe exposed to weather through the sleeve to a point 2 inches beyond the interior surface of the wall.

3.2.1.2.5 Penetrating Roofs

Insulate pipe as required for interior service to a point flush with the top of the flashing and sealed with flashing sealant. Tightly butt the insulation for exterior application to the top of flashing and interior insulation. Extend the exterior aluminum jacket 2 inches down beyond the

end of the insulation to form a counter flashing. Seal the flashing and counter flashing underneath with metal jacketing/flashing sealant.

3.2.1.2.6 Hot Water Pipes Supplying Lavatories or Other Similar Heated Service

Terminate the insulation on the backside of the finished wall. Protect the insulation termination with two coats of vapor barrier coating with a minimum total thickness of **1/16 inch** applied with glass tape embedded between coats (if applicable). Extend the coating out onto the insulation **2 inches** and seal the end of the insulation. Overlap glass tape seams **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 **3/8 inches**.

3.2.1.2.7 Domestic Cold Water Pipes Supplying Lavatories or Other Similar Cooling Service

Terminate the insulation on the finished side of the wall (i.e., insulation must cover the pipe throughout the wall penetration). Protect the insulation with two coats of weather barrier mastic (breather emulsion type weatherproof mastic impermeable to water and permeable to air) with a minimum total thickness of **1/16 inch**. Extend the mastic out onto the insulation **2 inches** and shall seal the end of the insulation. The annular space between the outer surface of the pipe insulation and caulk 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 **3/8 inches**.

3.2.1.3 Pipes Passing Through Hangers

Insulation, whether hot or cold application, shall be continuous through hangers. All horizontal pipes **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-58**. 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 **2 inches** shall be installed, or factory insulated hangers (designed with a load bearing core) can be used.

3.2.1.3.1 Horizontal Pipes Larger Than 2 Inches at 60 Degrees F and Above

Supported on hangers in accordance with **MSS SP-58**, and Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.2.1.3.2 Horizontal Pipes Larger Than 2 Inches and Below 60 Degrees F

Supported on hangers with the addition of a Type 40 protection shield in accordance with **MSS SP-58**. An insulation insert of cellular glass, prefabricated insulation pipe hangers, or perlite above **80 degrees F** 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 **2 inches** on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than **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.

3.2.1.3.3 Vertical Pipes

Supported with either Type 8 or Type 42 riser clamps with the addition of two Type 40 protection shields in accordance with MSS SP-58 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 2 inches on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than 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 30 feet, the weight of the pipe shall be additionally supported with hangers in the vertical run of the pipe that 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.

3.2.1.3.4 Inserts

Covered with a jacket material of the same appearance and quality as the adjoining pipe insulation jacket, overlap the adjoining pipe jacket 1-1/2 inches, and seal as required for the pipe jacket. The jacket material used to cover inserts in flexible elastomeric cellular insulation shall conform to ASTM C1136, Type 1, and is allowed to be of a different material than the adjoining insulation material.

3.2.1.4 Flexible Elastomeric Cellular Pipe Insulation

Flexible elastomeric cellular pipe insulation shall be tubular form for pipe sizes 6 inches and less. Grade 1, Type II sheet insulation used on pipes larger than 6 inches shall not be stretched around the pipe. On pipes larger than 12 inches, the insulation shall be adhered 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. Type II requires an additional exterior vapor retarder/barrier covering for high relative humidity and below ambient temperature applications.

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, aluminum or flexible laminate cladding (comprised of elastomeric, plastic or metal foil laminate) laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket, - less than 0.0000 permeability; (greater than 3 ply, standard grade, silver, white, black and embossed) aluminum jackets shall be utilized. Pipe insulation to the 6 foot level shall be protected.

3.2.1.6 Pipe Insulation Material and Thickness

Pipe insulation materials must be as listed in Table 1 and must meet or exceed the requirements of ASHRAE 90.1.

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
Chilled Water (Supply & Return, Dual Temperature Piping, 40 F nominal)					
	Cellular Glass	ASTM C552	II	2	Yes
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		Yes
Heating Hot Water Supply & Return, Heated Oil (Max 250 F)					
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Cellular Glass	ASTM C552	II	2	No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
Cold Domestic Water Piping, Makeup Water & Drinking Fountain Drain Piping					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Hot Domestic Water Supply & Recirculating Piping (Max 200 F)					
	Mineral Fiber	ASTM C547	I	1	No
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
Refrigerant Suction Piping (35 degrees F nominal)					

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Cellular Glass	ASTM C552	II	1	Yes
Compressed Air Discharge, Steam and Condensate Return (201 to 250 Degrees F)					
	Cellular Glass	ASTM C552	II		No
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicapped Personnel					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Horizontal Roof Drain Leaders (Including Underside of Roof Drain Fittings)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Cellular Glass	ASTM C552	III		Yes
Condensate Drain Located Inside Building					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Medium Temperature Hot Water, Steam and Condensate (251 to 350 Degrees F)					
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Cellular Glass	ASTM C552	I or II		No
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
High Temperature Hot Water & Steam (351 to 700 Degrees F)					

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
	Mineral Fiber	ASTM C547	I	2	No
	Calcium Silicate	ASTM C533	I		No
	Perlite	ASTM C610			No
	Cellular Glass	ASTM C552			No
Brine Systems Cryogenics (-30 to 0 Degrees F)					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Brine Systems Cryogenics (0 to 34 Degrees F)					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Note: VR/VB = Vapor Retarder/Vapor Barrier					

TABLE 2						
Piping Insulation Thickness (inch)						
Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.						
Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
Chilled Water (Supply & Return, Dual Temperature Piping, 40 Degrees F nominal)						
	Cellular Glass	1.5	2	2	2.5	3
	Mineral Fiber with Wicking Material	1	1.5	1.5	2	2
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Chilled Water (Supply & Return, Dual Temperature Piping, 40 Degrees F nominal)						

TABLE 2						
Piping Insulation Thickness (inch) Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.						
Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
	Cellular Glass	1.5	1.5	1.5	1.5	2
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
	Mineral Fiber with Wicking Material	1	1.5	1.5	2	2
Heating Hot Water Supply & Return, Heated Oil (Max 250 F)						
	Mineral Fiber	1.5	1.5	2	2	2
	Calcium Silicate	2.5	2.5	3	3	3
	Cellular Glass	2	2.5	3	3	3
	Perlite	2.5	2.5	3	3	3
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Cold Domestic Water Piping, Makeup Water & Drinking Fountain Drain Piping						
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Hot Domestic Water Supply & Recirculating Piping (Max 200 F)						
	Mineral Fiber	1	1	1	1.5	1.5
	Cellular Glass	1.5	1.5	1.5	2	2
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Refrigerant Suction Piping (35 degrees F nominal)						
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
	Cellular Glass	1.5	1.5	1.5	1.5	1.5

TABLE 2						
Piping Insulation Thickness (inch) Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.						
Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
Compressed Air Discharge, Steam and Condensate Return (201 to 250 Degrees F)						
	Mineral Fiber	1.5	1.5	2	2	2
		1.5*	2*	2.5*	3*	3.5*
	Calcium Silicate	2.5	3	4	4	4.5
	Cellular Glass	2	2.5	3	3	3
	Perlite	2.5	3	4	4	4.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicapped Personnel						
	Flexible Elastomeric Cellular	0.5	0.5	0.5	0.5	0.5
Horizontal Roof Drain Leaders (Including Underside of Roof Drain Fittings)						
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
	Faced Phenolic Foam	1	1	1	1	1
Condensate Drain Located Inside Building						
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Medium Temperature Hot Water, Steam and Condensate (251 to 350 Degrees F)						
	Mineral Fiber	1.5	3	3	4	4
		2.5*	*	3.5*		

TABLE 2						
Piping Insulation Thickness (inch) Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.						
Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
	Calcium Silicate	2.5	3.5	4.5	4.5	5
	Perlite	2.5	3.5	4.5	4.5	5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
High Temperature Hot Water & Steam (351 to 700 Degrees F)						
	Mineral Fiber	2.5	3	3	4	4
	Calcium Silicate	4	4.5	6	6	6
	Perlite	4	4.5	6	6	6
Brine Systems Cryogenics (-30 to 0 Degrees F)						
	Cellular Glass	2.5	2.5	3	3	3.5
	Flexible Elastomeric Cellular	1	1	N/A	N/A	N/A
Brine Systems Cryogenics (0 to 34 Degrees F)						
	Cellular Glass	2	2	2	2.5	3
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A

3.2.2 Aboveground Cold Pipelines

The following cold pipelines for minus 30 to plus 60 degrees F, shall be insulated in accordance with Table 2 except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted. This includes but is not limited to the following:

- Make-up water.
- Horizontal and vertical portions of interior roof drains.
- Refrigerant suction lines.

- d. Chilled water.
- e. Air conditioner condensate drains.

3.2.2.1 Insulation Material and Thickness

Insulation thickness for cold pipelines shall be determined using Table 2.

3.2.2.2 Factory or Field applied Jacket

Insulation shall be covered with a factory applied vapor retarder jacket/vapor barrier or field applied seal welded PVC jacket or greater than 3 ply laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, standard grade, silver, white, black and embossed for use with Mineral Fiber, Cellular Glass, and Phenolic Foam Insulated Pipe. Insulation inside the building, to be protected with an aluminum jacket or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, Embossed Silver, White & Black, shall have the insulation and vapor retarder jacket installed as specified herein. The aluminum jacket or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, embossed silver, White & Black, 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 or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, embossed silver, white & black, shall be provided for pipe insulation to the 6 ft level.

3.2.2.3 Installing Insulation for Straight Runs Hot and Cold Pipe

Apply insulation to the pipe with tight butt joints. Seal all butted joints and ends with joint sealant and seal with a vapor retarder coating, greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or PVDC adhesive tape.

3.2.2.3.1 Longitudinal Laps of the Jacket Material

Overlap not less than 1-1/2 inches. Provide butt strips 3 inches wide for circumferential joints.

3.2.2.3.2 Laps and Butt Strips

Secure with adhesive and staple on 4 inch centers if not factory self-sealing. If staples are used, seal in accordance with paragraph STAPLES below. Note that staples are not required with cellular glass systems.

3.2.2.3.3 Factory Self-Sealing Lap Systems

May be used when the ambient temperature is between 40 and 120 degrees F during installation. Install the lap system in accordance with manufacturer's recommendations. Use a stapler only if specifically

recommended by the manufacturer. Where gaps occur, replace the section or repair the gap by applying adhesive under the lap and then stapling.

3.2.2.3.4 Staples

Coat all staples, including those used to repair factory self-seal lap systems, with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - 0.0000 perm adhesive tape. Coat all seams, except those on factory self-seal systems, with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.5 Breaks and Punctures in the Jacket Material

Patch by wrapping a strip of jacket material around the pipe and secure it with adhesive, staple, and coat with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. Extend the patch not less than 1-1/2 inches past the break.

3.2.2.3.6 Penetrations Such as Thermometers

Fill the voids in the insulation and seal with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.7 Flexible Elastomeric Cellular Pipe Insulation

Install by slitting the tubular sections and applying them onto the piping or tubing. Alternately, whenever possible slide un-slit sections over the open ends of piping or tubing. Secure all seams and butt joints and seal with adhesive. When using self seal products only the butt joints shall be secured with adhesive. Push insulation on the pipe, never pulled. Stretching of insulation may result in open seams and joints. Clean cut all edges. Rough or jagged edges of the insulation are not be permitted. Use proper tools such as sharp knives. Do not stretch Grade 1, Type II sheet insulation around the pipe when used on pipe larger than 6 inches. On pipes larger than 12 inches, adhere sheet insulation directly to the pipe on the lower 1/3 of the pipe.

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 sealed with joint sealant and sealed with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.
- 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 2 inches or one pipe diameter. Elbows insulated using segments shall conform to MICA

Tables 12.20 "Mitered Insulation Elbow". Submit a booklet containing completed **MICA Insulation Stds** plates detailing each insulating system for each pipe, duct, or equipment insulating system, after approval of materials and prior to applying insulation.

- (1) The MICA plates shall detail the materials to be installed and the specific insulation application. Submit all MICA plates required showing the entire insulating system, including plates required to show insulation penetrations, vessel bottom and top heads, legs, and skirt insulation as applicable. The MICA plates shall present all variations of insulation systems including locations, materials, vaporproofing, jackets and insulation accessories.
 - (2) If the Contractor elects to submit detailed drawings instead of edited MICA Plates, the detail drawings shall be technically equivalent to the edited MICA Plate submittal.
- 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 PVDC or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or two coats of vapor retarder coating with a minimum total thickness of **1/16 inch**, applied with glass tape embedded between coats. Tape seams shall overlap **1 inch**. The coating shall extend out onto the adjoining pipe insulation **2 inches**. Fabricated insulation with a factory vapor retarder jacket shall be protected with either greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape, standard grade, silver, white, black and embossed or PVDC adhesive tape or two coats of vapor retarder coating with a minimum thickness of **1/16 inch** and with a **2 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 **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 **6 inches** from the insulation surface.
- e. Insulation shall be marked showing the location of unions, strainers, and check valves.

3.2.3 Aboveground Hot Pipelines

3.2.3.1 General Requirements

All hot pipe lines above **60 degrees F**, except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted, shall be insulated in accordance with Table 2. This includes but is not limited to the following:

- a. Hot water heating.

Insulation shall be covered, in accordance with manufacturer's recommendations, with a factory applied Type I jacket or field applied aluminum where required or seal welded PVC.

3.2.3.2 Insulation for Fittings and Accessories

Pipe insulation shall be tightly butted to the insulation of the fittings and accessories. The butted joints and ends shall be sealed with joint sealant. Insulation shall be marked showing the location of unions, strainers, check valves and other components that would otherwise be hidden from view by the insulation.

3.2.3.2.1 Precut or Preformed

Place precut or preformed insulation around all fittings and accessories. Insulation shall be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity.

3.2.3.2.2 Rigid Preformed

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 **2 inches** or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow".

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, a laminated self-adhesive (minimum **2 mils** adhesive, **3 mils** embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability (greater than 3 ply, standard grade, silver, white, black and embossed aluminum jacket, stainless steel 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 elastomeric cellular insulation exposed to weather shall be treated in accordance with paragraph INSTALLATION OF FLEXIBLE ELASTOMERIC CELLULAR INSULATION in PART 3.

3.2.4.1 Aluminum Jacket

The jacket for hot piping may be factory applied. The jacket shall overlap not less than **2 inches** at longitudinal and circumferential joints and shall be secured with bands at not more than **12 inch** centers. Longitudinal joints shall be overlapped down to shed water and located at 4 or 8 o'clock positions. Joints on piping **60 degrees F** and below shall be sealed with metal jacketing/flashing sealant while overlapping to prevent moisture penetration. Where jacketing on piping **60 degrees F** and below abuts an un-insulated surface, joints shall be caulked to prevent moisture penetration. Joints on piping above **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 **1 inch** and the adjoining aluminum jacket not less than **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 laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed, and UV resistant).

3.3 DUCT INSULATION SYSTEMS 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. 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 Minimum Thickness

Duct insulation minimum thickness in accordance with Table 4.

Table 4 - Minimum Duct Insulation (inches)	
Cold Air Ducts	2.0
Relief Ducts	1.5
Fresh Air Intake Ducts	1.5
Warm Air Ducts	2.0
Relief Ducts	1.5
Fresh Air Intake Ducts	1.5

3.3.2 Insulation and Vapor Retarder/Vapor Barrier for Cold Air Duct

Insulation and vapor retarder/vapor barrier shall be provided for the following cold air ducts and associated equipment.

- Supply ducts.
- Return air ducts.
- Relief ducts.
- Flexible run-outs (field-insulated).
- Plenums.
- Duct-mounted coil casings.
- Coil headers and return bends.
- 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 3/4 pcf, and rigid type where exposed, minimum density 3 pcf. Insulation for both concealed or exposed round/oval ducts shall be flexible type, minimum density 3/4 pcf or a semi rigid board, minimum density 3 pcf, formed or fabricated to a tight fit, edges beveled and joints tightly butted and staggered. Insulation for all exposed ducts shall be provided with either a white, paint-able, factory-applied Type I jacket or a field applied vapor retarder/vapor barrier jacket coating finish as specified, the total field applied dry film thickness shall be approximately 1/16 inch. Insulation on all concealed duct shall be provided with a factory-applied Type I or II vapor retarder/vapor barrier jacket. Duct insulation shall be continuous through sleeves and prepared openings except firewall 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/vapor barrier shall cover the collar, neck, and un-insulated surfaces of diffusers, registers and grills. Vapor retarder/vapor barrier materials shall be applied to form a complete unbroken vapor seal over the insulation. Sheet Metal Duct shall be sealed in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.3.2.1 Installation on Concealed Duct

- a. For rectangular, oval or round ducts, flexible insulation shall be attached by applying adhesive around the entire perimeter of the duct in 6 inch wide strips on 12 inch centers.
- b. For rectangular and oval ducts, 24 inches and larger insulation shall be additionally secured to bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on 16 inch centers and not more than 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 16 inch centers and not more than 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/vapor barrier jacket joints overlap 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. Where mechanical fasteners are used, self-locking washers shall be installed and the pin trimmed 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 or PVDC adhesive tape or greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.
- 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 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 or PVDC adhesive tape or greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.
- 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 or PVDC adhesive tape greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.
- 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 un-insulated surface 2 inches. Pin puncture coatings shall extend 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 12 inches apart and not more than 3 inches from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct 12 inches and larger. One row shall be provided for each side of duct less than 12 inches. Mechanical fasteners shall be as corrosion resistant as G60 coated galvanized steel, and shall indefinitely sustain a 50 lb tensile dead load test perpendicular to the duct wall.
- b. Form duct insulation with minimum jacket seams. Fasten each piece of rigid insulation 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/barrier 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. Apply insulation with joints tightly butted. Neatly bevel insulation around name plates and access plates and doors.
- c. Impale insulation on the fasteners; self-locking washers shall be installed and the pin trimmed and bent over.

- d. Seal joints in the insulation jacket with a 4 inch wide strip of tape. Seal taped seams 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 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 flashing sealant.
- 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 un-insulated surface 2 inches. Pin puncture coatings shall extend 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 3/4 pcf, attached as in accordance with 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 run-outs (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.
- o. Exhaust ducts passing through concealed spaces exhausting conditioned air.

Insulation for rectangular ducts shall be flexible type where concealed, and rigid type where exposed. Insulation on exposed ducts shall be provided with a white, paint-able, factory-applied Type II jacket, or finished with adhesive finish. Flexible type insulation shall be used for round ducts, 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 **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 **6 inch** wide strips on **12 inch** centers.
- b. For rectangular and oval ducts **24 inches** and larger, insulation shall be secured to the bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on **18 inch** centers and not more than **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 **18 inch** centers and not more than **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 **2 inches** at joints and the lap shall be secured and stapled on **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 **16 inches** apart and not more than **6 inches** from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct **12 inches** and larger and a minimum of one row for each side of duct less than **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 trimmed and bent over.
- d. Joints on jacketed insulation shall be sealed with a 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 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 3/4 pcf attached by staples spaced not more than 16 inches and not more than 6 inches from the degrees of joints. Joints shall be sealed in accordance with item "d." above.

3.3.4 Ducts Handling Air for Dual Purpose

For air handling ducts for dual purpose below and above 60 degrees F, ducts shall be insulated as specified for cold air duct.

3.3.5 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.

3.3.6 Duct Exposed to Weather

3.3.6.1 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.

3.3.6.2 Round Duct

Laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - Less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply, heavy duty, white and natural) membrane shall be applied overlapping material by 3 inches no bands or caulking needed - see manufacturer's recommended installation instructions. Aluminum jacket with factory applied moisture retarder shall be applied with the joints lapped not less than 3 inches and secured with bands located at circumferential laps and at not more than 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 metal jacketing sealant to prevent moisture penetration. Where jacketing abuts an un-insulated surface, joints shall be sealed with metal jacketing sealant.

3.3.6.3 Fittings

Fittings and other irregular shapes shall be finished as specified for rectangular ducts.

3.3.6.4 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 **1/16 inch** minimum thickness. The exterior shall be a metal jacketing applied for mechanical abuse and weather protection, and secured with screws or vapor barrier/weatherproofing jacket less than 0.0000 permeability greater than 3 ply, standard grade, silver, white, black, and embossed or greater than 8 ply, heavy duty white and natural. Membrane shall be applied overlapping material by **3 inches**. No bands or caulking needed-see manufacturing recommend installation instructions.

3.4 EQUIPMENT INSULATION SYSTEMS INSTALLATION

3.4.1 General

Removable insulation sections shall be provided to cover parts of equipment that must be opened periodically for maintenance including vessel covers, fasteners, flanges and accessories. Equipment insulation shall be omitted on the following:

- a. Hand-holes.
- b. Boiler manholes.
- c. Cleanouts.
- d. ASME stamps.
- e. Manufacturer's nameplates.
- f. Duct Test/Balance Test Holes.

3.4.2 Insulation for Cold Equipment

Cold equipment below **60 degrees F**: Insulation shall be furnished on equipment handling media below **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. Material and thicknesses shall be as shown in Table 5:

TABLE 5		
Insulation Thickness for Cold Equipment (inches)		
Equipment handling media at indicated temperature		
	Material	Thickness (inches)
35 to 60 degrees F		
	Cellular Glass	1.5
	Flexible Elastomeric Cellular	1
1 to 34 degrees F		
	Cellular Glass	3
	Flexible Elastomeric Cellular	1.5
Minus 30 to 0 degrees F		
	Cellular Glass	3.5
	Flexible Elastomeric Cellular	1.75

3.4.2.2 Pump Insulation

- a. Insulate pumps by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints that 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 elastomeric cellular insulation. The box shall conform to the requirements of MICA Insulation Std's plate No. 49 when using flexible elastomeric 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 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. Flashing sealant 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 12 inch centers except flexible elastomeric cellular which shall be adhered with contact adhesive. Insulation corners shall be protected under wires and bands with suitable corner angles.
- c. Cellular glass shall be installed in accordance with manufacturer's instructions. Joints and ends shall be sealed with joint sealant, and sealed with a vapor retarder coating.
- 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 1/16 inch.
- e. Exposed insulation corners shall be protected with corner angles.
- f. Insulation on equipment with ribs shall be applied over 6 by 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 2 by 2 inches washers or shall be securely banded or wired in place on 12 inch centers.

3.4.2.4 Vapor Retarder/Vapor Barrier

Upon completion of installation of insulation, penetrations shall be caulked. Two coats of vapor retarder coating or vapor barrier jacket 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 1/16 inch. Flashing sealant or vapor barrier tape 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 60 degrees F including the following:

- a. Converters.
- b. Heat exchangers.
- c. Hot water generators.

- d. Water heaters.
- e. Pumps handling media above 130 degrees F.
- f. Fuel oil heaters.
- g. Hot water storage tanks.
- h. Air separation tanks.
- i. Surge tanks.
- j. Flash tanks.
- k. Feed-water 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 6:

TABLE 6		
Insulation Thickness for Hot Equipment (inches)		
Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (inches)
15 psig or 250 degrees F		
	Rigid Mineral Fiber	2
	Flexible Mineral Fiber	2
	Calcium Silicate/Perlite	4
	Cellular Glass	3
	Faced Phenolic Foam	1.5
	Flexible Elastomeric Cellular (<200 F)	1
200psig or 400 degrees F		

TABLE 6		
Insulation Thickness for Hot Equipment (inches)		
Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (inches)
	Rigid Mineral Fiber	3
	Flexible Mineral Fiber	3
	Calcium Silicate/Perlite	4
	Cellular Glass	4
600 degrees F		
	Rigid Mineral Fiber	5
	Flexible Mineral Fiber	6
	Calcium Silicate/Perlite	6
	Cellular Glass	6
600 degrees F: Thickness necessary to limit the external temperature of the insulation to 120 F. Heat transfer calculations shall be submitted to substantiate insulation and thickness selection.		

3.4.3.2 Insulation of Pumps

Insulate pumps by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Bottom and sides shall be banded to form a rigid housing that 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 **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 **12 inch** centers except flexible elastomeric 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 6 by 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 2 by 2 inch washers or shall be securely banded or wired in place on 12 inch (maximum) centers.
- g. On equipment handling media above 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 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 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 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.

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SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 GENERAL

1.1 SUMMARY

Provide a complete Direct Digital Control (DDC) system, except for the Front End which is specified in Section 25 10 10 UTILITY MONITORING AND CONTROL (UMCS) FRONT END AND INTEGRATION, suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as indicated and shown and in accordance with Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet or Niagara BACnet systems, and other referenced Sections.

1.1.1 Proprietary Systems

1.1.1.1 Proprietary Systems Exempted From Open Protocol Requirements

The following systems are specifically exempted from the open protocol requirements of Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS:

- a. A simple split (DX) system consisting of a single indoor unit and a single outdoor unit from the same manufacturer.
- b. Systems in Table I (previously approved by the designer in accordance with UFC 3-410-02).

TABLE I: Systems Approved to Use Proprietary Communications		
System	Type (Multi-Split/VRF or Chiller/Boiler Plant)	Proprietary Multi-Split Engineering Tool Software Required (for Multi-Split/VRF only)

- c. A system (not already shown Table I) of multiple boilers or multiple chillers communicating with a proprietary network for which an approved request has been obtained and for which: all units are from the same manufacturer, they are all co-located in the same room, the network connecting them is fully contained in that room, and the units are operating using a common "plant" sequence of operation which stages the units in a manner that requires operational parameters be shared between them and which cannot be accomplished with a single lead-lag command from a third-party controller.

1.1.1.2 Implementation of Proprietary Systems

For proprietary systems exempted from open protocol requirements, a proprietary network and DDC hardware communicating via proprietary

protocol are permitted. For these systems a building control network meeting the requirements of [Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS](#) must also be provided, along with a gateway or interface to connect the proprietary system to the open building control network.

The proprietary system gateway or interface must provide the required functionality as shown on the points schedule. Scheduling, alarming, trending, overrides, network inputs, network outputs and other protocol related requirements must be met on the open protocol control system as specified in [Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS](#).

1.1.1.3 Proprietary Multi-Split Engineering Tool Software

For each permitted proprietary systems in Table 1 shown as requiring Proprietary Multi-Split Engineering Tool Software, provide the software needed to replace a unit and configure the replacement. Submit hard copies of the software user manuals with the software submittal.

Submit Proprietary Multi-Split Engineering Tool Software on CD-ROM as a Technical Data Package. Submit 4 hard copies of the software user manual for each piece of software.

1.1.2 System Requirements

Provide systems meeting the requirements this Section and other Sections referenced by this Section, and which have the following characteristics:

- a. The system implements the control sequences of operation [shown in the Contract Drawings or described in the Contract Specifications](#) using DDC hardware to control mechanical and electrical equipment
- b. The system meet the requirements of this specification as a stand-alone system and does not require connection to any other system.
- c. Control sequences reside in DDC hardware in the building. The building control network is not dependent upon connection to a Utility Monitoring and Control System (UMCS) Front End or to any other system for performance of control sequences. To the greatest extent practical, the hardware performs control sequences without reliance on the building network, [unless otherwise pre-approved by the Contracting Officer](#).
- d. The hardware is installed such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.
- e. All necessary documentation, configuration information, programming tools, programs, drivers, and other software are licensed to and otherwise remain with the Government such that the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer.
- f. Sufficient documentation and data, including rights to documentation and data, are provided such that the Government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the

Contractor, Vendor or Manufacturer.

- g. Hardware is installed and configured such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the Contractor, Vendor or Manufacturer.

1.1.3 End to End Accuracy

Select products, install and configure the system such that the maximum error of a measured value as read from the DDC Hardware over the network is less than the maximum allowable error specified for the sensor or instrumentation.

1.1.4 Verification of Dimensions

After becoming 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.

1.1.5 Drawings

The Government will not indicate all offsets, fittings, and accessories that may be required on the drawings. Carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, arrange such work accordingly, and provide all work necessary to meet such conditions.

1.2 RELATED SECTIONS

Related work specified elsewhere:

- a. Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet systems with or without Niagara Framework.
- b. Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC
- c. Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEMS (UMCS) FRONT END AND INTEGRATION

1.3 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 OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135

(2020; Interpretation 1-8 2021; Errata 1-2 2021; Addenda CD 2021; Addenda BY-CE 2022; Interpretation 9-10 2022) BACnet-A Data

Communication Protocol for Building
Automation and Control Networks

ASHRAE FUN IP

(2021) Fundamentals Handbook, I-P Edition

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41

(1991; R 1995) Recommended Practice on
Surge Voltages in Low-Voltage AC Power
Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250

(2020) Enclosures for Electrical Equipment
(1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70

(2023) National Electrical Code

NFPA 90A

(2021) Standard for the Installation of
Air Conditioning and Ventilating Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-410-02

(2018; with Change 2, 2021) Direct Digital
Control for HVAC and Other Building
Control Systems

UNDERWRITERS LABORATORIES (UL)

UL 5085-3

(2006; Reprint Jan 2022) UL Standard for
Safety Low Voltage Transformers - Part 3:
Class 2 and Class 3 Transformers

1.4 DEFINITIONS

The following list of definitions includes terms used in Sections referenced by this Section and are included here for completeness. The definitions contained in this Section may disagree with how terms are defined or used in other documents, including documents referenced by this Section. The definitions included here are the authoritative definitions for this Section and all Sections referenced by this Section.

After each term the protocol related to that term is included in parenthesis.

1.4.1 Alarm Generation (All protocols)

Alarm Generation is the monitoring of a value, comparison of the value to alarm conditions and the creation of an alarm when the conditions set for the alarm are met. Note that this does NOT include delivery of the alarm to the final destination (such as a user interface) - see paragraph ALARM ROUTING in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION.

1.4.2 Building Automation and Control Network (BACnet) (BACnet)

The term BACnet is used in two ways. First meaning the BACnet Protocol

Standard - the communication requirements as defined by [ASHRAE 135](#) including all annexes and addenda. The second to refer to the overall technology related to the [ASHRAE 135](#) protocol.

1.4.3 BACnet Advanced Application Controller (B-AAC) (BACnet)

A hardware device BTL Listed as a B-AAC, which is required to support BACnet Interoperability Building Blocks (BIBBs) for scheduling and alarming, but is not required to support as many BIBBs as a B-BC.

1.4.4 BACnet Application Specific Controller (B-ASC) (BACnet)

A hardware device BTL Listed as a B-ASC, with fewer BIBB requirements than a B-AAC. It is intended for use in a specific application.

1.4.5 BACnet Building Controller (B-BC) (BACnet)

A hardware device BTL Listed as a B-BC. A general-purpose, field-programmable device capable of carrying out a variety of building automation and control tasks including control and monitoring via direct digital control (DDC) of specific systems and data storage for trend information, time schedules, and alarm data. Like the other BTL Listed controller types (B-AAC, B-ASC etc.) a B-BC device is required to support the server ("B") side of the ReadProperty and WriteProperty services, but unlike the other controller types it is also required to support the client ("A") side of these services. Communication between controllers requires that one of them support the client side and the other support the server side, so a B-BC is often used when communication between controllers is needed.

1.4.6 BACnet Broadcast Management Device (BBMD) (BACnet)

A communications device, typically combined with a BACnet router. A BBMD forwards BACnet broadcast messages to BACnet/IP devices and other BBMDs connected to the same BACnet/IP network. Each IP subnet that is part of a BACnet/IP network must have at least one BBMD. Note there are additional restrictions when multiple BBMDs share an IP subnet.

1.4.7 BACnet/IP (BACnet)

An extension of BACnet, Annex J, defines the use of a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnets that share the same BACnet network number. See also paragraph BACNET BROADCAST MANAGEMENT DEVICE.

1.4.8 BACnet Internetwork (BACnet)

Two or more BACnet networks, connected with BACnet routers. In a BACnet Internetwork, there exists only one message path between devices.

1.4.9 BACnet Interoperability Building Blocks (BIBBs) (BACnet)

A BIBB is a collection of one or more [ASHRAE 135](#) Services intended to define a higher level of interoperability. BIBBs are combined to build the BACnet functional requirements for a device in a specification. Some BIBBs define additional requirements (beyond requiring support for specific services) in order to achieve a level of interoperability. For example, the BIBB DS-V-A (Data Sharing-View-A), which would typically be used by a front-end, not only requires the client to support the ReadProperty

Service, but also provides a list of data types (Object / Properties) which the client must be able to interpret and display for the user.

In the BIBB shorthand notation, -A is the client side and -B is the server side.

The following is a list of some BIBBs used by this or referenced Sections:	
DS-COV-A	Data Sharing-Change of Value (A side)
DS-COV-B	Data Sharing-Change of Value (B side)
NM-RC-B	Network Management-Router Configuration (B side)
DS-RP-A	Data Sharing-Read Property (A side)
DS-RP-B	Data Sharing-Read Property (B side)
DS-RPM-A	Data Sharing-Read Property Multiple (A Side)
DS-RPM-B	Data Sharing-Read Property Multiple (B Side)
DS-WP-A	Data Sharing-Write Property (A Side)
DM-TS-B	Device Management-Time Synchronization (B Side)
DM-UTC-B	Device Management-UTC Time Synchronization (B Side)
DS-WP-B	Data Sharing-Write Property (B side)
SCHED-E-B	Scheduling-External (B side)
DM-OCD-B	Device Management-Object Creation and Deletion (B side)
AE-N-I-B	Alarm and Event-Notification Internal (B Side)
AE-N-E-B	Alarm and Event-Notification External (B Side)
T-VMT-I-B	Trending-Viewing and Modifying Trends Internal (B Side)
T-VMT-E-B	Trending-Viewing and Modifying Trends External (B Side)

1.4.10 BACnet Network (BACnet)

In BACnet, a portion of the control Internetwork consisting of one or more segments connected by repeaters. Networks are separated by routers.

1.4.11 BACnet Operator Display (B-OD) (BACnet)

A basic operator interface with limited capabilities relative to a B-OWS. It is not intended to perform direct digital control. A B-OD profile could be used for LCD devices, displays affixed to BACnet devices, handheld terminals or other very simple user interfaces.

1.4.12 BACnet Segment (BACnet)

One or more physical segments interconnected by repeaters (ASHRAE 135).

1.4.13 BACnet Smart Actuator (B-SA) (BACnet)

A simple actuator device with limited resources intended for specific applications.

1.4.14 BACnet Smart Sensor (B-SS) (BACnet)

A simple sensing device with limited resources.

1.4.15 BACnet Testing Laboratories (BTL) (BACnet)

Established by BACnet International to support compliance testing and interoperability testing activities and consists of BTL Manager and the BTL Working Group (BTL-WG). BTL also publishes Implementation Guidelines.

1.4.16 BACnet Testing Laboratories (BTL) Listed (BACnet)

A device that has been listed by BACnet Testing Laboratory. Devices may be certified to a specific device profile, in which case the listing indicates that the device supports the required capabilities for that profile, or may be listed as "other".

1.4.17 Binary (All protocols)

A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. 'Digital' is sometimes used interchangeably with 'binary'.

1.4.18 Broadcast (BACnet)

Unlike most messages, which are intended for a specific recipient device, a broadcast message is intended for all devices on the network.

1.4.19 Building Control Network (BCN) (All protocols)

The network connecting all DDC Hardware within a building (or specific group of buildings).

1.4.20 Building Point of Connection (BPOC) (All protocols)

A FPOC for a Building Control System. (This term is being phased out of use in preference for FPOC but is still used in some specifications and criteria. When it was used, it typically referred to a piece of control hardware. The current FPOC definition typically refers instead to IT hardware.)

1.4.21 Commandable (All protocols)

See Overridable.

1.4.22 Commandable Objects (BACnet)

Commandable Objects have a Commandable Property, Priority_Array, and Relinquish_Default Property as defined in ASHRAE 135, Clause 19.2, Command Prioritization.

1.4.23 Configurable (All protocols)

A property, setting, or value is configurable if it can be changed via hardware settings on the device, via the use of engineering software or over the control network from the front end, and is retained through (after) loss of power.

In a BACnet system, a property, setting, or value is configurable if it can be changed via one or more of:

- 1) via BACnet services (including proprietary BACnet services)
- 2) via hardware settings on the device

Note this is more stringent than the **ASHRAE 135** definition.

1.4.24 Control Logic Diagram (All protocols)

A graphical representation of control logic for multiple processes that make up a system.

1.4.25 Device (BACnet)

A Digital Controller that contains a BACnet Device Object and uses BACnet to communicate with other devices.

1.4.26 Device Object (BACnet)

Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet Internetwork. This number is often referred to as the device instance or device ID.

1.4.27 Device Profile (BACnet)

A collection of BIBBs determining minimum BACnet capabilities of a device, defined in **ASHRAE 135**. Standard device profiles include BACnet Advanced Workstations (B-AWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS).

1.4.28 Digital Controller (All protocols)

An electronic controller, usually with internal programming logic and digital and analog input/output capability, which performs control functions.

1.4.29 Direct Digital Control (DDC) (All protocols)

Digital controllers performing control logic. Usually the controller directly senses physical values, makes control decisions with internal programs, and outputs control signals to directly operate switches, valves, dampers, and motor controllers.

1.4.30 Field Point of Connection (FPOC) (All protocols)

The FPOC is the point of connection between the UMCS IP Network and the field control network (either an IP network, a non-IP network, or a combination of both). The hardware at this location which provides the connection is generally an IT device such as a switch, IP router, or

firewall.

In general, the term "FPOC Location" means the place where this connection occurs, and "FPOC Hardware" means the device that provides the connection. Sometimes the term "FPOC" is used to mean either and its actual meaning (i.e. location or hardware) is determined by the context in which it is used.

1.4.31 Gateway (All protocols)

A device that translates from one protocol application data format to another. Devices that change only the transport mechanism of the protocol - "translating" from TP/FT-10 to Ethernet/IP or from BACnet MS/TP to BACnet over IP for example - are not gateways as the underlying data format does not change. Gateways are also called Communications Bridges or Protocol Translators.

1.4.32 IEEE 802.3 Ethernet (All protocols)

A family of local-area-network technologies providing high-speed networking features over various media, typically Cat 5, 5e or Cat 6 twisted pair copper or fiber optic cable.

1.4.33 Internet Protocol (IP, TCP/IP, UDP/IP) (All protocols)

A communication method, the most common use is the World Wide Web. At the lowest level, it is based on Internet Protocol (IP), a method for conveying and routing packets of information over various LAN media. Two common protocols using IP are User Datagram Protocol (UDP) and Transmission Control Protocol (TCP). UDP conveys information to well-known "sockets" without confirmation of receipt. TCP establishes connections, also known as "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

1.4.34 Input/Output (I/O) (All protocols)

Physical inputs and outputs to and from a device, although the term sometimes describes network or "virtual" inputs or outputs. See also "Points".

1.4.35 I/O Expansion Unit (All protocols)

An I/O expansion unit provides additional point capacity to a digital controller

1.4.36 IP subnet (All protocols)

A group of devices which share a defined range IP addresses. Devices on a common IP subnet can share data (including broadcasts) directly without the need for the traffic to traverse an IP router.

1.4.37 Local-Area Network (LAN) (All protocols)

A communication network that spans a limited geographic area and uses the same basic communication technology throughout.

1.4.38 Local Display Panels (LDPs) (All protocols)

A DDC Hardware with a display and navigation buttons, and must provide

display and adjustment of points as shown on the Points Schedule and as indicated.

1.4.39 MAC Address (All protocols)

Media Access Control address. The physical device address that identifies a device on a Local Area Network.

1.4.40 Master-Slave/Token-Passing (MS/TP) (BACnet)

Data link protocol as defined by the BACnet standard. Multiple speeds (data rates) are permitted by the BACnet MS/TP standard.

1.4.41 Monitoring and Control (M&C) Software (All protocols)

The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

1.4.42 Network Number (BACnet)

A site-specific number assigned to each network. This network number must be unique throughout the BACnet Internetwork.

1.4.43 Object (BACnet)

An **ASHRAE 135** Object. The concept of organizing BACnet information into standard components with various associated Properties. Examples include Analog Input objects and Binary Output objects.

1.4.44 Object Identifier (BACnet)

A grouping of two Object properties: Object Type (e.g. Analog Value, Schedule, etc.) and Object Instance (in this case, a number). Object Identifiers must be unique within a device.

1.4.45 Object Instance (BACnet)

See paragraph OBJECT IDENTIFIER

1.4.46 Object Properties (BACnet)

Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in **ASHRAE 135**; some are optional and some are required. Objects are controlled by reading from and writing to object properties.

1.4.47 Operator Configurable (All protocols)

Operator configurable values are values that can be changed from a single common front end user interface across multiple vendor systems.

For non Niagara-based BACnet systems, a property, setting, or value in a device is Operator Configurable when it is Configurable and is either:

- a. a Writable Property of a Standard BACnet Object; or
- b. a Property of a Standard BACnet Object that is Writable when Out_Of_Service is TRUE and Out_Of_Service is Writable.

1.4.48 Override (All protocols)

Changing the value of a point outside of the normal sequence of operation where the change has priority over the sequence and where there is a mechanism for releasing the change such that the point returns to the normal value. Overrides persist until released or overridden at the same or higher priority but are not required to persist through a loss of power. Overrides are often used by operators to change values, and generally originate at a user interface (workstation or local display panel).

1.4.49 Packaged Equipment (All protocols)

Packaged equipment is a single piece of equipment provided by a manufacturer in a substantially complete and operable condition, where the controls (DDC Hardware) are factory installed, and the equipment is sold and shipped from the manufacturer as a single entity. Disassembly and reassembly of a large piece of equipment for shipping does not prevent it from being packaged equipment. Package units may require field installation of remote sensors. Packaged equipment is also called a "packaged unit".

Note industry may use the term "Packaged System" to mean a collection of equipment that is designed to work together where each piece of equipment is packaged equipment and there is a network that connects the equipment together. A "packaged system" of this type is NOT packaged equipment; it is a collection of packaged equipment, and each piece of equipment must individually meet specification requirements.

1.4.50 Packaged Unit (All protocols)

See packaged equipment.

1.4.51 Performance Verification Test (PVT) (All protocols)

The procedure for determining if the installed BAS meets design criteria prior to final acceptance. The PVT is performed after installation, testing, and balancing of mechanical systems. Typically the PVT is performed by the Contractor in the presence of the Government.

1.4.52 Physical Segment (BACnet)

A single contiguous medium to which BACnet devices are attached (ASHRAE 135).

1.4.53 Polling (All protocols)

A device periodically requesting data from another device.

1.4.54 Points (All protocols)

Physical and virtual inputs and outputs. See also paragraph INPUT/OUTPUT (I/O).

1.4.55 Proportional, Integral, and Derivative (PID) Control Loop (All protocols)

Three parameters used to control modulating equipment to maintain a setpoint. Derivative control is often not required for HVAC systems

(leaving "PI" control).

1.4.56 Proprietary (BACnet)

Within the context of BACnet, any extension of or addition to object types, properties, PrivateTransfer services, or enumerations specified in [ASHRAE 135](#). Objects with Object_Type values of 128 and above are Proprietary Objects. Properties with Property_Identifier of 512 and above are proprietary Properties.

1.4.57 Protocol Implementation Conformance Statement (PICS) (BACnet)

A document, created by the manufacturer of a device, which describes which portions of the BACnet standard may be implemented by a given device. [ASHRAE 135](#) requires that all [ASHRAE 135](#) devices have a PICS, and also defines a minimum set of information that must be in it. A device as installed for a specific project may not implement everything in its PICS.

1.4.58 Repeater (All protocols)

A device that connects two control network segments and retransmits all information received on one side onto the other.

1.4.59 Router (All protocols)

A device that connects two [ASHRAE 135 networks](#) and controls traffic between the two by retransmitting signals received from one side onto the other based on the signal destination. Routers are used to subdivide a [BACnet internetwork](#) and to limit network traffic.

1.4.60 Segment (All protocols)

A 'single' section of a control network that contains no repeaters or routers. There is generally a limit on the number of devices on a segment, and this limit is dependent on the topology/media and device type.

1.4.61 Standard BACnet Objects (BACnet)

Objects with Object_Type values below 128 and specifically enumerated in Clause 21 of [ASHRAE 135](#). Objects which are not proprietary. See paragraph PROPRIETARY.

1.4.62 Standard BACnet Properties (BACnet)

Properties with Property_Identifier values below 512 and specifically enumerated in Clause 21 of [ASHRAE 135](#). Properties which are not proprietary. See Proprietary.

1.4.63 Standard BACnet Services (BACnet)

[ASHRAE 135](#) services other than ConfirmedPrivateTransfer or UnconfirmedPrivateTransfer. See paragraph PROPRIETARY.

1.4.64 UMCS (All protocols)

UMCS stands for Utility Monitoring and Control System. The term refers to all components by which a project site monitors, manages, and controls real-time operation of HVAC and other building systems. These components

include the UMCS "front-end" and all field building control systems connected to the front-end. The front-end consists of Monitoring and Control Software (user interface software), browser-based user interfaces and network infrastructure.

The network infrastructure (the "UMCS Network"), is an IP network connecting multiple building or facility control networks to the Monitoring and Control Software.

1.4.65 UMCS Network (All protocols)

The UMCS Network connects multiple building or facility control networks to the Monitoring and Control Software.

1.4.66 Writable Property (BACnet)

A Property is Writable when it can be changed through the use of one or more of the WriteProperty services defined in ASHRAE 135, Clause 15 regardless of the value of any other Property. Note that in the ASHRAE 135 standard, some Properties may be writable when the Out of Service Property is TRUE; for purposes of this Section, Properties that are only writable when the Out of Service Property is TRUE are not considered to be Writable.

1.5 PROJECT SEQUENCING

TABLE II: PROJECT SEQUENCING lists the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3 EXECUTION (denoted by an 'E' in the 'TYPE' column). TABLE II does not specify overall project milestone and completion dates.

- a. Sequencing for Submittals: The sequencing specified for submittals is the deadline by which the submittal must be initially submitted to the Government. Following submission there will be a Government review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, revise the submittal and resubmit it to the Government within 14 days of notification that the submittal has been rejected. Upon resubmittal there will be an additional Government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.
- b. Sequencing for Activities: The sequencing specified for activities indicates the earliest the activity may begin.
- c. Abbreviations: In TABLE II the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

TABLE II. PROJECT SEQUENCING			
ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE FOR SUBMITTAL)
1	S	Existing Conditions Report	
2	S	DDC Contractor Design Drawings	

TABLE II. PROJECT SEQUENCING			
ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE FOR SUBMITTAL)
3	S	Manufacturer's Product Data	
4	S	Pre-construction QC Checklist	
5	E	Install Building Control System	AAO #1 thru #4
6	E	Start-Up and Start-Up Testing	ACO #5
7	S	Post-Construction QC Checklist	ACO #6
8	S	Programming Software Configuration Software	ACO #6
9	S	Draft As-Built Drawings	ACO #6
10	S	Start-Up Testing Report	ACO #6
11	S	PVT Procedures	before schedule start of #12 and AAO #10
12	E	Execute PVT	AAO #9 and #11
13	S	PVT Report	ACO #12
14	S	Controller Application Programs Controller Configuration Settings	AAO #13

TABLE II. PROJECT SEQUENCING			
ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE FOR SUBMITTAL)
15	S	Final As-Built Drawings	AAO #13
16	S	O&M Instructions	AAO #15
17	S	Training Documentation	AAO #10 and before scheduled start of #18
18	E	Training	AAO #16 and #17
19	S	Closeout QC Checklist	ACO #18

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

DDC Contractor Design Drawings; G

Draft As-Built Drawings; G

Final As-Built Drawings; G

SD-03 Product Data

Programming Software; G

Controller Application Programs; G

Configuration Software; G

Controller Configuration Settings; G

Proprietary Multi-Split Engineering Tool Software; G

Manufacturer's Product Data; G

SD-05 Design Data

Boiler Or Chiller Plant Gateway Request

SD-06 Test Reports

Existing Conditions Report

Pre-Construction Quality Control (QC) Checklist; G

Post-Construction Quality Control (QC) Checklist; G

Start-Up Testing Report; G

PVT Procedures; G

PVT Report; G

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G

Training Documentation; G

SD-11 Closeout Submittals

Enclosure Keys; G

Password Summary Report; G

Closeout Quality Control (QC) Checklist; G

1.7 DATA PACKAGE AND SUBMITTAL REQUIREMENTS

Technical data packages consisting of technical data and computer software (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications must be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered must be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered 'shop drawings' under the Federal Acquisition Regulation Supplement (FARS) and must contain no proprietary information and be delivered with unrestricted rights.

1.8 SOFTWARE FOR DDC HARDWARE AND GATEWAYS

Provide all software related to the programming and configuration of DDC Hardware and Gateways as indicated. License all Software to the project site. The term "controller" as used in these requirements means both DDC Hardware and Gateways.

1.8.1 Configuration Software

For each type of controller, provide the configuration tool software in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copies of the software user manuals for each software with the software submittal.

Submit Configuration Software on CD-ROM as a Technical Data Package. Submit 4 hard copies of the software user manual for each piece of software.

1.8.2 Controller Configuration Settings

For each controller, provide copies of the installed configuration settings as source code compatible with the configuration tool software for that controller in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Controller Configuration Settings on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which files are associated with each device. Submit 4 copies of the Controller Configuration Settings CD-ROM.

1.8.3 Programming Software

For each type of programmable controller, provide the programming software in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copies of software user manuals for each software with the software submittal.

Submit Programming Software on CD-ROM as a Technical Data Package. Submit 4 hard copies of the software user manual for each piece of software.

1.8.4 Controller Application Programs

For each programmable controller, provide copies of the application program as source code compatible with the programming software for that controller in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Controller Application Programs on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which application program is associated with each device. Submit 4 copies of the Controller Application Programs CD-ROM.

1.9 BOILER OR CHILLER PLANT GATEWAY REQUEST

If requesting the use of a gateway to a boiler or chiller plant as indicated in paragraph Proprietary Systems Exempted From Open Protocol Requirements, submit a Boiler or Chiller Plant Gateway Request describing the configuration of the boilers or chillers including model numbers for equipment and controllers, the sequence of operation for the units, and a justification for the need to operate the units on a shared non-BACnet network.

1.10 QUALITY CONTROL CHECKLISTS

The QC Checklist for BACnet Systems in APPENDIX A of this Section must be completed by the Contractor's Chief Quality Control (QC) Representative and submitted as indicated.

The QC Representative must verify each item indicated and initial in the space provided to indicate that the requirement has been met. The QC Representative must sign and date the Checklist prior to submission to the Government.

1.10.1 Pre-Construction Quality Control (QC) Checklist

Complete items indicated as Pre-Construction QC Checklist items in the QC Checklist. Submit four copies of the Pre-Construction QC Checklist.

1.10.2 Post-Construction Quality Control (QC) Checklist

Complete items indicated as Post-Construction QC Checklist items in the QC Checklist. Submit four copies of the Post-Construction QC Checklist.

1.10.3 Closeout Quality Control (QC) Checklist

Complete items indicated as Closeout QC Checklist items in the QC Checklist. Submit four copies of the Closeout QC Checklist.

PART 2 PRODUCTS

Provide products meeting the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet or Niagara BACnet systems, other referenced Sections, and this Section.

2.1 GENERAL PRODUCT REQUIREMENTS

Units of the same type of equipment must be products of a single manufacturer. Each major component of equipment must have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment must be standard products of a manufacturer regularly engaged in the manufacturing of these and similar products. The standard products must have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two year use must include applications of equipment and materials under similar circumstances and of similar size. DDC Hardware not meeting the two-year field service requirement is acceptable provided it has been successfully used by the Contractor in a minimum of two previous projects. The equipment items must be supported by a service organization. Items of the same type and purpose must be identical, including equipment, assemblies, parts and components.

2.2 PRODUCT DATA

Provide manufacturer's product data sheets documenting compliance with product specifications for each product provided under Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS, or this Section. Provide product data for all products in a single indexed compendium, organized by product type.

For all BACnet hardware: for each manufacturer, model and version (revision) of DDC Hardware provide the Protocol Implementation Conformance Statement (PICS) in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Manufacturer's Product Data on CD-ROM.

2.3 OPERATION ENVIRONMENT

Unless otherwise specified, provide products rated for continuous

operation under the following conditions:

- a. Pressure: Pressure conditions normally encountered in the installed location.
- b. Vibration: Vibration conditions normally encountered in the installed location.
- c. Temperature:
 - (1) Products installed indoors: Ambient temperatures in the range of 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.
 - (2) Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of -35 to +151 degrees F and temperature conditions outside this range normally encountered at the installed location.
- d. Humidity: 10 to 95 percent relative humidity, noncondensing and humidity conditions outside this range normally encountered at the installed location.

2.4 WIRELESS CAPABILITY

For products incorporating any wireless capability (including but not limited to radio frequency (RF), infrared and optical), provide products for which wireless capability can be permanently disabled at the device. Optical and infrared capabilities may be disabled via a permanently affixed opaque cover plate.

2.5 ENCLOSURES

Enclosures supplied as an integral (pre-packaged) part of another product are acceptable. Provide two Enclosure Keys for each lockable enclosure on a single ring per enclosure with a tag identifying the enclosure the keys operate. Provide enclosures meeting the following minimum requirements:

2.5.1 Outdoors

For enclosures located outdoors, provide enclosures meeting NEMA 250 Type 4 requirements.

2.5.2 Mechanical and Electrical Rooms

For enclosures located in mechanical or electrical rooms, provide enclosures meeting NEMA 250 Type 2 requirements.

2.5.3 Other Locations

For enclosures in other locations including but not limited to occupied spaces, above ceilings, and in plenum returns, provide enclosures meeting NEMA 250 Type 1 requirements.

2.6 WIRE AND CABLE

Provide wire and cable meeting the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification and referenced specifications.

2.6.1 Terminal Blocks

For terminal blocks which are not integral to other equipment, provide terminal blocks which are insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, suitable for DIN rail mounting, and which have enclosed sides or end plates and partition plates for separation.

2.6.2 Control Wiring for Binary Signals

For Control Wiring for Binary Signals, provide 18 AWG copper or thicker wire rated for 300-volt service.

2.6.3 Control Wiring for Analog Signals

For Control Wiring for Analog Signals, provide 18 AWG or thicker, copper, single- or multiple-twisted wire meeting the following requirements:

- a. minimum 2 inch lay of twist
- b. 100 percent shielded pairs
- c. at least 300-volt insulation
- d. each pair has a 20 AWG tinned-copper drain wire and individual overall pair insulation
- e. cables have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.6.4 Power Wiring for Control Devices

For 24-volt circuits, provide insulated copper 18 AWG or thicker wire rated for 300 VAC service. For 120-volt circuits, provide 14 AWG or thicker stranded copper wire rated for 600-volt service.

2.6.5 Transformers

Provide UL 5085-3 approved transformers. Select transformers sized so that the connected load is no greater than 80 percent of the transformer rated capacity.

PART 3 EXECUTION

3.1 EXISTING CONDITIONS

3.1.1 Existing Conditions Survey

Perform a field survey, including testing and inspection of the equipment to be controlled and submit an Existing Conditions Report documenting the current status and its impact on the Contractor's ability to meet this specification. For those items considered nonfunctional, document the deficiency in the report including explanation of the deficiencies and estimated costs to correct the deficiencies. As part of the report, define the scheduled need date for connection to existing equipment. Make written requests and obtain Government approval prior to disconnecting any controls and obtaining equipment downtime.

Submit four copies of the Existing Conditions Report.

3.1.2 Existing Equipment Downtime

Make written requests and obtain Government approval prior to disconnecting any controls and obtaining equipment downtime.

3.1.3 Existing Control System Devices

Inspect, calibrate, and adjust as necessary to place in proper working order all existing devices which are to be reused.

3.2 INSTALLATION

Fully install and test the control system in accordance Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet or Niagara BACnet systems, and this Section.

3.2.1 Dielectric Isolation

Provide dielectric isolation where dissimilar metals are used for connection and support. Install control system in a manner that provides clearance for control system maintenance by maintaining access space required to calibrate, remove, repair, or replace control system devices. Install control system such that it does not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.2.2 Penetrations in Building Exterior

Make all penetrations through and mounting holes in the building exterior watertight.

3.2.3 Device Mounting Criteria

Install devices in accordance with the manufacturer's recommendations and as indicated and shown. Provide a weathershield for all devices installed outdoors. Provide clearance for control system maintenance by maintaining access space required to calibrate, remove, repair, or replace control system devices. Provide clearance for mechanical and electrical system maintenance; do not not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.2.4 Labels and Tags

Key all labels and tags to the unique identifiers shown on the As-Built drawings. For labels exterior to protective enclosures provide engraved plastic labels mechanically attached to the enclosure or DDC Hardware. Labels inside protective enclosures may be attached using adhesive, but must not be hand written. For tags, provide plastic or metal tags mechanically attached directly to each device or attached by a metal chain or wire.

a. Label all Enclosures and DDC Hardware.

b. Tag Airflow measurement arrays (AFMA) with flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient.

- c. Tag duct static pressure taps at the location of the pressure tap

3.2.5 Surge Protection

3.2.5.1 Power-Line Surge Protection

Protect equipment connected to AC circuits to withstand power-line surges in accordance with [IEEE C62.41](#). Do not use fuses for surge protection.

3.2.5.2 Surge Protection for Transmitter and Control Wiring

Protect DDC hardware against or provided DDC hardware capable of withstanding surges induced on control and transmitter wiring installed outdoors and as shown. Protect equipment against the following two waveforms:

- a. A waveform with a 10-microsecond rise time, a 1000-microsecond decay time and a peak current of 60 amps.
- b. A waveform with an 8-microsecond rise time, a 20-microsecond decay time and a peak current of 500 amperes.

3.2.6 Basic Cybersecurity Requirements

3.2.6.1 Passwords

For all devices with a password, change the password from the default password. Do not use the same password for more than one device. Coordinate selection of passwords with [Contracting Officer](#). Provide a [Password Summary Report](#) documenting the password for each device and describing the procedure to change the password for each device.

Provide [four](#) hardcopies of the Password Summary Report, each copy in its own sealed envelope.

3.2.6.2 Wireless Capability

Unless otherwise indicated, disable wireless capability (including but not limited to radio frequency (RF), infrared and optical) for all devices with wireless capability. Optical and infrared capabilities may be disabled via a permanently affixed opaque cover plate. Password protecting a wireless connections does not meet this requirement; the wireless capability must be disabled.

3.2.6.3 IP Network Physical Security

Install all IP Network media in conduit. Install all IP devices including but not limited to IP-enabled DDC hardware and IP Network Hardware in lockable enclosures.

3.3 DRAWINGS AND CALCULATIONS

Provide drawings in the form and arrangement indicated and shown. Use the same abbreviations, symbols, nomenclature and identifiers shown. Assign a unique identifier as shown to each control system element on a drawing. When packaging drawings, group schedules by system. When space allows, it is permissible to include multiple schedules for the same system on a single sheet. Except for drawings covering all systems, do not put information for different systems on the same sheet.

Submit hardcopy drawings on 17 by 11 inches sheets, and electronic drawings in PDF and in AutoCAD format. In addition, submit electronic drawings in editable Excel format for all drawings that are tabular, including but not limited to the Point Schedule and Equipment Schedule.

- a. Submit DDC Contractor Design Drawings consisting of each drawing indicated with pre-construction information depicting the intended control system design and plans. Submit DDC Contractor Design Drawings as a single complete package: four hard copies and four copies on CD-ROM.
- b. Submit Draft As-Built Drawings consisting of each drawing indicated updated with as-built data for the system prior to PVT. Submit Draft As-Built Drawings as a single complete package: four hard copies and four copies on CD-ROM.
- c. Submit Final As-Built Drawings consisting of each drawing indicated updated with all final as-built data. Final As-Built Drawings as a single complete package: four hard copies and four copies on CD-ROM.

3.3.1 Sample Drawings

Sample drawings in electronic format are available at the Whole Building Design Guide page for this section:

<http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-23-09-00>

These drawings may prove useful in demonstrating expected drawing formatting and example content and are provided for illustrative purposes only. Note that these drawings do not meet the content requirements of this Section and must be completed to meet project requirements.

3.3.2 Drawing Index and Legend

Provide an HVAC Control System Drawing Index showing the name and number of the building, military site, State or other similar designation, and Country. In the Drawing Index, list all Contractor Design Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. In the Design Drawing Legend, show and describe all symbols, abbreviations and acronyms used on the Design Drawings. Provide a single Index and Legend for the entire drawing package.

3.3.3 Thermostat and Occupancy Sensor Schedule

Provide a thermostat and occupancy sensor schedule containing each thermostat's unique identifier, room identifier and control features and functions as shown. Provide a single thermostat and occupancy sensor schedule for the entire project.

3.3.4 Valve Schedule

Provide a valve schedule containing each valve's unique identifier, size, flow coefficient Kv (Cv), pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure to torque data, dimensions, and access and clearance requirements data. In the valve schedule include actuator selection data supported by calculations of the force required to move and seal the valve, access and clearance requirements. Provide a single valve schedule for the entire project.

3.3.5 Damper Schedule

Provide a damper schedule containing each damper's unique identifier, type (opposed or parallel blade), nominal and actual sizes, orientation of axis and frame, direction of blade rotation, actuator size and spring ranges, operation rate, positive positioner range, location of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. Include the AMCA 511 maximum leakage rate at the operating static-pressure differential for each damper in the Damper Schedule. Provide a single damper schedule for the entire project.

3.3.6 Project Summary Equipment Schedule

Provide a project summary equipment schedule containing the manufacturer, model number, part number and descriptive name for each control device, hardware and component provided under this specification. Provide a single project equipment schedule for the entire project.

3.3.7 Equipment Schedule

Provide system equipment schedules containing the unique identifier, manufacturer, model number, part number and descriptive name for each control device, hardware and component provided under this specification. Provide a separate equipment schedule for each HVAC system.

3.3.8 Occupancy Schedule

Provide an occupancy schedule drawing containing the same fields as the occupancy schedule Contract Drawing with Contractor updated information. Provide a single occupancy schedule for the entire project.

3.3.9 DDC Hardware Schedule

Provide a single DDC Hardware Schedule for the entire project and including following information for each device.

3.3.9.1 DDC Hardware Identifier

The Unique DDC Hardware Identifier for the device.

3.3.9.2 HVAC System

The system "name" used to identify a specific system (the name used on the system schematic drawing for that system).

3.3.9.3 BACnet Device Information

3.3.9.3.1 Device Object Identifier

The Device Object Identifier: The Object_Identifier of the Device Object

3.3.9.3.2 Network Number

The Network Number for the device.

3.3.9.3.3 MAC Address

The MAC Address for the device

3.3.9.3.4 BTL Listing

The BTL Listing of the device. If the device is listed under multiple BTL Profiles, indicate the profile that matches the use and configuration of the device as installed.

3.3.9.3.5 Proprietary Services Information

If the device uses non-standard **ASHRAE 135** services as defined and permitted in Section **23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS**, indicate that the device uses non-standard services and include a description of all non-standard services used. Describe usage and content such that a device from another vendor can interoperate with the device using the non-standard service. Provide descriptions with sufficient detail to allow a device from a different manufacturer to be programmed to both read and write the non-standard service request:

- a. read: interpret the data contained in the non-standard service and;
- b. write: given similar data, generate the appropriate non-standard service request.

3.3.9.3.6 Alarming Information

Indicate whether the device is used for alarm generation, and which types of alarm generation the device implements: intrinsic, local algorithmic, remote algorithmic.

3.3.9.3.7 Scheduling Information

Indicate whether the device is used for scheduling.

3.3.9.3.8 Trending Information

Indicate whether the device is used for trending, and indicate if the device is used to trend local values, remote values, or both.

3.3.10 Points Schedule

Provide a Points Schedule in tabular form for each HVAC system, with the indicated columns and with each row representing a hardware point, network point or configuration point in the system.

- a. When a Points Schedule was included in the Contract Drawing package, use the same fields as the Contract Drawing with updated information in addition to the indicated fields.
- b. When Point Schedules are included in the contract package, items requiring contractor verification or input have been shown in angle brackets ("**<**" and "**>**"), such as **<__>** for a required entry or **<value>** for a value requiring confirmation. Complete all items in brackets as well as any blank cells. Do not modify values which are not in brackets without approval.

Points Schedule Columns must include:

3.3.10.1 Point Name

The abbreviated name for the point using the indicated naming convention.

3.3.10.2 Description

A brief functional description of the point such as "Supply Air Temperature".

3.3.10.3 DDC Hardware Identifier

The Unique DDC Hardware Identifier shown on the DDC Hardware Schedule and used across all drawings for the DDC Hardware containing the point.

3.3.10.4 Settings

The value and units of any setpoints, configured setpoints, configuration parameters, and settings related to each point.

3.3.10.5 Range

The range of values, including units, associated with the point, including but not limited to a zone temperature setpoint adjustment range, a sensor measurement range, occupancy values for an occupancy input, or the status of a safety.

3.3.10.6 Input or Output (I/O) Type

The type of input or output signal associated with the point. Use the following abbreviations for entries in this column:

- a. AI: The value comes from a hardware (physical) Analog Input
- b. AO: The value is output as a hardware (physical) Analog Output
- c. BI: The value comes from a hardware (physical) Binary Input
- d. BO: The value is output as a hardware (physical) Binary Output
- e. PULSE: The value comes from a hardware (physical) Pulse Accumulator Input
- f. NET-IN: The value is provided from the network (generally from another device). Use this entry only when the value is received from another device as part of scheduling or as part of a sequence of operation, not when the value is received on the network for supervisory functions such as trending, alarming, override or display at a user interface.
- g. NET-OUT: The value is provided to another controller over the network. Use this entry only when the value is transmitted to another device as part of scheduling or as part of a sequence of operation, not when the value is transmitted on the network for supervisory functions such as trending, alarming, override or display at a user interface.

3.3.10.7 Object and Property Information

The Object Type and Instance Number for the Object associated with the

point. If the value of the point is not in the Present_Value Property, then also provide the Property ID for the Property containing the value of the point. Any point that is displayed at the front end or on an LDP, is trended, is used by another device on the network, or has an alarm condition must be documented here.

3.3.10.8 Network Data Exchange Information (Gets Data From, Sends Data To)

Provide the DDC Hardware Identifier of other DDC Hardware the point is shared with.

3.3.10.9 Override Information (Object Type and Instance Number)

For each point requiring an Override, indicate if the Object for the point is Commandable or, if the use of a separate Object was specifically approved by the Contracting Officer, provide the Object Type and Instance Number of the Object to be used in overriding the point.

3.3.10.10 Trend Object Information

For each point requiring a trend, indicate if the trend is Local or Remote, the trend Object type and the trend Object instance number. For remote trends provide the DDC Hardware Identifier for the device containing the trend Object in the Points Schedule notes.

3.3.10.11 Alarm Information

Indicate the Alarm Generation Type, Event Enrollment Object Instance Number, and Notification Class Object Instance Number for each point requiring an alarm. (Note that not all alarms will have Event Enrollment Objects.)

3.3.10.12 Configuration Information

Indicate the means of configuration associated with each point.

- a. For Operator Configurable Points indicate BACnet Object and Property information (Name, Type, Identifiers) containing the configurable value. Indicate whether the property is writable always, or only when Out_Of_Service is TRUE.
- b. For Configurable Points indicate the BACnet Object and Property information as for Operator Configurable points, or identification of the configurable settings from within the engineering software for the device or identification of the hardware settings on the device.

3.3.11 Riser Diagram

The Riser Diagram of the Building Control Network may be in tabular form, and must show all DDC Hardware and all Network Hardware, including network terminators. For each item, provide the unique identifier, common descriptive name, physical sequential order (previous and next device on the network), room identifier and location within room. A single riser diagram must be submitted for the entire system.

3.3.12 Control System Schematics

Provide control system schematics in the same form as the control system schematic Contract Drawing with Contractor updated information. Provide a

control system schematic for each HVAC system.

3.3.13 Sequences of Operation Including Control Logic Diagrams

Provide HVAC control system sequence of operation and control logic diagrams in the same format as the Contract Drawings. Within these drawings, refer to devices by their unique identifiers. Submit sequences of operation and control logic diagrams for each HVAC system

3.3.14 Controller, Motor Starter and Relay Wiring Diagram

Provide controller wiring diagrams as functional wiring diagrams which show the interconnection of conductors and cables to each controller and to the identified terminals of input and output devices, starters and package equipment. Show necessary jumpers and ground connections and the labels of all conductors. Identify sources of power required for control systems and for packaged equipment control systems back to the panel board circuit breaker number, controller enclosures, magnetic starter, or packaged equipment control circuit. Show each power supply and transformer not integral to a controller, starter, or packaged equipment. Show the connected volt-ampere load and the power supply volt-ampere rating. Provide wiring diagrams for each HVAC system.

3.4 CONTROLLER TUNING

Tune each controller in a manner consistent with that described in the **ASHRAE FUN IP** and in the manufacturer's instruction manual. Tuning must consist of adjustment of the proportional, integral, and where applicable, the derivative (PID) settings to provide stable closed-loop control. Each loop must be tuned while the system or plant is operating at a high gain (worst case) condition, where high gain can generally be defined as a low-flow or low-load condition. Upon final adjustment of the PID settings, in response to a change in controller setpoint, the controlled variable must settle out at the new setpoint with no more than two (2) oscillations above and below setpoint. Upon settling out at the new setpoint the controller output must be steady. With the exception of naturally slow processes such as zone temperature control, the controller must settle out at the new setpoint within five (5) minutes. Set the controller to its correct setpoint and record and submit the final PID configuration settings with the O&M Instructions and on the associated Points Schedule.

3.5 START-UP

3.5.1 Start-Up Test

Perform the following startup tests for each control system to ensure that the described control system components are installed and functioning per this specification.

Adjust, calibrate, measure, program, configure, set the time schedules, and otherwise perform all necessary actions to ensure that the systems function as indicated and shown in the sequence of operation and other contract documents.

3.5.1.1 Systems Check

An item-by-item check must be performed for each HVAC system

3.5.1.1.1 Step 1 - System Inspection

With the system in unoccupied mode and with fan hand-off-auto switches in the OFF position, verify that power and main air are available where required and that all output devices are in their failsafe and normal positions. Inspect each local display panel to verify that all displays indicate shutdown conditions.

3.5.1.1.2 Step 2 - Calibration Accuracy Check

Perform a two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter by comparing the value from the test instrument to the network value provided by the DDC Hardware. Use digital indicating test instruments, such as digital thermometers, motor-driven psychrometers, and tachometers. Use test instruments with accuracy at least twice as accurate as the specified sensor accuracy and with calibration traceable to National Institute of Standards and Technology standards. Check one the first check point in the bottom one-third of the sensor range, and the second in the top one-third of the sensor range. Verify that the sensing element-to-DDC readout accuracies at two points are within the specified product accuracy tolerances, and if not recalibrate or replace the device and repeat the calibration check.

3.5.1.1.3 Step 3 - Actuator Range Check

With the system running, apply a signal to each actuator through the DDC Hardware controller. Verify proper operation of the actuators and positioners for all actuated devices and record the signal levels for the extreme positions of each device. Vary the signal over its full range, and verify that the actuators travel from zero stroke to full stroke within the signal range. Where applicable, verify 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. For valve actuators and damper actuators, perform the actuator range check under normal system pressures.

3.5.1.2 Weather Dependent Test

Perform weather dependent test procedures in the appropriate climatic season.

3.5.2 Start-Up Testing Report

Submit 4 copies of the Start-Up Testing Report. The report may be submitted as a Technical Data Package documenting the results of the tests performed and certifying that the system is installed and functioning per this specification, and is ready for the Performance Verification Test (PVT).

3.6 PERFORMANCE VERIFICATION TEST (PVT)

3.6.1 PVT Procedures

Prepare PVT Procedures explaining step-by-step, the actions and expected results that will demonstrate that the control system performs in accordance with the sequences of operation, and other contract documents. Submit 4 copies of the PVT Procedures. The PVT Procedures may be submitted as a Technical Data Package.

3.6.1.1 Sensor Accuracy Checks

Include a one-point accuracy check of each sensor in the PVT procedures.

3.6.1.2 Endurance Test

Include a one-week endurance test as part of the PVT during which the system is operated continuously.

Use the building control system BACnet Trend Log or Trend Log Multiple Objects to trend all points shown as requiring a trend on the Point Schedule for the entire endurance test. If insufficient buffer capacity exists to trend the entire endurance test, upload trend logs during the course of the endurance test to ensure that no trend data is lost.

3.6.1.3 PVT Equipment List

Include in the PVT procedures a control system performance verification test equipment list that lists the equipment to be used during performance verification testing. For each piece of equipment, include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration

3.6.2 PVT Execution

Demonstrate compliance of the control system with the contract documents. Using test plans and procedures approved by the Government, software capable of reading and writing COV Notification Subscriptions, Notification Class Recipient List Properties, event enrollments, demonstrate all physical and functional requirements of the project. Show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. Do not start the performance verification test until after receipt of written permission by the Government, based on Government approval of the PVT Plan and Draft As-Builts and completion of balancing. UNLESS GOVERNMENT WITNESSING OF A TEST IS SPECIFICALLY WAIVED BY THE GOVERNMENT, PERFORM ALL TESTS WITH A GOVERNMENT WITNESS. Do not conduct tests during scheduled seasonal off periods of base heating and cooling systems. If the system experiences any failures during the endurance test portion of the PVT, repair the system repeat the endurance test portion of the PVT until the system operates continuously and without failure for the specified endurance test period.

3.6.3 PVT Report

Prepare and submit a PVT report documenting all tests performed during the PVT and their results. Include all tests in the PVT procedures and any additional tests performed during PVT. Document test failures and repairs conducted with the test results.

Submit four copies of the PVT Report. The PVT Report may be submitted as a Technical Data Package.

3.7 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Provide HVAC control System Operation and Maintenance Instructions which include:

- a. "Data Package 3" as indicated in Section 01 78 23 OPERATION AND

MAINTENANCE DATA for each piece of control equipment.

- b. "Data Package 4" as described in Section 01 78 23 OPERATION AND MAINTENANCE DATA for all air compressors.
- c. HVAC control system sequences of operation formatted as indicated.
- d. Procedures for the HVAC system start-up, operation and shut-down including the manufacturer's supplied procedures for each piece of equipment, and procedures for the overall HVAC system.
- e. As-built HVAC control system detail drawings formatted as indicated.
- f. Routine maintenance checklist. Provide the routine maintenance checklist arranged in a columnar format, where the first column lists all installed devices, the second column states the maintenance activity or that no maintenance required, the third column states the frequency of the maintenance activity, and the fourth column is used for additional comments or reference.
- g. Qualified service organization list, including at a minimum company name, contact name and phone number.
- h. Start-Up Testing Report.
- i. Performance Verification Test (PVT) Procedures and Report.

Submit four (4) copies of the Operation and Maintenance Instructions, indexed and in booklet form. The Operation and Maintenance Instructions may be submitted as a Technical Data Package.

3.8 TRAINING

Conduct a training course for ten (10) operating staff members designated by the Government in the maintenance and operation of the system, including specified hardware and software. Conduct eight (8) hours of training at the project site within 30 days after successful completion of the performance verification test. The Government reserves the right to make audio and visual recordings (using Government supplied equipment) of the training sessions for later use. Provide audiovisual equipment and other training materials and supplies required to conduct training. 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.

3.8.1 Training Documentation

Prepare training documentation consisting of:

- a. Course Attendee List: Develop the list of course attendees in coordination with and signed by the HVAC shop supervisor.
- b. Training Manuals: Provide training manuals which include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. When presenting portions of the course material by audiovisuals, deliver copies of those audiovisuals as a part of the printed training manuals.

3.8.2 Training Course Content

For guidance in planning the required instruction, assume that attendees will have a high school education, and are familiar with HVAC systems. During the training course, cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each controller enclosure, the layout of one of each type of equipment and the locations of each, the location of each 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. Present the results of the performance verification test and the Start-Up Testing Report as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

3.8.3 Training Documentation Submittal Requirements

Submit hardcopy training manuals and all training materials on CD-ROM. Provide one hardcopy manual for each trainee on the Course Attendee List and four (4) additional copies for archive at the project site. Provide four (4) copies of the Course Attendee List with the archival copies. Training Documentation may be submitted as a Technical Data Package.

APPENDIX A

<u>QC CHECKLIST FOR BACNET SYSTEMS</u>		
This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such. Instructions: Initial each item in the space provided (____) verifying that the requirement has been met.		
This checklist is for (circle one:) Pre-Construction QC Checklist Submittal Post-Construction QC Checklist Submittal Close-out QC Checklist Submittal		
Items verified for Pre-Construction, Post-Construction and Closeout QC Checklist Submittals:		
1	All DDC Hardware is numbered on Control System Schematic Drawings.	____
2	Signal lines on Control System Schematic are labeled with the signal type.	____
3	Local Display Panel (LDP) Locations are shown on Control System Schematic drawings.	____
Items verified for Post-Construction and Closeout QC Checklist Submittals:		
4	All sequences are performed as specified using DDC Hardware.	____
5	Training schedule and course attendee list has been developed and coordinated with shops and submitted.	____
Items verified for Closeout QC Checklist Submittal:		
6	Final As-built Drawings, including all Points Schedule drawings, accurately represent the final installed system.	____
7	Programming software has been submitted for all programmable controllers.	____
8	All software has been licensed to the Government.	____

<u>QC CHECKLIST FOR BACNET SYSTEMS</u>		
9	O&M Instructions have been completed and submitted.	____
10	Training course has been completed.	____
11	All DDC Hardware is installed on a BACnet ASHRAE 135 network using either MS/TP in accordance with Clause 9 or IP in accordance with Annex J.	____
12	All DDC Hardware is BTL listed.	____
13	Communication between DDC Hardware is only via BACnet using standard services, except as specifically permitted by the specification. Non-standard services have been fully documented in the DDC Hardware Schedule.	____
14	Scheduling, Alarming, and Trending have been implemented using the standard BACnet Objects for these functions.	____
15	All Properties indicated as required to be Writable are Writable and Overrides have been provided as indicated	____
	(QC Representative Signature)	(Date)

-- End of Section --

SECTION 23 09 13

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.1 SUMMARY

This section provides for the instrumentation control system components excluding direct digital controllers, network controllers, gateways etc. that are necessary for a completely functional automatic control system. When combined with a Direct Digital Control (DDC) system, the Instrumentation and Control Devices covered under this section must be a complete system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and indicated.

- a. Install hardware to perform the control sequences as specified and indicated and to provide control of the equipment as specified and indicated.
- b. Install hardware such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.
- c. Install and configure hardware such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the installing Contractor.

1.1.1 Verification of Dimensions

After becoming 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.

1.1.2 Drawings

The Government will not indicate all offsets, fittings, and accessories that may be required on the drawings. Carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, arrange such work accordingly, and provide all work necessary to meet such conditions.

1.2 RELATED SECTIONS

Related work specified elsewhere.

Section 23 30 00 HVAC AIR DISTRIBUTION

Section 23 05 15 COMMON PIPING FOR HVAC

Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

1.3 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 MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 500-D (2018) Laboratory Methods of Testing
Dampers for Rating

AMCA 511 (2010; R 2016) Certified Ratings Program
for Air Control Devices

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (2014; Errata 2016) Electric Meters - Code
for Electricity Metering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.15 (2018) Cast Copper Alloy Threaded Fittings
Classes 125 and 250

ASME B16.34 (2021) Valves - Flanged, Threaded and
Welding End

ASME B40.100 (2013) Pressure Gauges and Gauge
Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A536 (1984; R 2019; E 2019) Standard
Specification for Ductile Iron Castings

FLUID CONTROLS INSTITUTE (FCI)

FCI 70-2 (2021) Control Valve Seat Leakage

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142 (2007; Errata 2014) Recommended Practice
for Grounding of Industrial and Commercial
Power Systems - IEEE Green Book

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.20 (2015; E 2018) Electricity Meters - 0.1,
0.2, and 0.5 Accuracy Classes

NEMA 250 (2020) Enclosures for Electrical Equipment
(1000 Volts Maximum)

NEMA/ANSI C12.10 (2011; R 2021) Physical Aspects of
Watthour Meters - Safety Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

NFPA 90A (2021) Standard for the Installation of
Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 555 (2006; Reprint Aug 2016) UL Standard for
Safety Fire Dampers

UL 555S (2014; Reprint Oct 2020) UL Standard for
Safety Smoke Dampers

UL 5085-3 (2006; Reprint Jan 2022) UL Standard for
Safety Low Voltage Transformers - Part 3:
Class 2 and Class 3 Transformers

1.4 SUBMITTALS

Submittal requirements are specified in Section 23 09 00 INSTRUMENTATION
AND CONTROL FOR HVAC.

1.5 DELIVERY AND STORAGE

Store and protect products from the weather, humidity, and temperature
variations, dirt and dust, and other contaminants, within the storage
condition limits published by the equipment manufacturer.

1.6 INPUT MEASUREMENT ACCURACY

Select, install and configure sensors, transmitters and DDC Hardware such
that the maximum error of the measured value at the input of the DDC
hardware is less than the maximum allowable error specified for the sensor
or instrumentation.

1.7 SUBCONTRACTOR SPECIAL REQUIREMENTS

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 General Requirements

All products used to meet this specification must meet the indicated
requirements, but not all products specified here will be required by
every project. All products must meet the requirements both Section
23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section.

2.1.2 Operation Environment Requirements

Unless otherwise specified, provide products rated for continuous
operation under the following conditions:

2.1.2.1 Pressure

Pressure conditions normally encountered in the installed location.

2.1.2.2 Vibration

Vibration conditions normally encountered in the installed location.

2.1.2.3 Temperature

- a. Products installed indoors: Ambient temperatures in the range of 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.
- b. Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of 0 to +151 degrees F and temperature conditions outside this range normally encountered at the installed location.

2.1.2.4 Humidity

10 to 95 percent relative humidity, non-condensing and also humidity conditions outside this range normally encountered at the installed location.

2.2 WEATHERSHIELDS

Provide weathershields constructed of galvanized steel painted white, unpainted aluminum, aluminum painted white, or white PVC.

2.3 WIRE AND CABLE

Provide wire and cable meeting the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification and referenced specifications.

2.3.1 Terminal Blocks

For terminal blocks which are not integral to other equipment, provide terminal blocks which are insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, suitable for DIN rail mounting, and which have enclosed sides or end plates and partition plates for separation.

2.3.2 Control Wiring for Binary Signals

For Control Wiring for Binary Signals, provide 18 AWG copper or thicker wire rated for 300-volt service.

2.3.3 Control Wiring for Analog Signals

For Control Wiring for Analog Signals, provide 18 AWG or thicker, copper, single- or multiple-twisted wire meeting the following requirements:

- a. minimum 2 inch lay of twist
- b. 100 percent shielded pairs

- c. at least 300-volt insulation
- d. each pair has a 20 AWG tinned-copper drain wire and individual overall pair insulation
- e. cables have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.3.4 Power Wiring for Control Devices

For 24-volt circuits, provide insulated copper 18 AWG or thicker wire rated for 300 VAC service. For 120-volt circuits, provide 14 AWG or thicker stranded copper wire rated for 600-volt service.

2.3.5 Transformers

Provide [UL 5085-3](#) approved transformers. Select transformers sized so that the connected load is no greater than 80 percent of the transformer rated capacity.

2.4 AUTOMATIC CONTROL VALVES

Provide valves with stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Provide valves with bodies meeting [ASME B16.34](#) or [ASME B16.15](#) pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure. Unless otherwise specified or indicated, provide valves meeting [FCI 70-2](#) Class III leakage rating. Provide valves rated for modulating or two-position service as indicated, which close against a differential pressure indicated as the Close-Off pressure and which are Normally-Open, Normally-Closed, or Fail-In-Last-Position as indicated.

2.4.1 Valve Type

2.4.1.1 Liquid Service 150 Degrees F or Less

Use either globe valves or ball valves except that butterfly valves may be used for sizes [4 inch](#) and larger.

2.4.1.2 Liquid Service Above 150 Degrees F

- a. Two-position valves: Use either globe valves or ball valves except that butterfly valves may be used for sizes [4 inch](#) and larger.
- b. Modulating valves: Use globe valves except that butterfly valves may be used for sizes [4 inch](#) and larger.

2.4.1.3 Steam Service

Use globe valves except that butterfly valves may be used for sizes [4 inch](#) and larger.

2.4.2 Valve Flow Coefficient and Flow Characteristic

2.4.2.1 Two-Way Modulating Valves

Provide the valve coefficient ([Cv](#)) indicated. Provide equal-percentage

flow characteristic for liquid service except for butterfly valves.
Provide linear flow characteristic for steam service except for butterfly valves.

2.4.2.2 Three-Way Modulating Valves

Provide the valve coefficient (**Cv**) indicated. Provide linear flow characteristic with constant total flow throughout full plug travel.

2.4.3 Two-Position Valves

Use full line size full port valves with maximum available (**Cv**).

2.4.4 Globe Valves

2.4.4.1 Liquid Service Not Exceeding 150 Degrees F

a. Valve body and body connections:

- (1) valves 1-1/2 inches and smaller: brass or bronze body, with threaded or union ends
- (2) valves from 2 inches to 3 inches inclusive: brass, bronze, or iron bodies. 2 inch valves with threaded connections; 2-1/2 to 3 inches valves with flanged connections

b. Internal valve trim: Brass or bronze.

c. Stems: Stainless steel.

d. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol.

2.4.4.2 Liquid Service Not Exceeding 250 Degrees F

a. Valve body and body connections:

- (1) valves 1-1/2 inches and smaller: brass or bronze body, with threaded or union ends

- (2) valves from 2 inches to 3 inches inclusive: brass, bronze, or iron bodies. 2 inch valves with threaded connections; 2-1/2 to 3 inches valves with flanged connections

b. Internal trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.

c. Provide valves with non-metallic parts suitable for a minimum continuous operating temperature of 250 degrees F or 50 degrees F above the system design temperature, whichever is higher.

d. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol

2.4.4.3 Hot water service 250 Degrees F and above

- a. Provide valve bodies conforming to ASME B16.34 Class 300. For valves 1 inch and larger provide valves with bodies which are carbon steel, globe type with welded ends. For valves smaller than 1 inch provide

valves with socket-weld ends. Provide valves with virgin polytetrafluoroethylene (PTFE) packing. Provide valve and actuator combinations which are normally closed.

- b. Internal trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.

2.4.4.4 Steam Service

For steam service, provide valves meeting the following requirements:

- a. Valve body and connections:
 - (1) valves 1-1/2 inches and smaller: complete body of brass or bronze, with threaded or union ends
 - (2) valves from 2 inches to 3 inches inclusive: body of brass, bronze, or carbon steel
 - (3) valves 4 inches and larger: body of carbon steel. 2 inch valves with threaded connections; valves 2-1/2 inches and larger with flanged connections.
- b. Internal Trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.
- c. Valve sizing: sized for 15 psig inlet steam pressure with a maximum 12 psi differential through the valve at rated flow, except where indicated otherwise.

2.4.5 Ball Valves

2.4.5.1 Liquid Service Not Exceeding 150 Degrees F

- a. Valve body and connections:
 - (1) valves 1-1/2 inches and smaller: bodies of brass or bronze, with threaded or union ends
 - (2) valves from 2 inches to 3 inches inclusive: bodies of brass, bronze, or iron. 2 inch valves with threaded connections; valves from 2-1/2 to 3 inches with flanged connections.
- b. Ball: Stainless steel or nickel-plated brass or chrome-plated brass.
- c. Seals: Reinforced Teflon seals and EPDM O-rings.
- d. Stem: Stainless steel, blow-out proof.
- e. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol.

2.4.6 Butterfly Valves

Provide butterfly valves which are threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies or with ductile iron bodies in accordance with ASTM A536. Provide butterfly valves with non-corrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from -20

to +250 degrees F. Provide valves with rated Cv of the Cv at 70 percent (60 degrees) open position. Provide valves meeting FCI 70-2 Class VI leakage rating.

2.4.7 Pressure Independent Control Valves (PICV)

Provide pressure independent control valves which include a regulator valve which maintains the differential pressure across a flow control valve. Pressure independent control valves must accurately control the flow from 0-100 percent full rated flow regardless of changes in the piping pressure and not vary the flow more than plus or minus 5 percent at any given flow control valve position when the PICV differential pressure lies between the manufacturer's stated minimum and maximum. The rated minimum differential pressure for steady flow must not exceed 5 psid across the PICV. Provide either globe or ball type valves meeting the indicated requirements for globe and ball valves. Provide valves with a flow tag listing full rated flow and minimum required pressure drop. Provide valves with factory installed Pressure/Temperature ports ("Pete's Plugs") to measure the pressure drop to determine the valve flow rate.

2.4.8 Duct-Coil and Terminal-Unit-Coil Valves

For duct or terminal-unit coils provide control valves with either screw type or solder-type ends. Provide flare nuts for each flare-type end valve.

2.5 DAMPERS

2.5.1 Damper Assembly

Provide single damper sections with blades no longer than 48 inches and which are no higher than 72 inches and damper blade width of 8 inches or less. When larger sizes are required, combine damper sections. Provide dampers made of steel, or other materials where indicated and with assembly frames constructed of 0.07 inch minimum thickness galvanized steel channels with mitered and welded corners. Steel channel frames constructed of 0.06 inch minimum thickness are acceptable provided the corners are reinforced.

- a. Flat blades must be made rigid by folding the edges. Blade-operating linkages must be within the frame so that blade-connecting devices within the same damper section must not be located directly in the air stream.
- b. Damper axles must be 1/2 inch minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically must be supported by thrust bearings.
- c. Provide dampers which do not exceed a pressure drop through the damper of 0.04 inches water gauge at 1000 ft/min in the wide-open position. Provide dampers with frames not less than 2 inch in width. Provide dampers which have been tested in accordance with AMCA 500-D.

2.5.2 Operating Linkages

For operating links external to dampers, such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, provide links able to withstand a load equal to at least 300 percent of the maximum required damper-operating force without deforming.

Rod lengths must be adjustable. Links must be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises must be brass, bronze, or stainless steel. Adjustments of crank arms must control the open and closed positions of dampers.

2.5.3 Damper Types

2.5.3.1 Flow Control Dampers

Provide parallel-blade or opposed blade type dampers for outside air, return air, relief air, exhaust, face and bypass dampers as indicated on the Damper Schedule. Blades must have interlocking edges. The channel frames of the dampers must be provided with jamb seals to minimize air leakage. Unless otherwise indicated, dampers must meet [AMCA 511](#) Class 1A requirements. Outside air damper seals must be suitable for an operating temperature range of [-40 to +167 degrees F](#). Dampers must be rated at not less than [2000 ft/min](#) air velocity.

2.5.3.2 Mechanical Rooms and Other Utility Space Ventilation Dampers

Provide utility space ventilation dampers as indicated. Unless otherwise indicated provide [AMCA 511](#) class 3 dampers. Provide dampers rated at not less than [1500 ft/min](#) air velocity.

2.5.3.3 Smoke Dampers

Provide smoke-damper and actuator assemblies which meet the current requirements of [NFPA 90A](#), [UL 555](#), and [UL 555S](#). For combination fire and smoke dampers provide dampers rated for [250 degrees F](#) Class II leakage per [UL 555S](#).

2.6 SENSORS AND INSTRUMENTATION

Unless otherwise specified, provide sensors and instrumentation which incorporate an integral transmitter. Sensors and instrumentation, including their transmitters, must meet the specified accuracy and drift requirements at the input of the connected DDC Hardware's analog-to-digital conversion.

2.6.1 Analog and Binary Transmitters

Provide transmitters which match the characteristics of the sensor. Transmitters providing analog values must produce a linear 4-20 mAdc, 0-10 Vdc signal corresponding to the required operating range and must have zero and span adjustment. Transmitters providing binary values must have dry contacts rated at 1A at 24 Volts AC.

2.6.2 Network Transmitters

Sensors and Instrumentation incorporating an integral network connection are considered DDC Hardware and must meet the DDC Hardware requirements of Section [23 09 23.01](#) LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS when used in a Lonworks network, or the requirements of [23 09 23.02](#) BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS when used in a BACnet network.

2.6.3 Temperature Sensors

Provide the same sensor type throughout the project. Temperature sensors

may be provided without transmitters. Where transmitters are used, the range must be the smallest available from the manufacturer and suitable for the application such that the range encompasses the expected range of temperatures to be measured. The end to end accuracy includes the combined effect of sensitivity, hysteresis, linearity and repeatability between the measured variable and the end user interface (graphic presentation) including transmitters if used.

2.6.3.1 Sensor Accuracy and Stability of Control

2.6.3.1.1 Conditioned Space Temperature

Plus or minus 0.5 degree F over the operating range.

2.6.3.1.2 Unconditioned Space Temperature

- a. Plus or minus 1 degree F over the range of 30 to 131 degrees F AND
- b. Plus or minus 4 degrees F over the rest of the operating range.

2.6.3.1.3 Duct Temperature

Plus or minus 0.5 degree F

2.6.3.1.4 Outside Air Temperature

- a. Plus or minus 2 degrees F over the range of -30 to +130 degrees F AND
- b. Plus or minus 1 degree F over the range of 30 to 130 degrees F.

2.6.3.1.5 High Temperature Hot Water

Plus or minus 3.6 degrees F.

2.6.3.1.6 Chilled Water

Plus or minus 0.8 degrees F over the range of 35 to 65 degrees F.

2.6.3.1.7 Dual Temperature Water

Plus or minus 2 degrees F.

2.6.3.1.8 Heating Hot Water

Plus or minus 2 degrees F.

2.6.3.1.9 Condenser Water

Plus or minus 2 degrees F.

2.6.3.2 Transmitter Drift

The maximum allowable transmitter drift: 0.25 degrees F per year.

2.6.3.3 Point Temperature Sensors

Point Sensors must be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.

2.6.3.4 Temperature Sensor Details

2.6.3.4.1 Room Type

Provide the sensing element components within a decorative protective cover suitable for surrounding decor.

2.6.3.4.2 Duct Probe Type

Ensure the probe is long enough to properly sense the air stream temperature.

2.6.3.4.3 Duct Averaging Type

Continuous averaging sensors must be one foot in length for each 1 square foot of duct cross-sectional area, and a minimum length of 5 feet.

2.6.3.4.4 Pipe Immersion Type

For pipes with larger than 3 inch diameter, provide minimum 3 inch immersion. For pipes with less than 3 inch diameter, provide immersion at least half the diameter of the pipe. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells must be stainless steel when used in steel piping, and brass when used in copper piping.

2.6.3.4.5 Outside Air Type

Provide the sensing element rated for outdoor use

2.6.4 Relative Humidity Sensor

Relative humidity sensors must use bulk polymer resistive or thin film capacitive type non-saturating sensing elements capable of withstanding a saturated condition without permanently affecting calibration or sustaining damage. The sensors must include removable protective membrane filters. Where required for exterior installation, sensors must be capable of surviving below freezing temperatures and direct contact with moisture without affecting sensor calibration. When used indoors, the sensor must be capable of being exposed to a condensing air stream (100 percent relative humidity) with no adverse effect to the sensor's calibration or other harm to the instrument. The sensor must be of the wall-mounted or duct-mounted type, as required by the application, and must be provided with any required accessories. Sensors used in duct high-limit applications must have a bulk polymer resistive sensing element. Duct-mounted sensors must be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. Relative humidity (RH) sensors must measure relative humidity over a range of 0 percent to 100 percent with an accuracy of plus or minus 2 percent. RH sensors must function over a temperature range of 40 to 135 degrees F and must not drift more than 1 percent per year.

2.6.5 Carbon Dioxide (CO2) Sensors

Provide photometric type CO2 sensors with integral transducers and linear output. Carbon dioxide (CO2) sensors must measure CO2 concentrations between 0 to 2000 parts per million (ppm) using non-dispersible infrared (NDIR) technology with an accuracy of plus or minus 50 ppm and a maximum response time of 1 minute. The sensor must be rated for operation at

ambient air temperatures within the range of 32 to 122 degrees F and relative humidity within the range of 20 to 95 percent (non-condensing). The sensor must have a maximum drift of 2 percent per year. The sensor chamber must be manufactured with a non-corrosive material that does not affect carbon dioxide sample concentration. Duct mounted sensors must be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. The sensor must have a calibration interval no less than 5 years.

2.6.6 Differential Pressure Instrumentation

2.6.6.1 Differential Pressure Sensors

Provide Differential Pressure Sensors with ranges as indicated or as required for the application. Pressure sensor ranges must not exceed the high end range indicated on the Points Schedule by more than 50 percent. The over pressure rating must be a minimum of 150 percent of the highest design pressure of either input to the sensor. The accuracy must be plus or minus 1 percent of full scale. The sensor must have a maximum drift of 2 percent per year

2.6.6.2 Differential Pressure Switch

Provide differential pressure switches with a user-adjustable setpoint which are sized for the application such that the setpoint is between 25 percent and 75 percent of the full range. The over pressure rating must be a minimum of 150 percent of the highest design pressure of either input to the sensor. The switch must have two sets of contacts and each contact must have a rating greater than it's connected load. Contacts must open or close upon rise of pressure above the setpoint or drop of pressure below the setpoint as indicated.

2.6.7 Flow Sensors

2.6.7.1 Airflow Measurement Array (AFMA)

2.6.7.1.1 Airflow Straightener

Provide AFMAs which contain an airflow straightener if required by the AFMA manufacturer's published installation instructions. The straightener must be contained inside a flanged sheet metal casing, with the AFMA located as specified according to the published recommendation of the AFMA manufacturer. In the absence of published documentation, provide airflow straighteners if there is any duct obstruction within 5 duct diameters upstream of the AFMA. Air-flow straighteners, where required, must be constructed of 0.125 inch aluminum honeycomb and the depth of the straightener must not be less than 1.5 inches.

2.6.7.1.2 Resistance to Airflow

The resistance to air flow through the AFMA, including the airflow straightener must not exceed 0.085 inch water gauge at an airflow of 2,000 fpm. AFMA construction must be suitable for operation at airflows of up to 5000 fpm over a temperature range of 40 to 120 degrees F.

2.6.7.1.3 Outside Air Temperature

In outside air measurement or in low-temperature air delivery applications, provide an AFMA certified by the manufacturer to be accurate

as specified over a temperature range of 0 to +120 degrees F.

2.6.7.1.4 Pitot Tube AFMA

Each Pitot Tube AFMA must contain an array of velocity sensing elements. The velocity sensing elements must be of the multiple pitot tube type with averaging manifolds. The sensing elements must be distributed across the duct cross section in the quantity and pattern specified or recommended by the published installation instructions of the AFMA manufacturer.

- a. Pitot Tube AFMAs for use in airflows over 600 fpm must have an accuracy of plus or minus 5 percent over a range of 500 to 2500 fpm.
- b. Pitot Tube AFMAs for use in airflows under 600 fpm must have an accuracy of plus or minus 5 percent over a range of 125 to 2500 fpm.

2.6.7.1.5 Electronic AFMA

Each electronic AFMA must consist of an array of velocity sensing elements of the resistance temperature detector (RTD) or thermistor type. The sensing elements must be distributed across the duct cross section in the quantity and pattern specified or recommended by the published application data of the AFMA manufacturer. Electronic AFMAs must have an accuracy of plus or minus 5 percent over a range of 125 to 5,000 fpm and the output must be temperature compensated over a range of 32 to 212 degrees F.

2.6.7.1.6 Fan Inlet Measurement Devices

Fan inlet measurement devices cannot be used unless indicated on the drawings or schedules.

2.6.7.2 Orifice Plate

Orifice plate must be made of an austenitic stainless steel sheet of 0.125 inch nominal thickness with an accuracy of plus or minus 1 percent of full flow. The orifice plate must be flat within 0.002 inches. The orifice surface roughness must not exceed 20 micro-inches. The thickness of the cylindrical face of the orifice must not exceed 2 percent of the pipe inside diameter or 12.5 percent of the orifice diameter, whichever is smaller. The upstream edge of the orifice must be square and sharp. Where orifice plates are used, concentric orifice plates must be used in all applications except steam flow measurement in horizontal pipelines.

2.6.7.3 Flow Nozzle

Flow nozzle must be made of austenitic stainless steel with an accuracy of plus or minus 1 percent of full flow. The inlet nozzle form must be elliptical and the nozzle throat must be the quadrant of an ellipse. The thickness of the nozzle wall and flange must be such that distortion of the nozzle throat from strains caused by the pipeline temperature and pressure, flange bolting, or other methods of installing the nozzle in the pipeline must not cause the accuracy to degrade beyond the specified limit. The outside diameter of the nozzle flange or the design of the flange facing must be such that the nozzle throat must be centered accurately in the pipe.

2.6.7.4 Venturi Tube

Venturi tube must be made of cast iron or cast steel and must have an

accuracy of plus or minus 1 percent of full flow. The throat section must be lined with austenitic stainless steel. Thermal expansion characteristics of the lining must be the same as that of the throat casting material. The surface of the throat lining must be machined to a plus or minus 50 micro inch finish, including the short curvature leading from the converging entrance section into the throat.

2.6.7.5 Annular Pitot Tube

Annular pitot tube must be made of austenitic stainless steel with an accuracy of plus or minus 2 percent of full flow and a repeatability of plus or minus 0.5 percent of measured value. The unit must have at least one static port and no less than four total head pressure ports with an averaging manifold.

2.6.7.6 Insertion Turbine Flowmeter

Provide dual axial turbine flowmeter with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. All parts must meet or exceed the pressure classification of the pipe system it is installed in. Insertion Turbine Flowmeter accuracy must be plus or minus 0.5 percent of rate at calibrated velocity., within plus or minus of rate over a 10:1 turndown and within plus or minus 2 percent of rate over a 50:1 turndown. Repeatability must be plus or minus 0.25 percent of reading. The meter flow sensing element must operate over a range suitable for the installed location with a pressure loss limited to 1 percent of operating pressure at maximum flow rate. The flowmeter ,must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc outputs. The turbine rotor assembly must be constructed of Series 300 stainless steel and use Teflon seals.

2.6.7.7 Vortex Shedding Flowmeter

Vortex Shedding Flowmeter accuracy must be within plus or minus 0.8 percent of the actual reading over the range of the meter. Steam meters must contain density compensation by direct measurement of temperature. Mass flow inferred from specified steam pressure are not acceptable. The flow meter body must be made of austenitic stainless steel and include a weather tight NEMA 4X electronics enclosure. The vortex shedding flowmeter body must not require removal from the piping in order to replace the shedding sensor.

2.6.7.8 Ultrasonic Flow Meter

Provide Ultrasonic Flow Meters complete with matched transducers, self aligning installation hardware and transducer cables. Ultrasonic transducers must be optimized for the specific pipe and process conditions for the application. The flow meter accuracy must plus or minus 1 percent of rate from 0 to 40 ft/sec. The flowmeter must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc output.

2.6.7.9 Insertion Magnetic Flow Meter

Provide insertion type magnetic flowmeters with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. All parts must meet or exceed the pressure classification of the pipe system it is installed in. Flowmeter accuracy must be no greater than plus or minus 1 percent of rate from 2 to 20 feet/sec. Wetted material parts must be 300 series stainless steel. The flowmeter must

include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc outputs.

2.6.7.10 Positive Displacement Flow Meter

The flow meter must be a direct reading, gerotor, nutating disc or vane type displacement device rated for liquid service as indicated. A counter must be mounted on top of the meter, and must consist of a non-resettable mechanical totalizer for local reading, and a pulse transmitter for remote reading. The totalizer must have a six digit register to indicate the volume passed through the meter in gallons, and a sweep-hand dial to indicate down to 0.25 gallons. The pulse transmitter must have a hermetically sealed reed switch which is activated by magnets fixed on gears of the counter. The meter must have a bronze body with threaded or flanged connections as required for the application. Output accuracy must be plus or minus 2 percent of the flow range. The maximum pressure drop at full flow must be 5 psig.

2.6.7.11 Flow Meters, Paddle Type

Sensor must be non-magnetic, with forward curved impeller blades designed for water containing debris. Sensor accuracy must be plus or minus 1 percent of rate of flow, minimum operating flow velocity must be 1 foot per second. Sensor repeatability and linearity must be plus or minus 1 percent. Materials which will be wetted must be made from non-corrosive materials and must not contaminate water. The sensor must be rated for installation in pipes of 3 to 40 inch diameters. The transmitter housing must be a NEMA 250 Type 4 enclosure.

2.6.7.12 Flow Switch

Flow switch must have a repetitive accuracy of plus or minus 10 percent of actual flow setting. Switch actuation must be adjustable over the operating flow range, and must be sized for the application such that the setpoint is between 25 percent and 75 percent of the full range.. The switch must have Form C snap-action contacts, rated for the application. The flow switch must have non flexible paddle with magnetically actuated contacts and be rated for service at a pressure greater than the installed conditions. Flow switch for use in sewage system must be rated for use in corrosive environments encountered.

2.6.7.13 Gas Flow Meter

Gas flow meter must be diaphragm or bellows type (gas positive displacement meters) for flows up to 2500 SCFH and axial flow turbine type for flows above 2500 SCFH, designed specifically for natural gas supply metering, and rated for the pressure, temperature, and flow rates of the installation. Meter must have a minimum turndown ratio of 10 to 1 with an accuracy of plus or minus 1 percent of actual flow rate. The meter index must include a direct reading mechanical totalizing register and electrical impulse dry contact output for remote monitoring. The electrical impulse dry contact output must not require field adjustment or calibration. The electrical impulse dry contact output must have a minimum resolution of 100 cubic feet of gas per pulse and must not exceed 15 pulses per second at the design flow.

2.6.8 Electrical Instruments

Provide Electrical Instruments with an input range as indicated or sized

for the application. Unless otherwise specified, AC instrumentation must be suitable for 60 Hz operation.

2.6.8.1 Current Transducers

Current transducers must accept an AC current input and must have an accuracy of plus or minus 0.5 percent of full scale. The device must have a means for calibration. Current transducers for variable frequency applications must be rated for variable frequency operation.

2.6.8.2 Current Sensing Relays (CSRs)

Current sensing relays (CSRs) must provide a normally-open contact with a voltage and amperage rating greater than its connected load. Current sensing relays must be of split-core design. The CSR must be rated for operation at 200 percent of the connected load. Voltage isolation must be a minimum of 600 volts. The CSR must auto-calibrate to the connected load or be adjustable and field calibrated. Current sensors for variable frequency applications must be rated for variable frequency operation.

2.6.8.3 Voltage Transducers

Voltage transducers must accept an AC voltage input and have an accuracy of plus or minus 0.25 percent of full scale. The device must have a means for calibration. Line side fuses for transducer protection must be provided.

2.6.8.4 Energy Metering

2.6.8.4.1 Watt or Watthour Transducers

Watt transducers must measure voltage and current and must output kW or kWh or both kW and kWh as indicated. kW outputs must have an accuracy of plus or minus 0.5 percent over a power factor range of 0.1 to 1. kWh outputs must have an accuracy of plus or minus 0.5 percent over a power factor range of 0.1 to 1.

2.6.8.4.2 Watthour Revenue Meter (with and without Demand Register)

All Watthour revenue meters must measure voltage and current and must be in accordance with ANSI C12.1 with an ANSI C12.20 Accuracy class of 0.5 and must have pulse initiators for remote monitoring of Watthour consumption. Pulse initiators must consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets must be in accordance with NEMA/ANSI C12.10. Watthour revenue meters with demand registers must output instantaneous demand in addition to the pulse initiators.

2.6.8.4.3 Steam Meters

Steam meters must be the vortex type, with pressure compensation, a minimum turndown ratio of 10 to 1, and an output signal compatible with the DDC system.

2.6.8.4.4 Hydronic BTU Meters

The BTU meter is to be supplied with wall mount hardware and be capable of being installed remote from the flow meter. The BTU meter must include an

LCD display for local indication of energy rate and for display of parameters and settings during configuration. Each BTU meter must be factory configured for its specific application and be completely field configurable by the user via a front panel keypad (no special interface device or computer required). The unit must output Energy Rate, Energy Total, Flow Rate, Supply Temperature, and Return Temperature. An integral transmitter is to provide a linear analog or configurable pulse output signal representing the energy rate; and the signal must be compatible with building automation system DDC Hardware to which the output is connected.

2.6.9 pH Sensor

The sensor must be suitable for applications and chemicals encountered in water treatment systems of boilers, chillers and condenser water systems. Construction, wiring, fittings and accessories must be corrosion and chemical resistant with fittings for tank or suspension installation. Housing must be polyvinylidene fluoride with O-rings made of chemical resistant materials which do not corrode or deteriorate with extended exposure to chemicals. The sensor must be encapsulated. Periodic replacement must not be required for continued sensor operation. Sensors must use a ceramic junction and pH sensitive glass membrane capable of withstanding a pressure of 100 psig at 150 degrees F. The reference cell must be double junction configuration. Sensor range must be 0 to 12 pH, stability 0.05, sensitivity 0.02, and repeatability of plus or minus 0.05 pH value, response of 90 percent of full scale in one second and a linearity of 99 percent of theoretical electrode output measured at 76 degrees F.

2.6.10 Oxygen Analyzer

Oxygen analyzer must consist of a zirconium oxide sensor for continuous sampling and an air-powered aspirator to draw flue gas samples. The analyzer must be equipped with filters to remove flue air particles. Sensor probe temperature rating must be 815 degrees F. The sensor assembly must be equipped for flue flange mounting.

2.6.11 Carbon Monoxide Analyzer

Carbon monoxide analyzer must consist of an infrared light source in a weather proof steel enclosure for duct or stack mounting. An optical detector/analyzer in a similar enclosure, suitable for duct or stack mounting must be provided. Both assemblies must include internal blower systems to keep optical windows free of dust and ash at all times. The third component of the analyzer must be the electronics cabinet. Automatic flue gas temperature compensation and manual/automatic zeroing devices must be provided. Unit must read parts per million (ppm) of carbon monoxide in the range of 0 to 600 ppm and the response time must be less than 3 seconds to 90 percent value. Unit measurement range must not exceed specified range by more than 50 percent. Repeatability must be plus or minus 1 percent of full scale with an accuracy of plus or minus 1 percent of full scale.

2.6.12 Occupancy Sensors

Occupancy sensors must have occupancy-sensing sensitivity adjustment and an adjustable off-delay timer with a setpoint of 15 minutes. Adjustments accessible from the face of the unit are preferred. Occupancy sensors must be rated for operation in ambient air temperatures ranging from 40 to

95 degrees F or temperatures normally encountered in the installed location. Sensors integral to wall mount on-off light switches must have an auto-off switch. Wall switch sensors must be decorator style and must fit behind a standard decorator type wall plate. All occupancy sensors, power packs, and slave packs must be UL listed. In addition to any outputs required for lighting control, the occupancy sensor must provide an output for the HVAC control system.

2.6.12.1 Passive Infrared (PIR) Occupancy Sensors

PIR occupancy sensors must have a multi-level, multi-segmented viewing lens and a conical field of view with a viewing angle of 180 degrees and a detection of at least 20 feet unless otherwise indicated or specified. PIR Sensors must provide field-adjustable background light-level adjustment with an adjustment range suitable to the light level in the sensed area, room or space. PIR sensors must be immune to false triggering from RFI and EMI.

2.6.12.2 Ultrasonic Occupancy Sensors

Ultrasonic sensors must operate at a minimum frequency 32 kHz and must be designed to not interfere with hearing aids.

2.6.12.3 Dual-Technology Occupancy Sensor (PIR and Ultrasonic)

Dual-Technology Occupancy Sensors must meet the requirements of both PIR and Ultrasonic Occupancy Sensors.

2.6.13 Vibration Switch

Vibration switch must be solid state, enclosed in a NEMA 250 Type 4 or Type 4X housing with sealed wire entry. Unit must have two independent sets of Form C switch contacts with one set to shutdown equipment upon excessive vibration and a second set for monitoring alarm level vibration. The vibration sensing range must be a true rms reading, suitable for the application. The unit must include either displacement response for low speed or velocity response for high speed application. The frequency range must be at least 3 Hz to 500 Hz. Contact time delay must be 3 seconds. The unit must have independent start-up and running delay on each switch contact. Alarm limits must be adjustable and setpoint accuracy must be plus or minus 10 percent of setting with repeatability of plus or minus 2 percent.

2.6.14 Conductivity Sensor

Sensor must include local indicating meter and must be suitable for measurement of conductivity of water in boilers, chilled water systems, condenser water systems, distillation systems, or potable water systems as indicated. Sensor must sense from 0 to 10 microSeimens per centimeter ($\mu\text{S}/\text{cm}$) for distillation systems, 0 to 100 $\mu\text{S}/\text{cm}$ for boiler, chilled water, and potable water systems and 0 to 1000 $\mu\text{S}/\text{cm}$ for condenser water systems. Contractor must field verify the ranges for particular applications and adjust the range as required. The output must be temperature compensated over a range of 32 to 212 degrees F. The accuracy must be plus or minus 2 percent of the full scale reading. Sensor must have automatic zeroing and must require no periodic maintenance or recalibration.

2.6.15 Compressed Air Dew Point Sensor

Sensor must be suitable for measurement of dew point from -40 +80 degrees F over a pressure range of 0 to 150 psig. The transmitter must provide both dry bulb and dew point temperatures on separate outputs. The end to end accuracy of the dew point must be plus or minus 5 degrees F and the dry bulb must be plus or minus 1 degree F. Sensor must be automatic zeroing and must require no normal maintenance or periodic recalibration.

2.6.16 NOx Monitor

Monitor must continuously monitor and give local indication of boiler stack gas for NOx content. It must be a complete system designed to verify compliance with the Clean Air Act standards for NOx normalized to a 3 percent oxygen basis and must have a range of from 0 to 100 ppm. Sensor must be accurate to plus or minus 5 ppm. Sensor must output NOx and oxygen levels and binary output that changes state when the NOx level is above a locally adjustable NOx setpoint. Sensor must have normal, trouble and alarm lights. Sensor must have heat traced lines if the stack pickup is remote from the sensor. Sensor must be complete with automatic zero and span calibration using a timed calibration gas system, and must not require periodic maintenance or recalibration.

2.6.17 Turbidity Sensor

Sensor must include a local indicating meter and must be suitable for measurement of turbidity of water. Sensor must sense from 0 to 1000 Nephelometric Turbidity Units (NTU). Range must be field-verified for the particular application and adjusted as required. The output must be temperature compensated over a range of 32 to 212 degrees F. The accuracy must be plus or minus 5 percent of full scale reading. Sensor must have automatic zeroing and must not require periodic maintenance or recalibration.

2.6.18 Chlorine Detector

The detector must measure concentrations of chlorine in water in the range 0 to 20 ppm with a repeatability of plus or minus 1 percent of full scale and an accuracy of plus or minus 2 percent of full scale. The Chlorine Detector transmitter must be housed in a non-corrosive NEMA 250 Type 4X enclosure. Detector must include a local panel with adjustable alarm trip level, local audio and visual alarm with silence function.

2.6.19 Floor Mounted Leak Detector

Leak detectors must use electrodes mounted at slab level with a minimum built-in-vertical adjustment of 0.125 inches. Detector must have a binary output. The indicator must be manual reset type.

2.6.20 Temperature Switch

2.6.20.1 Duct Mount Temperature Low Limit Safety Switch (Freezestat)

Duct mount temperature low limit switches (Freezestats) must be manual reset, low temperature safety switches at least 1 foot long per square foot of coverage which must respond to the coldest 18 inch segment with an accuracy of plus or minus 3.6 degrees F. The switch must have a field-adjustable setpoint with a range of at least 30 to 50 degrees F. The switch must have two sets of contacts, and each contact must have a

rating greater than its connected load. Contacts must open or close upon drop of temperature below setpoint as indicated and must remain in this state until reset.

2.6.20.2 Pipe Mount Temperature Limit Switch (Aquastat)

Pipe mount temperature limit switches (aquastats) must have a field adjustable setpoint between 60 and 90 degrees F, an accuracy of plus or minus 3.6 degrees F and a 10 degrees F fixed deadband. The switch must have two sets of contacts, and each contact must have a rating greater than its connected load. Contacts must open or close upon change of temperature above or below setpoint as indicated.

2.6.21 Damper End Switches

Each end switch must be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure must be suitable for mounting on the duct exterior and must permit setting the position of the trip lever that actuates the switch. The trip lever must be aligned with the damper blade.

End switches integral to an electric damper actuator are allowed as long as at least one is adjustable over the travel of the actuator.

2.6.22 Air Quality Sensors

Provide full spectrum air quality sensors using a hot wire element based on the Taguchi principle. The sensor must monitor a wide range of gaseous volatile organic components common in indoor air contaminants like paint fumes, solvents, cigarette smoke, and vehicle exhaust. The sensor must automatically compensate for temperature and humidity, have span and calibration potentiometers, operate on 24 VDC power with output of 0-10 VDC, and have a service rating of 32 to 140 degrees F and 5 to 95 percent relative humidity.

2.7 INDICATING DEVICES

All indicating devices must display readings in English (inch-pound) units.

2.7.1 Thermometers

Provide bi-metal type thermometers at locations indicated. Thermometers must have either 9 inch long scales or 3.5 inch diameter dials, with insertion, immersion, or averaging elements. Provide matching thermowells for pipe-mounted installations. Select scale ranges suitable for the intended service, with the normal operating temperature near the scale's midpoint. The thermometer's accuracy must be plus or minus 2 percent of the scale range.

2.7.1.1 Piping System Thermometers

Piping system thermometers must 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 9 inch scale. Piping system thermometers must have an accuracy of plus or minus 1 percent of scale range. Thermometers for piping systems must have rigid stems with straight, angular, or inclined pattern. Thermometer stems must have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem

must be filled with a heat-transfer medium.

2.7.1.2 Air-Duct Thermometers

Air-duct thermometers must have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.7.2 Pressure Gauges

Provide pipe-mounted pressure gauges at the locations indicated. Gauges must conform to ASME B40.100 and have a 4 inch diameter dial and shutoff cock. Select scale ranges suitable for the intended service, with the normal operating pressure near the scale's midpoint. The gauge's accuracy must be plus or minus 2 percent of the scale range.

Gauges must be suitable for field or panel mounting as required, must have black legend on white background, and must have a pointer traveling through a 270-degree arc. Gauge range must be suitable for the application with an upper end of the range not to exceed 150 percent of the design upper limit. Accuracy must be plus or minus 3 percent of scale range. Gauges must meet requirements of ASME B40.100.

2.7.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements must be a minimum of 3.5 inch (nominal) size with two sets of pressure taps, and must have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauge range must be suitable for the application with an upper end of the range not to exceed 150 percent of the design upper limit. Accuracy must be plus or minus two percent of scale range.

2.8 OUTPUT DEVICES

2.8.1 Actuators

Actuators must be electric (electronic) . All actuators must be normally open (NO), normally closed (NC) or fail-in-last-position (FILP) as indicated. Normally open and normally closed actuators must be of mechanical spring return type. Electric actuators must have an electronic cut off or other means to provide burnout protection if stalled. Actuators must have a visible position indicator. Electric actuators must provide position feedback to the controller as indicated. Actuators must smoothly and fully open or close the devices to which they are applied. Electric actuators must have a full stroke response time in both directions of 90 seconds or less at rated load. Electric actuators must be of the foot-mounted type with an oil-immersed gear train or the direct-coupled type. Where multiple electric actuators operate from a common signal, the actuators must provide an output signal identical to its input signal to the additional devices. All actuators must be rated for their operating environment. Actuators used outdoors must be designed and rated for outdoor use. Actuators under continuous exposure to water, such as those used in sumps, must be submersible.

Actuators incorporating an integral network connection are considered DDC Hardware and must meet the DDC Hardware requirements of Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

2.8.1.1 Valve Actuators

Valve actuators must provide shutoff pressures and torques as indicated on the Valve Schedule.

2.8.1.2 Damper Actuators

Damper actuators must provide the torque necessary per damper manufacturer's instructions to modulate the dampers smoothly over its full range of operation and torque must be at least 6 inch-pounds/1 square foot of damper area for opposed blade dampers and 9 inch-pounds/1 square foot of damper area for parallel blade dampers.

2.8.1.3 Electric Actuators

Each actuator must have distinct markings indicating the full-open and full-closed position. Each actuator must deliver the torque required for continuous uniform motion and must have internal end switches to limit the travel, or be capable of withstanding continuous stalling without damage. Actuators must function properly within 85 to 110 percent of rated line voltage. Provide actuators with hardened steel running shafts and gears of steel or copper alloy. Fiber or reinforced nylon gears may be used for torques less than 16 inch-pounds..

- a. Two-position actuators must be single direction, spring return, or reversing type. Two position actuator signals may either be the control power voltage or line voltage as needed for torque or appropriate interlock circuits.
- b. Modulating actuators must be capable of stopping at any point in the cycle, and starting in either direction from any point. Actuators must be equipped with a switch for reversing direction, and a button to disengage the clutch to allow manual adjustments. Provide the actuator with a hand crank for manual adjustments, as applicable. Modulating actuator input signals can either be a 4 to 20 mAdc or a 0-10 VDC signal.
- c. Floating or pulse width modulation actuators are acceptable for non-fail safe applications unless indicated otherwise provided that the floating point control (timed actuation) must have a scheduled re-calibration of span and position no more than once a day and no less than once a week. The schedule for the re-calibration should not affect occupied conditions and be staggered between equipment to prevent falsely loading or unloading central plant equipment.

2.8.2 Solenoid-Operated Electric to Pneumatic Switch (EPS)

Solenoid-Operated Electric to Pneumatic Switches (EPS) must accept a voltage input to actuate its air valve. Each valve must have three-port operation: common, normally open, and normally closed. Each valve must have an outer cast aluminum body and internal parts of brass, bronze, or stainless steel. The air connection must be a 0.38 inch NPT threaded connection. Valves must be rated for 50 psig.

2.8.3 Electric to Pneumatic Transducers (EP)

Electric to Pneumatic Transducers (EPs) must convert either a 4-20 mAdc input signal, a 0-10 Vdc input signal to a proportional 0 to 20 psig pneumatic output. The EP must withstand pressures at least 150 percent of

the system supply air pressure (main air). EPs must include independent offset and span adjustment. Steady state air consumption must not be greater than 0.05 scfm. EPs must have a manual adjustable override for the EP pneumatic output. EPs must have sufficient output capacity to provide full range stroke of the actuated device in both directions within 90 seconds.

2.8.4 Relays

Relays must have contacts rated for the intended application, indicator light, and dust proof enclosure. The indicator light must be lit when the coil is energized and off when coil is not energized.

Control relay contacts must have utilization category and ratings selected for the application. Each set of contacts must incorporate a normally open (NO), normally closed (NC) and common contact. Relays must be rated for a minimum life of one million operations.

2.9 USER INPUT DEVICES

User Input Devices, including potentiometers, switches and momentary contact push-buttons. Potentiometers must be of the thumb wheel or sliding bar type. Momentary Contact Push-Buttons may include an adjustable timer for their output. User input devices must be labeled for their function.

2.10 MULTIFUNCTION DEVICES

Multifunction devices are products which combine the functions of multiple sensor, user input or output devices into a single product. Unless otherwise specified, the multifunction device must meet all requirements of each component device. Where the requirements for the component devices conflict, the multifunction device must meet the most stringent of the requirements.

2.10.1 Current Sensing Relay Command Switch

The Current Sensing Relay portion must meet all requirements of the Current Sensing Relay input device. The Command Switch portion must meet all requirements of the Relay output device except that it must have at least one normally-open (NO) contact.

Current Sensing Relays used for Variable Frequency Drives must be rated for Variable Frequency applications unless installed on the source side of the drive. If used in this situation, the threshold for showing status must be set to allow for the VFD's control power when the drive is not enabled and provide indication of operation when the drive is enabled at minimum speed.

2.10.2 Space Sensor Module

Space Sensor Modules must be multifunction devices incorporating a temperature sensor and one or more of the following as specified and indicated on the Space Sensor Module Schedule:

- a. A temperature indicating device.
- b. A User Input Device which must adjust a temperature setpoint output.

- c. A User Input Momentary Contact Button and an output to the control system indicating zone occupancy.
- d. A three position User Input Switch labeled to indicate heating, cooling and off positions ('HEAT-COOL-OFF' switch) and providing corresponding outputs to the control system.
- e. A two position User Input Switch labeled with 'AUTO' and 'ON' positions and providing corresponding output to the control system..
- f. A multi-position User Input Switch with 'OFF' and at least two fan speed positions and providing corresponding outputs to the control system.

Space Sensor Modules cannot contain mercury (Hg).

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 General Installation Requirements

Perform the installation under the supervision of competent technicians regularly employed in the installation of DDC systems.

3.1.1.1 Device Mounting Criteria

All devices must be installed in accordance with manufacturer's recommendations and as specified and indicated. Control devices to be installed in piping and ductwork must be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements must not be used except as specified. Spare thermowells must be installed adjacent to each thermowell containing a sensor and as indicated. Devices located outdoors must have a weathershield.

3.1.1.2 Labels and Tags

Match labels and tags to the unique identifiers indicated on the As-Built drawings. Label all enclosures and instrumentation. Tag all sensors and actuators in mechanical rooms. Tag airflow measurement arrays to show flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient. Tag duct static pressure taps at the location of the pressure tap. Provide plastic or metal tags, mechanically attached directly to each device or attached by a metal chain or wire. Labels exterior to protective enclosures must be engraved plastic and mechanically attached to the enclosure or instrumentation. Labels inside protective enclosures may attached using adhesive, but must not be hand written.

3.1.2 Weathershield

Provide weathershields for sensors located outdoors. Install weathershields such that they prevent the sun from directly striking the sensor and prevent rain from directly striking or dripping onto the sensor. Install weather shields with adequate ventilation so that the sensing element responds to the ambient conditions of the surroundings. When installing weathershields near outside air intake ducts, install them

such that normal outside air flow does not cause rainwater to strike the sensor.

3.1.3 Room Instrument Mounting

Mount room instruments, including but not limited to wall mounted non-adjustable space sensor modules and sensors located in occupied spaces, **48 inches** above the floor unless otherwise indicated. Install adjustable devices to be ADA compliant unless otherwise indicated on the Room Sensor Schedule:

- a. Space Sensor Modules for Fan Coil Units may be either unit or wall mounted but not mounted on an exterior wall.
- b. Wall mount all other Space Sensor Modules.

3.1.4 Indication Devices Installed in Piping and Liquid Systems

Provide snubbers for gauges in piping systems subject to pulsation. For gauges for steam service use pigtail fittings with cock. Install thermometers and temperature sensing elements in liquid systems in thermowells. Provide spare Pressure/Temperature Ports (Pete's Plug) for all temperature and pressure sensing elements installed in liquid systems for calibration/testing.

3.1.5 Occupancy Sensors

Provide a sufficient quantity of occupancy sensors to provide complete coverage of the area (room or space). Occupancy sensors are to be ceiling mounted. Install occupancy sensors in accordance with **NFPA 70** requirements and the manufacturer's instructions. Do not locate occupancy sensors within **6 feet** of HVAC outlets or heating ducts, or where they can "see" beyond any doorway. Installation above doorway(s) is preferred. Do not use ultrasonic sensors in spaces containing ceiling fans. Install sensors to detect motion to within **2 feet** of all room entrances and to not trigger due to motion outside the room. Set the off-delay timer to 15 minutes unless otherwise indicated. Adjust sensors prior to beneficial occupancy, but after installation of furniture systems, shelving, partitions, etc. For each controlled area, provide one hundred percent coverage capable of detecting small hand-motion movements, accommodating all occupancy habits of single or multiple occupants at any location within the controlled room.

3.1.6 Switches

3.1.6.1 Temperature Limit Switch

Provide a temperature limit switch (freezestat) to sense the temperature at the location indicated. Provide a sufficient number of temperature limit switches (freezestats) to provide complete coverage of the duct section but no less than **1 foot** in length per **square foot** of cross sectional area. Install manual reset limit switches in approved, accessible locations where they can be reset easily. Install temperature limit switch (freezestat) sensing elements in a side-to-side (not top-to-bottom) serpentine pattern with the relay section at the highest point and in accordance with the manufacturer's installation instructions.

3.1.6.2 Hand-Off Auto Switches

Wire safety controls such as smoke detectors and freeze protection thermostats to protect the equipment during both hand and auto operation.

3.1.7 Temperature Sensors

Install temperature sensors in locations that are accessible and provide a good representation of sensed media. Installations in dead spaces are not acceptable. Calibrate and install sensors according to manufacturer's instructions. Select sensors only for intended application as designated or recommended by manufacturer.

3.1.7.1 Room Temperature Sensors

Mount the sensors on interior walls to sense the average room temperature at the locations indicated. Avoid locations near heat sources such as copy machines or locations by supply air outlet drafts. Mount the center of all user-adjustable sensors 48 inches above the floor to meet ADA requirements. Non user-adjustable sensors can be mounted as indicated in paragraph ROOM INSTRUMENT MOUNTING.

3.1.7.2 Duct Temperature Sensors

3.1.7.2.1 Probe Type

Place tip of the sensor in the middle of the airstream or in accordance with manufacturer's recommendations or instructions. Provide a gasket between the sensor housing and the duct wall. Seal the duct penetration air tight. When installed in insulated duct, provide enclosure or stand off fitting to accommodate the thickness of duct insulation to allow for maintenance or replacement of the sensor and wiring terminations. Seal the duct insulation penetration vapor tight.

3.1.7.2.2 Averaging Type

Weave the sensing element in a serpentine fashion from side to side perpendicular to the flow, across the duct or air handler cross-section, using durable non-metal supports in accordance with manufacturer's installation instructions. Avoid tight radius bends or kinking of the sensing element. Prevent contact between the sensing element and the duct or air handler internals. Provide a duct access door at the sensor location. The access door must be hinged on the side, factory insulated, have cam type locks, and be as large as the duct will permit, maximum 18 by 18 inches. For sensors inside air handlers, the sensors must be fully accessible through the air handler's access doors without removing any of the air handler's internals.

3.1.7.3 Immersion Temperature Sensors

Provide thermowells for sensors measuring piping, tank, or pressure vessel temperatures. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. When installed on insulated piping, provide stand enclosure or stand off fitting to accommodate the thickness of the pipe insulation and allow for maintenance or replacement of the sensor or wiring terminations. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to sense flow across entire area of well. Wells must not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to

avoid restriction. Provide the sensor well with a heat-sensitive transfer agent between the sensor and the well interior ensuring contact between the sensor and the well.

3.1.7.4 Outside Air Temperature Sensors

Provide outside air temperature sensors on the building's north side with a protective weather shade that does not inhibit free air flow across the sensing element, and protects the sensor from snow, ice, and rain. Location must not be near exhaust hoods and other areas such that it is not influenced by radiation or convection sources which may affect the reading. Provide a shield to shade the sensor from direct sunlight.

3.1.8 Air Flow Measurement Arrays (AFMA)

Locate Outside Air AFMAs downstream from the Outside Air filters.

Install AFMAs with the manufacturer's recommended minimum distances between upstream and downstream disturbances. Airflow straighteners may be used to reduce minimum distances as recommended by the AFMA manufacturer.

3.1.9 Duct Static Pressure Sensors

Locate the duct static pressure sensing tap at 75 percent of the distance between the first and last air terminal units. If the transmitter output is a 0-10Vdc signal, locate the transmitter in the same enclosure as the air handling unit (AHU) controller for the AHU serving the terminal units. If a remote duct static pressure sensor is to be used, run the signal wire back to the controller for the air handling unit.

3.1.10 Relative Humidity Sensors

Install relative humidity sensors in supply air ducts at least 10 feet downstream of humidity injection elements.

3.1.11 Meters

3.1.11.1 Flowmeters

Install flowmeters to ensure minimum straight unobstructed piping for at least 10 pipe diameters upstream and at least 5 pipe diameters downstream of the flowmeter, and in accordance with the manufacturer's installation instructions.

3.1.11.2 Energy Meters

Locate energy meters as indicated. Connect each meter output to the DDC system, to measure both instantaneous demand/energy and other variables as indicated.

3.1.12 Dampers

3.1.12.1 Damper Actuators

Provide spring return actuators which fail to a position that protects the served equipment and space on all control dampers related to freeze protection or force protection. For all outside, makeup and relief dampers provide dampers which fail closed. Terminal fan coil units,

terminal VAV units, convectors, and unit heaters may be non-spring return unless indicated otherwise. Do not mount actuators in the air stream. Do not connect multiple actuators to a common drive shaft. Install actuators so that their action seal the damper to the extent required to maintain leakage at or below the specified rate and so that they move the blades smoothly throughout the full range of motion.

3.1.12.2 Damper Installation

Install dampers straight and true, level in all planes, and square in all dimensions. Dampers must move freely without undue stress due to twisting, racking (parallelogramming), bowing, or other installation error. External linkages must operate smoothly over the entire range of motion, without deformation or slipping of any connecting rods, joints or brackets that will prevent a return to it's normal position. Blades must close completely and leakage must not exceed that specified at the rated static pressure. Provide structural support for multi-section dampers. Acceptable methods of structural support include but are not limited to U-channel, angle iron, corner angles and bolts, bent galvanized steel stiffeners, sleeve attachments, braces, and building structure. Where multi-section dampers are installed in ducts or sleeves, they must not sag due to lack of support. Do not use jackshafts to link more than three damper sections. Do not use blade to blade linkages. Install outside and return air dampers such that their blades direct their respective air streams towards each other to provide for maximum mixing of air streams.

3.1.13 Valves

Install the valves in accordance with the manufacturer's instructions.

3.1.13.1 Valve Actuators

Provide spring return actuators on all control valves where freeze protection is required. Spring return actuators for terminal fan coil units, terminal VAV units, convectors, and unit heaters are not required unless indicated otherwise.

3.1.14 Thermometers and Gauges

3.1.14.1 Thermometers

Mount devices to allow reading while standing on the floor or ground, as applicable.

3.1.15 Wire and Cable

Provide complete electrical wiring for the Control System, including wiring to transformer primaries. Wire and Cable must be installed without splices between control devices and in accordance with NFPA 70 and NFPA 90A. Instrumentation grounding must be installed per the device manufacturer's instructions and as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Test installed ground rods as specified in IEEE 142. Cables and conductor wires must be tagged at both ends, with the identifier indicated on the shop drawings. Electrical work must be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as indicated. Wiring external to enclosures must be run in raceways, except low-voltage control and low-voltage network wiring may be installed as follows:

- a. plenum rated cable in suspended ceilings over occupied spaces may be run without raceways
- b. nonmetallic-sheathed cables or metallic-armored cables may be installed as permitted by NFPA 70.

Install control circuit wiring not in raceways in a neat and safe manner. Wiring must not use the suspended ceiling system (including tiles, frames or hangers) for support. Where conduit or raceways are required, control circuit wiring must not run in the same conduit/raceway as power wiring over 50 volts. Run all circuits over 50 volts in conduit, metallic tubing, covered metal raceways, or armored cable.

3.1.16 Copper Tubing

Provide hard-drawn copper tubing in exposed areas and either hard-drawn or annealed copper tubing in concealed areas. Use only tool-made bends. Use only brass or copper solder joint type fittings, except for connections to apparatus. For connections to apparatus use brass compression type fittings.

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SECTION 23 09 23.01

LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

Provide a complete Direct Digital Control (DDC) system, except for the Front End which is specified in Section 25 10 10 UTILITY MONITORING AND CONTROL (UMCS) FRONT END AND INTEGRATION, suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and shown and in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.1.1 System Requirements

Provide a system meeting the requirements of both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section and with the following characteristics:

- a. The control system must be an open implementation of LonWorks technology using CEA-709.1-D as the communications protocol. The system must use LonMark Standard Network Variable Types as defined in LonMark SNVT List exclusively for communication over the network.

The control system must be an open implementation of LonWorks technology using CEA-709.1-D and Fox as the communications protocols. Except for communication between Niagara Framework components (between Niagara Framework Supervisory Gateways or between a Niagara Framework Supervisory Gateway and a Niagara Framework Front End) which must use the Fox Protocol, the system must use LonMark Standard Network Variable Types as defined in LonMark SNVT List exclusively for communication over the network.

- b. Use LonWorks Network Services (LNS) for all network management including addressing and binding of network variables. As specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC, submit copies of the complete, fully-commissioned, valid, as-built Final LNS database, including all LNS credits, for the complete control system provided under this specification. All devices must be on-line and commissioned into the LNS database.

Use the Niagara Framework for all network management including addressing and binding of network variables. Each Niagara Framework Supervisory Gateway must contain a database for all controllers connected to its non-IP ports.

- c. Install and configure control hardware, except as specified for Niagara Framework Supervisory Gateways, to provide all input and output Standard Network Variables (SNVTs) as indicated and as needed to meet the requirements of this specification. Points in Niagara Framework Supervisory Gateways which do not communicate with non-Niagara Framework DDC Hardware may be exposed via Fox instead.

- d. All DDC hardware installed under this specification must communicate via **CEA-709.1-D**, and Niagara Framework Supervisory Gateways must also communicate over the IP network via Fox. Install the control system such that a SNVT output from any node on the network can be bound to any other node in the same domain.
- e. Use **Niagara Framework** hardware and software exclusively for alarming, scheduling, trending, and communication with a front end (UMCS). Use the Fox protocol for all communication between Niagara Framework Supervisory Gateways; use the **CEA-709.1-D** protocol for all other building communication.
- f. Use Niagara Framework either AX or Version 4.0 or later.

1.1.2 Verification of Specification Requirements

Review all specifications related to the control system installation and advise the Contracting Officer of any discrepancies before performing any work. If Section **23 09 00** INSTRUMENTATION AND CONTROL FOR HVAC or any other Section referenced in this specification is not included in the project specifications advise the Contracting Officer and either obtain the missing Section or obtain Contracting Officer approval before performing any work.

1.2 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.

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1-D	(2014) Control Network Protocol Specification
CEA-709.3	(1999; R 2015) Free-Topology Twisted-Pair Channel Specification
CEA-852-C	(2014) Tunneling Device Area Network Protocols Over Internet Protocol Channels

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.3	(2022) Ethernet

INTERNET ENGINEERING TASK FORCE (IETF)

IETF RFC 4361	(2006) Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)

LONMARK INTERNATIONAL (LonMark)

LonMark Interoperability Guide	(2005) LonMark Application-Layer Interoperability Guide and LonMark Layer 1-6 Interoperability Guide; Version 3.4
LonMark SCPT List	(2014) LonMark SCPT Master List; Version 15

LonMark SNVT List (2014) LonMark SNVT Master List; Version 15

LonMark XIF Guide (2001) LonMark External Interface File
Reference Guide; Revision 4.402

TRIDIUM, INC (TRIDIUM)

Niagara Framework (2012) NiagaraAX User's Guide

Tridium Open NiCS (2005) Understanding the NiagaraAX
Compatibility Statement (NiCS)

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15 Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 916 (2015; Reprint Oct 2021) UL Standard for
Safety Energy Management Equipment

1.3 DEFINITIONS

For definitions related to this section, see Section 23 09 00
INSTRUMENTATION AND CONTROL FOR HVAC.

1.4 SUBMITTALS

Submittals related to this Section are specified in Section 23 09 00
INSTRUMENTATION AND CONTROL FOR HVAC.

PART 2 PRODUCTS

All products used to meet this specification must meet the specified requirements, but not all products specified here will be required by every project. Provide products which meet the requirements of both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section.

2.1 NETWORK HARDWARE

2.1.1 CEA-709.1-D Routers

CEA-709.1-D Routers must meet the requirements of CEA-709.1-D and must provide connection between two or more CEA-709.3 TP/FT-10 channels, or between one or more CEA-709.3 TP/FT-10 channels and a LonMark Interoperability Guide TP/XF-1250 channel.

2.1.2 CEA-709.1-D Repeaters

CEA-709.1-D Repeaters must be CEA-709.1-D Routers configured as repeaters. Physical layer repeaters are prohibited.

2.1.3 CEA-709.1-D Gateways

In addition to the requirements for DDC Hardware, CEA-709.1-D gateways must be a Niagara Framework Supervisory Gateway or must:

- a. Allow bi-directional mapping of data between the non-CEA-709.1-D protocol and SNVTs

- b. Incorporate a network connection to a TP/FT-10 network in accordance with CEA-709.3 and a separate connection appropriate for the a non-CEA-709.1-D network

Although Gateways must meet DDC Hardware requirements, except for Niagara Framework Supervisory Gateways, they are not DDC Hardware and must not be used when DDC Hardware is required. (Niagara Framework Supervisory Gateways are both Gateways and DDC Hardware.)

2.1.4 CEA-852-C Router

CEA-852-C Routers must perform layer 3 routing of CEA-709.1-D packets over an IP network in accordance with CEA-852-C. The router must provide the appropriate connection to the IP network and connections to the CEA-709.3 TP/FT-10 or LonMark Interoperability Guide TP/XF-1250 network. CEA-852-C Routers must support the Dynamic Host Configuration Protocol (DHCP; IETF RFC 4361 for IP configuration and the use of an CEA-852-C Configuration Server (for CEA-852-C configuration), but must not rely on these services for configuration. CEA-852-C Routers must be capable of manual configuration via a console RS-232 or USB port.

2.1.5 Ethernet Switch

Ethernet Switches must be managed switches and must autoconfigure between 10,100 and 1000 megabits per second (MBPS).

2.2 CONTROL NETWORK WIRING

- a. Provide TP/FT-10 control wiring in accordance with CEA-709.3.
- b. Provide TP/XF-1250 control wiring in accordance with the LonMark Interoperability Guide.
- c. For the Building Control Network IP Network provide media that is CAT-5e Ethernet media at a minimum and meets all requirements of IEEE 802.3 .

2.3 DIRECT DIGITAL CONTROL (DDC) HARDWARE

All DDC Hardware must meet the following general requirements:

- a. Except for Niagara Framework Supervisory Gateways, it must incorporate a "service pin" which, when pressed will cause the DDC Hardware to broadcast its 48-bit NodeID and its ProgramID over the network. The service pin must be distinguishable and accessible.
- b. It must incorporate a light to indicate the device is receiving power.
- c. Except for Niagara Framework Supervisory Gateways, it must incorporate a TP/FT-10 transceiver in accordance with CEA-709.3 and connections for TP/FT-10 control network wiring. Niagara Framework Supervisory Gateways must incorporate an IP connection and at least one other transceiver. These other transceivers must be either a TP/FT-10 transceiver in accordance with CEA-709.3 or a TP/XF-1250 transceiver in accordance with LonMark Interoperability Guide. Niagara Framework Supervisory gateways must have connection of the appropriate type for each transceiver.

- d. It must communicate on the network using only the CEA-709.1-D protocol or the Fox protocol.
- e. It must be capable of having network communications configured via LNS the Niagara Framework.
- f. It must be locally powered; link powered devices are not acceptable.
- g. LonMark external interface files (XIF files), as defined in the LonMark XIF Guide, must be submitted for each type of DDC Hardware except Niagara Framework Supervisory Gateways.
- h. Application programs and configuration settings must be stored in a manner such that a loss of power does not result in a loss of the application program or configuration settings:
 - (1) Loss of power must never result in the loss of application programs, regardless of the length of time power is lost.
 - (2) Loss of power for less than 2,500 hours must not result in the loss of configured settings.
- i. It must have all functionality specified and required to support the application (Sequence of Operation or portion thereof) in which it is used, including but not limited to:
 - (1) It must provide input and output SNVTs or Niagara Framework Points as specified, as indicated on the Points Schedule, and as otherwise required to support the sequence and application in which it is used. All SNVTs and Niagara Framework Points must have meaningful names identifying the value represented by the SNVT or Niagara Framework Points. Unless a standard network variable type of an appropriate engineering type is not available, all network variables must be of a standard network variable type with engineering units appropriate to the value the variable represents.
 - (2) All settings and parameters used by the application in which the DDC hardware is used must be configurable via one of the following: standard configuration properties (SCPTs) as defined in the LonMark SCPT List, user-defined configuration properties (UCPTs), network configuration inputs (*ncis*) of a SNVT type as defined in the LonMark SNVT List, network configuration inputs (*ncis*) of a user defined network variable type, or hardware settings on the controller itself. Niagara Framework Supervisory Gateways may instead be configurable via the Niagara Framework.
- j. It must meet FCC Part 15 requirements and have UL 916 or equivalent safety listing.
- k. In addition to these general requirements and the DDC Hardware Input-Output (I/O) Function requirements, all DDC Hardware must also meet the requirements of a Niagara Framework Supervisory Gateway, a Local Display Panel (LDP), Application Specific Controller (ASC), General Purpose Programmable Controller (GPPC), or an Application Generic Controller (AGC). All pieces of DDC Hardware must have their DDC Hardware Type identified as part of the Manufacturer's Product Data submittal as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Except for Local Display Panels

provided as part of another controller, where a single device meets the requirements of multiple types, select a single type for that specific device based on it's use. Where a Local Display Panel is provided as part of another device, indicate both the controller type and local display panel. One model of DDC hardware may be submitted as different DDC Hardware types when used in multiple applications.

- l. The user interface on all DDC Hardware with a user interface which allows for modification of a value must be password protected.
- m. Clocks in DDC Hardware incorporating a Clock must continue to function for 120 hours upon loss of power to the DDC Hardware.

2.3.1 Hardware Input-Output (I/O) Functions

DDC Hardware incorporating hardware input-output (I/O) functions must meet the following requirements:

2.3.1.1 Analog Inputs

DDC Hardware analog inputs (AIs) must perform analog to digital (A-to-D) conversion with a minimum resolution of 8 bits plus sign or better as needed to meet the accuracy requirements specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Signal conditioning including transient rejection must be provided for each analog input. Analog inputs must be capable of being individually calibrated for zero and span. Calibration via software scaling performed as part of point configuration is acceptable. The AI must incorporate common mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10,000 ohms.

2.3.1.2 Analog Outputs

DDC Hardware analog outputs (AOs) must perform digital to analog (D-to-A) conversion with a minimum resolution of 8 bits plus sign, and output a signal with a range of 4-20 mA_{dc} or 0-10 V_{dc}. Analog outputs must be capable of being individually calibrated for zero and span. Calibration via software scaling performed as part of point configuration is acceptable. DDC Hardware with Hand-Off-Auto (H-O-A) switches for analog outputs must provide for overriding the output through the range of 0 percent to 100 percent

2.3.1.3 Binary Inputs

DDC Hardware binary inputs (BIs) must accept contact closures and must ignore transients of less than 5 milli-second duration. Protection against a transient of 50 Vac must be provided.

2.3.1.4 Binary Outputs

DDC Hardware binary outputs (BOs) must provide relay contact closures or triac outputs for momentary and maintained operation of output devices. DDC Hardware with H-O-A switches for binary outputs must provide for overriding the output open or closed.

2.3.1.4.1 Relay Contact Closures

Closures must have a minimum duration of 0.1 second. Relays must provide

at least 180V of isolation. Electromagnetic interference suppression must be provided on all output lines to limit transients to 50 Vac. Minimum contact rating must be 0.5 amperes at 24 Vac.

2.3.1.4.2 Triac Outputs

Triac outputs must provide at least 180 V of isolation. Minimum contact rating must be 0.5 amperes at 24 Vac.

2.3.1.5 Pulse Accumulator

DDC Hardware pulse accumulators must have the same characteristics as the BI. In addition, a buffer must be provided to totalize pulses. The pulse accumulator must accept rates of at least 20 pulses per second. The totalized value must be resettable via a configurable parameter.

2.3.2 Local Display Panel (LDP)

The Local Display Panels (LDPs) must be DDC Hardware with a display and navigation buttons or a touch screen display, and must provide display and adjustment of [Niagara Framework points or](#) network variables as indicated on the Points Schedule and as specified. LDPs must be provided as stand-alone DDC Hardware or as an integral part of another piece of DDC Hardware. LDPs must come factory installed with all applications necessary for the device to function as an LDP.

The adjustment of values using display and navigation buttons must be password protected.

2.3.3 Application Specific Controller (ASC)

Application Specific Controllers (ASCs) have a fixed factory-installed application program (i.e. ProgramID) with configurable settings and do not have the ability to be programmed for custom applications. ASCs must meet the following requirements in addition to the General DDC Hardware and DDC Hardware Input-Output (I/O) Function requirements:

- a. ASCs must be LonMark Certified.
- b. [Unless otherwise approved, all necessary Configuration Properties and network configuration inputs \(ncis\) for the sequence and application in which the ASC is used must be fully configurable through the Niagara Framework. Application Specific Controller configurable via a Niagara Framework Wizard is preferred. Wizards must be submitted for each type \(manufacturer and model\) of Application Specific Controller which has a Wizard available for configuration. Wizards distributed under a license must be licensed to the project site. \(Note: configuration accomplished via hardware settings does not require configuration via Niagara Framework Wizard.\)](#)

[Unless otherwise approved, all necessary Configuration Properties and network configuration inputs \(ncis\) for the sequence and application in which the ASC is used must be fully configurable through an LNS plug-in. LNS Plug-ins must be submitted for each type \(manufacturer and model\) of Application Specific Controller. LNS Plug-ins distributed under a license must be licensed to the project site. \(Note: configuration accomplished via hardware settings does not require configuration via plug-in\)](#)

- c. ASCs may include an integral or tethered Local Display Panel

2.3.4 General Purpose Programmable Controller (GPPC)

A General Purpose Programmable Controller (GPPC) must be programmed for the application. GPPCs must meet the following requirements in addition to the general DDC Hardware requirements and Hardware Input-Output (I/O) Functions:

- a. The programmed GPPC must conform to the [LonMark Interoperability Guide](#).
- b. All programming software required to program the GPPC must be delivered to and licensed to the project site in accordance with Section [23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC](#). Submit the most recent version of the Programming software for each type (manufacturer and model) of General Purpose Programmable Controller (GPPC).
- c. Submit copies of the installed GPPC application programs (all software that is not common to every controller of the same manufacturer and model) as source code compatible with the supplied programming software in accordance with Section [23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC](#). The submitted GPPC application program must be the complete application necessary for the GPPC to function as installed and be sufficient to allow replacement of the installed controller with a GPPC of the same type.
- d. GPPCs may be include an integral or tethered Local Display Panel

2.3.5 Application Generic Controller (AGC)

An Application Generic Controller (AGC) has a fixed application program which includes the ability to be programmed for custom applications. AGCs must meet the following requirements in addition to the general DDC Hardware requirements and Hardware Input-Output (I/O) Functions:

- a. The programmed AGC must conform to the [LonMark Interoperability Guide](#).
- b. The AGC must have a fixed ProgramID and fixed XIF file.
- c. Unless otherwise approved, the ACG must be fully configurable and programmable for the application using one or more [LNS plug-ins Niagara Framework Wizards](#), all of which must be submitted as specified for each type of AGC (manufacturer and model).
- d. Submit copies of the installed AGC application programs as source code compatible with the supplied [LNS plug-in Niagara Framework Wizard](#) used for programming the device in accordance with Section [23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC](#). The submitted AGC application program must be the complete application program necessary for the AGC to function as installed and be sufficient to allow replacement of the installed controller with an AGC of the same type.
- e. AGCs may be include an integral or tethered Local Display Panel

2.3.6 Niagara Framework Supervisory Gateway

Any device implementing the Niagara Framework is a Niagara Framework Supervisory Gateway and must meet these requirements. In addition to the

general requirements for all DDC Hardware, Niagara Framework Supervisory Gateway Hardware must:

- a. Be direct digital control hardware.
- b. Have an unrestricted interoperability license and its Niagara Comparability Statement (NiCS) must follow the Tridium Open NiCS Specification.
- c. Manage communications between a field control network and the Niagara Framework Monitoring and Control Software, and between itself and other Niagara Framework Supervisory Gateways. Niagara Framework Supervisory Gateway Hardware must use Fox protocol for communication with other Niagara Framework Components, regardless of the manufacturer of the other components.
- d. Be fully programmable using the Niagara Framework Engineering Tool and must support the following:
 - (1) Time synchronization, Calendar, and Scheduling using Niagara Scheduling Objects
 - (2) Alarm generation and routing using the Niagara Alarm Service
 - (3) Trending using the Niagara History Service and Niagara Trend Log Objects
 - (4) Integration of field control networks using the Niagara Framework Engineering Tool
 - (5) Configuration of integrated field control system using the Niagara Framework Engineering Tool when supported by the field control system
- e. Meet the following minimum hardware requirements:
 - (1) One 10/100 Mbps Ethernet Port
- f. provide access to field control network data and supervisory functions via web interface and support a minimum of 16 simultaneous users.
Note: implementation of this capability may not be required on this project; see requirements in PART 3, EXECUTION of this Section.
- g. Submit a backup of each Niagara Framework Supervisory Gateway as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. The backup must be sufficient to restore a Niagara Framework Supervisory Gateway to the final as-built condition such that a new Niagara Framework Supervisory Gateway loaded with the backup is indistinguishable in functionality from the original.

2.4 NIAGARA FRAMEWORK ENGINEERING TOOL

The Niagara Framework Engineering Tool must be Niagara Workbench or an equivalent Niagara Framework engineering tool software must:

- a. have an unrestricted interoperability license and its Niagara Compatibility Statement (NiCS) must follow the Tridium Open NiCS

Specification.

- b. be capable of performing network configuration for Niagara Framework Supervisory Gateways and Niagara Framework Monitoring and Control Software.
- c. be capable of programming and configuring of Niagara Framework Supervisory Gateways and Niagara Framework Monitoring and Control Software.
- d. be capable of discovery of Niagara Framework Supervisory Gateways and all points mapped into each Niagara Framework Supervisory Gateway and making these points accessible to Niagara Framework Monitoring and Control Software.

Monitoring and Control Software is specified in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION.

PART 3 EXECUTION

3.1 CONTROL SYSTEM INSTALLATION

3.1.1 Niagara Framework Engineering Tool

Provide a Niagara Framework Engineering Tool as specified.

3.1.2 Building Control Network (BCN)

Provide a Building Control Network (BCN) connecting all DDC hardware as specified. The Building Control Network (BCN) must consist of an IP Network, one or more [Niagara Framework Supervisory Gateways CEA-852-C Routers](#), and one or more Non-IP Building Control Network Channels:

3.1.2.1 Building Control Network (BCN) Installation

Provide building control networks meeting the following requirements:

- a. Provide a Building Control Network IP Network, Non-IP Building Control Network Channels and [Niagara Framework Supervisory Gateways CEA-852-C Routers](#) to create a single building control network connecting all DDC Hardware.
- b. In addition to the connection to the [Niagara Framework Supervisory Gateway CEA-852-C Router](#), each Non-IP Building Control Network (BCN) Channel directly connected to a [Niagara Framework Supervisory Gateway CEA-852-C Router](#) must be directly connected to either DDC Hardware or to CEA-709.1-D Routers, but not to both. A channel containing only CEA-709.1-D Routers is a backbone channel and a channel containing DDC Hardware is a non-backbone channel.
- c. When only a single [Niagara Framework Supervisory Gateway CEA-852-C Router](#) is required, the IP network consists of only the [Niagara Framework Supervisory Gateway CEA-852-C Router](#). When multiple [Niagara Framework Supervisory Gateways CEA-852-C Routers](#) are required, provide an IP Network connecting all [Niagara Framework Supervisory Gateways CEA-852-C Routers](#).
- d. Connect all DDC Hardware [other than Niagara Framework Supervisory Gateways](#) to a non-backbone BCN Channel. Connect all [Niagara Framework](#)

Supervisory Gateways to the Building Control Network (BCN) IP Network.

- e. Install components such that there is no more than one CEA-709.1-D Router between any DDC Hardware and a Niagara Framework Supervisory Gateway CEA-852-C Router
- f. Install the network such that the peak expected bandwidth usage for each and every channel is less than 70 percent, including device-to-device traffic and traffic to the Utility Monitoring and Control System (UMCS) as indicated on the Points Schedule.
- g. Where multiple pieces of DDC Hardware are used in the execution of a single sequence of operation, directly connect all DDC Hardware used to execute the sequence to the same channel and do not install other DDC Hardware, other than a Niagara Framework Supervisory Gateway, to that channel.

3.1.2.2 Non-IP Building Control Network (BCN) Channel

Provide Non-IP Building Control Network (BCN) Channels meeting the following requirements:

- a. For each non-backbone channel, provide a TP/FT-10 channel in doubly terminated bus topology in accordance with CEA-709.3. For each backbone channel, provide either a TP/FT-10 channel in doubly terminated bus topology in accordance with CEA-709.3 or a TP/XF-1250 channel in accordance with the LonMark Interoperability Guide.
- b. Connect no more than 2/3 the maximum number of devices permitted by CEA-709.3 to each TP/FT-10 channel. Connect no more than 2/3 the maximum number of devices permitted by LonMark Interoperability Guide to TP/XF-1250 channel.
- c. Connect no more than 2/3 the maximum number of devices permitted by the manufacturer of the device transceivers to each channel. When more than one type of transceiver is used on the same channel, use the transceiver with the lowest maximum number of devices to calculate the 2/3 limit.

3.1.2.3 Building Control Network (BCN) IP Network

Install IP Network Cabling in conduit. Install Ethernet Switches in lockable enclosures. Install the Building Control Network (BCN) IP Network so that it is available at the Facility Point of Connection (FPOC) location. When the FPOC location is a room number, provide sufficient additional media to ensure that the Building Control Network (BCN) IP Network can be extended to any location in the room.

3.1.3 DDC Hardware

Install Niagara Framework Supervisory Gateways CEA-852-C Routers in lockable enclosures. Install other DDC Hardware which is not suspended ceilings in enclosures.

Configure and commission all DDC Hardware on the Building Control Network via the Niagara Framework via LNS using an LNS-based Network Configuration Tool. Use Application Specific Controllers whenever an Application Specific Controller suitable for the application exists. When an Application Specific Controller suitable for the application does not

exist use a Niagara Framework Supervisory Gateway .

3.1.3.1 Hand-Off-Auto (H-O-A) Switches

Provide Hand-Off-Auto (H-O-A) switches as specified and as indicated on the Points Schedule. H-O-A switches must be integral to the controller hardware, an external device co-located with (in the same enclosure as) the controller, integral to the controlled equipment, or an external device co-located with (in the same enclosure as) the controlled equipment.

- a. For H-O-A switches integral to DDC Hardware, meet the requirements specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE.
- b. For external H-O-A switches for binary outputs, provide switches capable of overriding the output open or closed.
- c. For external H-O-A switches for analog outputs, provide switches capable of overriding through the range of 0 percent to 100 percent.

3.1.3.2 Local Display Panels

Provide LDPs to display and override values of points in a Niagara Framework Supervisory Gateway or Network Variables as indicated on the Points Schedule. Install LDPs displaying points for anything other than a terminal unit in the same room as the equipment. Install LDPs displaying points for only terminal units in a mechanical room central to the group of terminal units it serves.

3.1.3.3 Overrides for GPPCs and AGCs

Provide the capability to override points for all General Purpose Programmable Controllers and Application Generic Controllers as specified and as indicated on the Points Schedule using one of the following methods:

- a. Override SNVT of Same SNVT Type method:
 - (1) Use this method for all setpoint overrides and for overrides of inputs and outputs whenever practical.
 - (2) Provide a SNVT input to the DDC hardware containing the point to be overridden of the same SNVT type as the point to be overridden.
 - (3) Program and configure the DDC hardware such that:
 - (a) If the value of the SNVT on the override input is the *Invalid Value* defined for that SNVT by the LonMark SNVT List, then the point is not overridden (its value is determined from the sequence).
 - (b) If the value of the SNVT on the override input is not the *Invalid Value* defined for that SNVT by the LonMark SNVT List then set the value of the point to be overridden to the value of the SNVT on the override input.
- b. HVAC Override SNVT method:
 - (1) Use this method for override of inputs and outputs when the "Override SNVT Shares SNVT Type" method is impractical.

- (2) Provide a SNVT input to the DDC hardware containing the point to be overridden of SNVT type *SNVT_hvac_overid*. Show on the Points Schedule how to perform the specified override using this SNVT.

3.1.3.4 Overrides for ASCs

Whenever possible use the methods specified for General Purpose Programmable Controllers and Application Generic Controllers to perform overrides for all Application Specific Controllers. If neither the "Override SNVT of Same SNVT Type" method or "HVAC Override SNVT" method are supported by the Application Specific Controller show this on the Points Schedule and perform overrides as follows:

- a. Provide one or more SNVT input(s) to the DDC hardware containing the point to be overridden. Document the number and type of each SNVT provided on the Points Schedule.
- b. Configure the Application Specific Controller such that:
 - (1) For some specific combination or combinations of values at the SNVT override input(s) the point is not overridden, and its value is determined from the sequence as usual. Show on the Points Schedule the values required at the SNVT override input(s) to not override the point.
 - (2) For other specific combinations of SNVT override input(s), the value of the point to be overridden is determined from the value of the override input(s). Show on the Points Schedule the correlation between the SNVT override input(s) and the resulting value of the overridden point.

3.1.4 Scheduling, Alarming, Trending and Overrides

3.1.4.1 Scheduling

Configure schedules in Niagara Framework Supervisory Gateway using Niagara Schedule Objects as indicated on the Points Schedule and as specified. When the schedule is controlling occupancy modes in DDC Hardware other than a Niagara Framework Supervisory Gateway use a network variable of type SNVT_Occupancy. Provide DDC Hardware with LonMark Objects meeting the Simple Scheduler Functional Profile and configure schedules as specified on the Points Schedule and as specified.

3.1.4.1.1 Schedule Groupings

Provide a separate schedule for each AHU including it's associated Terminal Units and for each stand-alone Terminal Unit (those not dependent upon AHU service).

3.1.4.1.2 Occupancy Mode Mapping to SNVT Values

Use the following mapping between SNVT_Occupancy enumerations and occupancy modes:

- a. OCCUPIED mode: Enumeration value of OC_OCCUPIED
- b. UNOCCUPIED mode: Enumeration value of OC_UNOCCUPIED
- c. WARM-UP/COOL-DOWN (PRE-OCCUPANCY) mode: Enumeration value of OC_STANDBY

3.1.4.2 Alarming

For each point which is shown on the Points Schedule with an alarm condition, provide a SNVT output for the point to be used for alarm generation by the UMCS Front End

For each point not in a Niagara Framework Supervisory Gateway which is shown on the Points Schedule with an alarm condition, provide a SNVT output for the point to be used for alarm generation. For each point which is shown on the Points Schedule with an alarm condition, configure alarms in Niagara Framework Supervisory Gateway using Niagara Alarm Extensions and Alarm Services.

3.1.4.3 Trending

For each point which is shown on the Points Schedule as requiring a trend, provide a SNVT output for the point to be used for trending by the UMCS Front End.

For each point not in a Niagara Framework Supervisory Gateway which is shown on the Points Schedule as requiring a trend, provide a SNVT output for the point to be used for trending. For each point which is shown on the Points Schedule as requiring a trend, configure a trend in a Niagara Framework Supervisory Gateway using Niagara Framework History Extensions and the Niagara Framework History Service.

3.1.4.4 Overrides

For each point shown on the Points Schedule as requiring an override, provide an override as specified in paragraphs "Overrides for GPPCs and AGCs" and "Overrides for ASCs".

Provide overrides for points as indicated on the Points Schedule. For overrides to points in Niagara Framework Supervisory Gateways, use the Niagara Framework. For overrides to other points, provide an override to a point in a Niagara Framework Supervisory Gateway via the Niagara Framework where the Niagara Framework Supervisory Gateway overrides the other point as specified in paragraphs "Overrides for GPPCs and AGCs" and "Overrides for ASCs"

3.1.5 Gateways

The requirements in this paragraph do not themselves permit the installation of hardware not meeting the other requirements of this section. Except for proprietary systems specifically indicated in Section 23 09 00, all control hardware installed under this project must meet the requirements of this specification, including the control hardware providing the network interface for a package unit or split system specified under this Section or another Section. Only use gateways to connect to pre-existing control devices and to proprietary systems specifically permitted by Section 23 09 00.

Provide Gateways to connect non-CEA-709.1-D control hardware in accordance with the following:

- a. Configure gateway to map writeable data points in the controlled equipment to Network Variable Inputs of Standard Network Variable Types as defined by the LonMark SNVT List, or to Niagara Framework

points, as indicated in the Points Schedule and as specified.

- b. Configure gateway to map readable data points in the controlled equipment to Network Variable Outputs of Standard Network Variable Types as defined by the LonMark SNVT List, or to Niagara Framework points, as indicated in the Points Schedule and as specified.
- c. Do not use non-CEA-709.1-D control hardware for controlling built-up units or any other equipment that was not furnished with factory-installed controls. (Note: A Niagara Framework Supervisory Gateway is CEA-709.1-D control hardware.)
- d. Do not use non-CEA-709.1-D control hardware for system scheduling functions.
- e. Each gateway must communicate with and perform protocol translation for non-CEA-709.1-D control hardware controlling one and only one package unit or a single non-CEA-709.1-D system specifically permitted by Section 23 09 00.
- f. Connect one network port on the gateway to the Building Control Network and the other port to the single piece of controlled equipment or the non-CEA-709.1-D network specifically permitted by Section 23 09 00.
- g. For gateways to existing package units or simple split systems, non-CEA-709.1-D network wiring connecting the gateway to the package unit or split system interface must not exceed 10 feet in length and must connect to exactly two devices: the controlled equipment or split system interface and the gateway.

3.1.6 Network Interface Jack

Provide standard network interface jacks such that each node on the control network is within 10 ft of an interface jack. For terminal unit controllers with hardwired thermostats this network interface jack may instead be located at the thermostat. Locating the interface jack near the controller is preferred. If the network interface jack is other than a 1/8 inch phone jack, provide an interface cable with a standard 1/8 inch phone jack on one end and a connector suitable for mating with installed network interface jack on the other. No more than one type of interface cable must be required to access all network interface jacks. Furnish one interface cable(s).

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SECTION 23 09 23.02

BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

Provide a complete Direct Digital Control (DDC) system, except for the front end which is specified in Section 25 10 10 UTILITY MONITORING AND CONTROL (UMCS) FRONT END AND INTEGRATION, suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and shown and in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.1.1 System Requirements

Provide a system meeting the requirements of both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section and with the following characteristics:

- a. Except for Gateways, the control system must be an open implementation of BACnet technology using ASHRAE 135 as the communications protocol. The system must use standard ASHRAE 135 Objects and Properties. The system must use standard ASHRAE 135 Services exclusively for communication over the network. Gateways to packaged units must communicate with other DDC hardware using ASHRAE 135 exclusively and may communicate with packaged equipment using other protocols. The control system must be installed such that any two devices on the Internetwork can communicate using standard ASHRAE 135 Services.
- b. Install and configure control hardware to provide ASHRAE 135 Objects and Properties as indicated and as needed to meet the requirements of this specification.

1.1.2 Verification of Specification Requirements

Review all specifications related to the control system installation and advise the Contracting Officer of any discrepancies before performing any work. If Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC or any other Section referenced in this specification is not included in the project specifications advise the Contracting Officer and either obtain the missing Section or obtain Contracting Officer approval before performing any work.

1.2 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 OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135

(2020; Interpretation 1-8 2021; Errata 1-2 2021; Addenda CD 2021; Addenda BY-CE 2022; Interpretation 9-10 2022) BACnet-A Data

Communication Protocol for Building
Automation and Control Networks

BACNET INTERNATIONAL (BTL)

BTL Guide (v.49; 2017) BACnet Testing Laboratory
Implementation Guidelines

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.3 (2022) Ethernet

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-485 (1998a; R 2012) Electrical Characteristics
of Generators and Receivers for Use in
Balanced Digital Multipoint Systems

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15 Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 916 (2015; Reprint Oct 2021) UL Standard for
Safety Energy Management Equipment

1.3 DEFINITIONS

For definitions related to this section, see Section **23 09 00**
INSTRUMENTATION AND CONTROL FOR HVAC.

1.4 SUBMITTALS

Submittal requirements related to this Section are specified in Section
23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

PART 2 PRODUCTS

All products used to meet this specification must meet the indicated
requirements, but not all products specified here will be required by
every project. All products must meet the requirements both Section
23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section.

2.1 NETWORK HARDWARE

2.1.1 BACnet Router

All BACnet Routers must be BACnet/IP Routers and must perform layer 3
routing of **ASHRAE 135** packets over an IP network in accordance with
ASHRAE 135 Annex J and Clause 6. The router must provide the appropriate
connection to the IP network and connections to one or more **ASHRAE 135**
MS/TP networks. Devices used as BACnet Routers must meet the
requirements for DDC Hardware, and must support the NM-RC-B BIBB.

2.1.2 BACnet Gateways

In addition to the requirements for DDC Hardware, the BACnet Gateway must
meet the following requirements:

- a. It must perform bi-directional protocol translation from one non-ASHRAE 135 protocol to ASHRAE 135. BACnet Gateways must incorporate a network connection to an ASHRAE 135 network (either BACnet over IP in accordance with Annex J or MS/TP) and a separate connection appropriate for the non-ASHRAE 135 protocol and media.
- b. It must retain its configuration after a power loss of an indefinite time, and must automatically return to their pre-power loss state once power is restored.
- c. It must allow bi-directional mapping of data between the non-ASHRAE 135 protocol and Standard Objects as defined in ASHRAE 135. It must support the DS-RP-B BIBB for Objects requiring read access and the DS-WP-B BIBB for Objects requiring write access.
- d. It must support the DS-COV-B BIBB.

Although Gateways must meet DDC Hardware requirements they are not DDC Hardware and must not be used when DDC Hardware is required.

2.2 CONTROL NETWORK WIRING

- a. BACnet MS/TP communications wiring must be in accordance with ASHRAE 135. The wiring must use shielded, three wire (twisted-pair with reference) cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors must be less than 30 pF per foot.
- b. Building Control Network Backbone IP Network must use Ethernet media. Ethernet cables must be CAT-5e at a minimum and meet all requirements of IEEE 802.3 .

2.3 DIRECT DIGITAL CONTROL (DDC) HARDWARE

2.3.1 General Requirements

All DDC Hardware must meet the following requirements:

- a. It must be locally powered and must incorporate a light to indicate the device is receiving power.
- b. It must conform to the BTL Guide
- c. It must be BACnet Testing Laboratory (BTL) Listed.
- d. The Manufacturer's Product Data submittal for each piece of DDC Hardware must include the Protocol Implementation Conformance Statement (PICS) for that hardware as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.
- e. It must communicate and be interoperable in accordance with ASHRAE 135 and have connections for BACnet IP or MS/TP control network wiring.
- f. Other than devices controlling terminal units or functioning solely as a BACnet Router, it must support DS-COV-B, DS-RPM-A and DS-RPM-B BIBBs.
- g. Devices supporting the DS-RP-A BIBB must also support the DS-COV-A BIBB.

- h. Application programs, configuration settings and communication information must be stored in a manner such that they persist through loss of power:
 - (1) Application programs must persist regardless of the length of time power is lost.
 - (2) Configured settings must persist for any loss of power less than 2,500 hours.
 - (3) Communication information, including but not limited to COV subscriptions, event reporting destinations, Notification Class Object settings, and internal communication settings, must persist for any loss of power less than 2,500 hours.
- i. Internal Clocks:
 - (1) Clocks in DDC Hardware incorporating a Clock must continue to function for 120 hours upon loss of power to the DDC Hardware.
 - (2) DDC Hardware incorporating a Clock must support the DM-TS-B or DM-UTC-B BIBB.
- j. It must have all functionality indicated and required to support the application (Sequence of Operation or portion thereof) in which it is used, including but not limited to providing Objects as specified and as indicated on the Points Schedule.
- k. In addition to these general requirements and the DDC Hardware Input-Output (I/O) Function requirements, all DDC Hardware must also meet any additional requirements for the application in which it is used (e.g. scheduling, alarming, trending, etc.).
- l. It must meet **FCC Part 15** requirements and have **UL 916** or equivalent safety listing.
- m. Device must support Commandable Objects to support Override requirements as detailed in PART 3 EXECUTION
- n. User interfaces which allow for modification of Properties or settings must be password-protected.
- o. Devices communicating BACnet MS/TP must meet the following requirements:
 - (1) Must have a configurable Max_Master Property.
 - (2) DDC Hardware other than hardware controlling a single terminal unit must have a configurable Max_Info_Frames Property.
 - (3) Must respond to any valid request within 50 msec with either the appropriate response or with a response of "Reply Postponed".
 - (4) Must use twisted pair with reference and shield (3-wire media) wiring.
- p. Devices communicating BACnet/IP must use UDP Port 0xBAC0. Devices with configurable UDP Ports must default to 0xBAC0.

- q. All Device IDs, Network Numbers, and BACnet MAC addresses of devices must be fully configurable without limitation, except MS/TP MAC addresses may be limited by [ASHRAE 135](#) requirements.
- r. DDC Hardware controlling a single terminal unit must have:
 - (1) Objects (including the Device Object) with an Object Name Property of at least 8 characters in length.
 - (2) A configurable Device Object Name.
 - (3) A configurable Device Object Description Property at least 16 characters in length.
- s. Except for Objects in DDC Hardware controlling a single terminal unit, all Objects (including Device Objects) must:
 - (1) Have a configurable Object Name Property of at least 12 characters in length.
 - (2) Have a configurable Object Description Property of at least 24 characters in length.
- t. For programmable DDC Hardware, provide and license to the project site all programming software required to program the Hardware in accordance with Section [23 09 00](#) INSTRUMENTATION AND CONTROL FOR HVAC.
- u. For programmable DDC Hardware, provide copies of the installed application programs (all software that is not common to every controller of the same manufacturer and model) as source code compatible with the supplied programming software in accordance with Section [23 09 00](#) INSTRUMENTATION AND CONTROL FOR HVAC. The submitted application program must be the complete application necessary for controller to function as installed and be sufficient to allow replacement of the installed controller with another controller of the same type.
- v. Provide a minimum of twenty (20) percent spare for each type of hardware input-output (I/O).

2.3.2 Hardware Input-Output (I/O) Functions

DDC Hardware incorporating hardware input-output (I/O) functions must meet the following requirements:

2.3.2.1 Analog Inputs

DC Hardware analog inputs (AIs) must be implemented using [ASHRAE 135](#) Analog Input Objects and perform analog to digital (A-to-D) conversion with a minimum resolution of 8 bits plus sign or better as needed to meet the accuracy requirements specified in Section [23 09 00](#). Signal conditioning including transient rejection must be provided for each analog input. Analog inputs must be capable of being individually calibrated for zero and span. Calibration via software scaling performed as part of point configuration is acceptable. The AI must incorporate common mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10,000 ohms.

2.3.2.2 Analog Outputs

DDC Hardware analog outputs (AOs) must be implemented using [ASHRAE 135](#) Analog Output Objects and perform digital to analog (D-to-A) conversion with a minimum resolution of 8 bits plus sign, and output a signal with a range of 4-20 mA_{dc} or 0-10 V_{dc}. Analog outputs must be capable of being individually calibrated for zero and span. Calibration via software scaling performed as part of point configuration is acceptable. DDC Hardware with Hand-Off-Auto (H-O-A) switches for analog outputs must provide for overriding the output through the range of 0 percent to 100 percent

2.3.2.3 Binary Inputs

DDC Hardware binary inputs (BIs) must be implemented using [ASHRAE 135](#) Binary Input Objects and accept contact closures and must ignore transients of less than 5 milli-second duration. Protection against a transient 50VAC must be provided.

2.3.2.4 Binary Outputs

DDC Hardware binary outputs (BOs) must be implemented using [ASHRAE 135](#) Binary Output Objects and provide relay contact closures or triac outputs for momentary and maintained operation of output devices. DDC Hardware with H-O-A switches for binary outputs must provide for overriding the output open or closed.

2.3.2.4.1 Relay Contact Closures

Closures must have a minimum duration of 0.1 second. Relays must provide at least 180V of isolation. Electromagnetic interference suppression must be provided on all output lines to limit transients to 50 Vac. Minimum contact rating must be 0.5 amperes at 24 Vac.

2.3.2.4.2 Triac Outputs

Triac outputs must provide at least 180 V of isolation. Minimum contact rating must be 0.5 amperes at 24 Vac.

2.3.2.5 Pulse Accumulator

DDC Hardware pulse accumulators must be implemented using either an [ASHRAE 135](#) Accumulator Object or an [ASHRAE 135](#) Analog Value Object where the Present_Value is the totalized pulse count. Pulse accumulators must accept contact closures, ignore transients less than 5 msec duration, protect against transients of 50 VAC, and accept rates of at least 20 pulses per second.

2.3.2.6 ASHRAE 135 Objects for Hardware Inputs and Outputs

The requirements for use of [ASHRAE 135](#) objects for hardware input and outputs includes devices where the hardware sensor or actuator is integral to the controller (e.g. a VAV box with integral damper actuator, a smart sensor, a VFD, etc.)

2.3.2.7 Integrated H-O-A Switches

Where integrated H-O-A switches are provided on hardware outputs,

controller must provide means of monitoring position or status of H-O-A switch. This feedback may be provided via any valid BACnet method, including the use of proprietary Objects, Properties, or Services.

2.3.3 Local Display Panel (LDP)

The Local Display Panels (LDPs) must be DDC Hardware with a display and navigation buttons or a touch screen display, and must provide display and adjustment of [ASHRAE 135](#) Properties as indicated on the Points Schedule and as specified. LDPs must be either BTL Listed as a B-OD, B-OWS, B-AWS, or be an integral part of another piece of DDC Hardware listed as a B-BC. For LDPs listed as B-OWS or B-AWS, the hardware must be BTL listed and the product must come factory installed with all applications necessary for the device to function as an LDP.

The adjustment of values using display and navigation buttons must be password protected.

2.3.4 Expansion Modules and Tethered Hardware

A single piece of DDC Hardware may consist of a base unit and also:

- a. An unlimited number of hardware expansion modules, where the individual hardware expansion modules are designed to directly connect, both mechanically and electrically, to the base unit hardware. The expansion modules must be commercially available as an optional add-on to the base unit.
- b. A single piece of hardware connected (tethered) to a base unit by a single cable where the cable carries a proprietary protocol between the base unit and tethered hardware. The tethered hardware must not contain control logic and be commercially available as an optional add-on to the base unit as a single package.

Note that this restriction on tethered hardware does not apply to sensors or actuators using standard binary or analog signals (not a communications protocol); sensors or actuators using standard binary or analog signals are not considered part of the DDC Hardware.

Hardware capable of being installed stand-alone, or without a separate base unit, is DDC Hardware and must not be used as expansion modules or tethered hardware.

2.3.5 Supervisory Control Requirements

2.3.5.1 Scheduling Hardware

DDC Hardware used for scheduling must meet the following requirements:

- a. It must be BTL Listed as a B-BC and support the SCHED-E-B BIBB.
- b. It is preferred, but not required, that devices support the DM-OCD-B BIBB on all Calendar and Schedule Objects, such that a front end BTL listed as a B-AWS may create or delete Calendar and Schedule Objects. It is also preferred but not required that devices supporting the DM-OCD-B BIBB accept any valid value for properties of Calendar and Schedule Objects. Note that there are additional requirements in the EXECUTION Part of this Section for Devices which do not support the DM-OCD-B BIBB as specified.

- c. The Date_List property of all Calendar Objects must be writable.
- d. The Present_Value Property of Schedule must support the following values: 1, 2, 3, 4.

2.3.5.2 Alarm Generation Hardware

DDC Hardware used for alarm generation must meet the following requirements:

- a. Device must support the AE-N-I-B BIBB
- b. The Recipient_List Property must be Writable for all Notification Class Objects used for alarm generation.
- c. For all Objects implementing Intrinsic Alarming, the following Properties must be Writable:
 - (1) Time_Delay
 - (2) High_Limit
 - (3) Low_Limit
 - (4) Deadband
 - (5) Event_Enable
 - (6) If the issue date of this project specification is after 1 January 2016, Time_Delay_Normal must be writable.
- d. For Event Enrollment Objects used for alarm generation, the following Properties must be Writable:
 - (1) Event_Parameters
 - (2) Event_Enable
 - (3) If the issue date of this project specification is after 1 January 2016, Time_Delay_Normal must be writable.
- e. It is preferred, but not required, that devices support the DM-OCD-B BIBB on all Notification Class Objects and Event Enrollment Objects, such that a front end BTL listed as a B-AWS may create or delete Notification Class Objects and Event Enrollment Objects. It is also preferred, but not required that devices supporting the DM-OCD-B BIBB accept any valid value as an initial value for properties of Notification Class Objects and Event Enrollment Objects. Note that there are additional requirements in the EXECUTION Part of this Section for devices which do not support the DM-OCD-B BIBB as specified.
- f. Devices provided to meet the the requirements indicated under "Support for Future Alarm Generation" in the EXECUTION part of this specification must support the AE-N-E-B BIBB.

2.3.5.3 Trending Hardware

DDC Hardware used for collecting trend data must meet the following requirements:

- a. Device must support Trend Log or Trend Log Multiple Objects.
- b. Device must support the T-VMT-I-B BIBB.

- c. Devices provided to meet the EXECUTION requirement for support of Future Trending must support the T-VMT-E-B BIBB.
- d. The following properties of all Trend Log or Trend Log Multiple Objects must be present and Writable:
 - Start_Time
 - Stop_Time
 - Log_DeviceObjectProperty
 - Log Interval Log interval must support an interval of at least 60 minutes duration.
- e. Trend Log Objects must support using Intrinsic Reporting to send a BUFFER_FULL event.
- f. The device must have a Notification Class Object for the BUFFER_FULL event. The Recipient_List Property must be Writable.
- g. Devices must support values of at least 1,000 for Buffer_Size Properties.
- h. It is preferred, but not required, that devices support the DM-OCD-B BIBB on all Trend Log Objects, such that a front end BTL listed as a A-AWS may create or delete Trend Log Objects. It is also preferred, but not required that devices supporting the DM-OCD-B BIBB accept any valid value as an initial value for properties of Trend Log Objects. Note that there are additional EXECUTION requirements for devices which do not support the DM-OCD-B BIBB as specified.

PART 3 EXECUTION

3.1 CONTROL SYSTEM INSTALLATION

3.1.1 Building Control Network (BCN)

Install the Building Control Network (BCN) as a single BACnet Internetwork consisting of a single IP network as the BCN Backbone and zero or more BACnet MS/TP networks. Note that in some cases there may only be a single device on the BCN Backbone.

Except as permitted for the non-BACnet side of Gateways, use exclusively **ASHRAE 135** networks.

3.1.1.1 Building Control Network IP Backbone

Install IP Network Cabling in conduit. Install the Building Control Network (BCN) IP Backbone such that it is available at the Facility Point of Connection (FPOC) location **as shown on the drawings**. When the FPOC location is a room number, provide sufficient additional media to ensure that the Building Control Network (BCN) IP Backbone can be extended to any location in the room.

Use UDP port 0xBAC0 for all BACnet traffic on the IP network.

3.1.1.2 BACnet MS/TP Networks

When using MS/TP, provide MS/TP networks in accordance with **ASHRAE 135** and in accordance with the **ASHRAE 135** figure "Mixed Devices on 3-Conductor Cable with Shield" (Figure 9-1.4 in the 2012 version of ASHRAE 135). Ground the shield at the BACnet Router and at no other point. Ground the

reference wire at the BACnet Router through a 100 ohm resistor and do not ground it at any other point. In addition:

- a. Provide each segment in a doubly terminated bus topology in accordance with TIA-485.
- b. Provide each segment with 2 sets of network bias resistors in accordance with ASHRAE 135, with one set of resistors at each end of the MS/TP network.
- c. Use 3 wire (twisted pair and reference) with shield media for all MS/TP media installed inside. Use fiber optic isolation in accordance with ASHRAE 135 for all MS/TP media installed outside buildings, or between multiple buildings.
- d. For 18 AWG cable, use segments with a maximum length of 4000 ft. When using greater distances or different wire gauges comply with the electrical specifications of TIA-485.
- e. For each controller that does not use the reference wire provide transient suppression at the network connection of the controller if the controller itself does not incorporate transient suppression.
- f. Install no more than 32 devices on each MS/TP segment. Do not use MS/TP to MS/TP routers.
- g. Connect each MS/TP network to the BCN backbone via a BACnet Router.
- h. For BACnet Routers, configure the MS/TP MAC address to 0. Assign MAC Addresses to other devices consecutively beginning at 1, with no gaps.
- i. Configure the Max_Master Property of all devices to be 31.

3.1.1.3 Building Control Network (BCN) Installation

Provide a building control network meeting the following requirements:

- a. Install all DDC Hardware connected to the Building Control Network.
- b. Where multiple pieces of DDC Hardware are used to execute one sequence, install all DDC Hardware executing that sequence on a single MS/TP network dedicated to that sequence.
- c. Traffic between BACnet networks must be exclusively via BACnet routers.

3.1.2 DDC Hardware

Install all DDC Hardware that connects to an IP network in lockable enclosure. Install other DDC Hardware that is not in suspended ceilings in lockable enclosures. For all DDC hardware with a user interface, coordinate with site to determine proper passwords and configure passwords into device.

- a. Except for zone sensors (thermostats), install all Tethered Hardware within 6 feet of its base unit.
- b. Install and configure all BTL-Listed devices in a manner consistent with their BTL Listing such that the device as provided still meets all requirements necessary for its BTL Listing.

- c. Install and configure all BTL-Listed devices in a manner consistent with the BTL Device Implementation Guidelines such that the device as provided meets all those Guidelines.

3.1.2.1 Device Identifiers, Network Addresses, and IP addresses

- a. Do not use any Device Identifier or Network Number already used by another BACnet system at the project site. Coordinate Device IDs and Network Numbers with the installation. .
- b. Coordinate device IP addresses with installation. .

3.1.2.2 Object Name Property and Object Description Property

Configure the Object_Names and Object_Descriptions properties of all Objects (including Device Objects) as indicated on the Points Schedule (Point Name and Point Description) and as specified. At a minimum:

- a. Except for DDC Hardware controlling a single terminal unit, configure the Object_Name and Object_Description properties of all Objects (including Device Objects) as indicated on the Points Schedule and as specified.
- b. In DDC Hardware controlling a single terminal unit, configure the Device Object_Name and Device Object_Description as indicated on the Points Schedule and as specified.

When Points Schedule entries exceed the length limitations in the device, notify the Contracting Officer and provide recommended alternatives for approval.

3.1.2.3 Controllers

All controllers shall be Siemens Apogee.

3.1.2.4 Hand-Off-Auto (H-O-A) Switches

Provide Hand-Off-Auto (H-O-A) switches for all DDC Hardware analog outputs and binary outputs used for control of systems other than terminal units, as specified and as indicated on the Points Schedule. Provide H-O-A switches that are integral to the controller hardware, an external device co-located with (in the same enclosure as) the controller, integral to the controlled equipment, or an external device co-located with (in the same enclosure as) the controlled equipment.

- a. For H-O-A switches integral to DDC Hardware, meet the requirements specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE.
- b. For external H-O-A switches used for binary outputs, provide for overriding the output open or closed.
- c. For external H-O-A switches used for analog outputs, provide for overriding through the range of 0 percent to 100 percent.

3.1.2.5 Local Display Panels

Provide LDPs to display and override values of ASHRAE 135 Object Properties as indicated on the Points Schedule. Install LDPs displaying

points for anything other than a terminal unit in the same room as the equipment. Install LDPs displaying points for only terminal units in a mechanical room central to the group of terminal units it serves. For LDPs using WriteProperty to commandable objects to implement an override, write values with priority 9.

3.1.2.6 MS/TP Slave Devices

Configure all MS/TP devices as Master devices. Do not configure any devices to act as slave devices.

3.1.2.7 Change of Value (COV) and Read Property

- a. To the greatest extent possible, configure all devices to support the SubscribeCOV service (the DS-COV-B BIBB). At a minimum, all devices supporting the DS-RP-B BIBB, other than devices controlling only a single terminal unit, must be configured to support the DS-COV-B BIBB.
- b. Whenever supported by the server side, configure client devices to use the DS-COV-A BIBB.

3.1.2.8 Engineering Units

Configure devices to use English (Inch-Pound) engineering units as follows:

- a. Temperature in degrees F
- b. Air or natural gas flows in cubic feet per minute (CFM)
- c. Water in gallons per minute (GPM)
- d. Steam flow in pounds per hour (pph)
- e. Differential Air pressures in inches of water column (IWC)
- f. Water, steam, and natural gas pressures in PSI
- g. Enthalpy in BTU/lb
- h. Heating and cooling energy in MBTU (1MBTU = 1,000,000 BTU)
- i. Cooling load in tons (1 ton = 12,000 BTU/hour)
- j. Heating load in MBTU/hour (1MBTU = 1,000,000 BTU)
- k. Electrical Power: kilowatts (kW)
- l. Electrical Energy: kilowatt-hours (kWh)

3.1.2.9 Occupancy Modes

Use the following correspondence between value and occupancy mode whenever an occupancy state or value is required:

- a. OCCUPIED mode: a value of one
- b. UNOCCUPIED mode: a value of two
- c. WARM-UP/COOL-DOWN (PRE-OCCUPANCY) mode: a value of three

Note that elsewhere in this Section the Schedule Object is required to

also support a value of four, which is reserved for future use. Also note that the behavior of a system in each of these occupancy modes is indicated in the sequence of operation for the system.

3.1.2.10 Use of BACnet Objects

Use only standard non-proprietary **ASHRAE 135** Objects and services to accomplish the project scope of work as follows:

- a. Use Analog Input or Analog Output Objects for all analog hardware I/O. Do not use Analog Value Object for analog hardware I/O) .
- b. Use Binary Input or Binary Output Objects for all binary hardware I/O. Do not use Binary Value Objects for binary hardware I/O.
- c. Use Analog Value Objects for analog setpoints.
- d. Use Accumulator Objects or Analog Value Objects for pulse inputs.
- e. For occupancy modes, use Multistate Value Objects and the correspondence between value and occupancy mode specified in paragraph OCCUPANCY MODES.
- f. Use Schedule Objects and Calendar Objects for all scheduling. Use Trend Log Objects or Trend Log Multiple Objects for all trending and Notification Class Objects for trend log upload. Use a combination of Event Enrollment Objects, Intrinsic Alarming, and Notification Class Objects for alarm generation.
- g. For all other points shown on the Points Schedule as requiring an **ASHRAE 135** Object, use the Object type shown on the Points Schedule or, if no Object Type is shown, use a standard Object appropriate to the point.

3.1.2.11 Use of Standard BACnet Services

Except as noted in this paragraph, for all DDC Hardware use Standard BACnet Services as defined in this specification (which excludes some **ASHRAE 135** services) exclusively for application control functionality and communication.

DDC Hardware that cannot meet this requirement may use non-standard services provided they can provide identical functionality using Standard BACnet Services when communicating with BACnet devices from a different vendor. When implementing non-standard services, document all non-standard services in the DDC Hardware Schedule as specified and as specified in Section **23 09 00** INSTRUMENTATION AND CONTROL FOR HVAC.

3.1.2.12 Device Application Configuration

- a. For every property, setting or value shown on the Points Schedule or otherwise indicated as Configurable, provide a value that is retained through loss of power and can be changed via one or more of:
 - (1) BACnet services (including proprietary services)
 - (2) Hardware settings on the device
- b. For every property, setting or value shown on the Points Schedule or

otherwise indicated as Operator Configurable, provide a value that is retained through loss of power and can be changed via one or more of:

- (1) A Writable Property of a standard BACnet Object
- (2) A Property of a standard BACnet Object that is Writable when Out_Of_Service is TRUE and Out_Of_Service is Writable.

3.1.3 Scheduling, Alarming, Trending, and Overrides

3.1.3.1 Scheduling

Configure schedules in BACnet Scheduling Objects to schedule systems as indicated on the Points Schedule and as specified using the indicated correspondence between value and occupancy mode. If no devices supports both the SCHED-E-B and DM-OC-D-B BIBBS for Schedule Objects, provide 5 blank Schedule Objects in DDC Hardware BTL listed as B-BCs and supporting the SCHED-E-B BIBB for later use by the site.

Provide a separate schedule for each AHU including it's associated Terminal Units and for each stand-alone Terminal Unit (those not dependent upon AHU service).

3.1.3.2 Configuration of Alarm Generation

- a. Send alarm events as Alarms (not Events).
- b. Use the ConfirmedNotification Service for alarm events.
- c. For alarm generation, support two priority levels for alarms: critical and non-critical. Configure the Priority of Notification Class Objects to use Priority 112 for critical and 224 for non-critical alarms.
- d. Number of Notification Class Objects for Alarm Generation:
 - (1) If the device implements non-critical alarms, or if any Object in the device supports Intrinsic Alarms, then provide a single Notification Class Object specifically for (shared by) all non-critical alarms.
 - (2) If the device implements critical alarms, provide a single Notification Class Object specifically for (shared by) all critical alarms.
 - (3) If the device implements both critical and non-critical alarms, provide both Notification Class Objects (one for critical, one for non-critical).
 - (4) If the device controls equipment other than a single terminal unit, provide both Notification Class Objects (one for critical, one for non-critical) even if no alarm generation is required at time of installation.
- e. For all intrinsic alarms configure the Limit_Enable Property to set both HighLimitEnable and LowLimitEnable to TRUE. If the specified alarm conditions are for a single-sided alarm (only High_Limit used or only Low_Limit used) assign a value to the unused limit such that the unused alarm condition will not occur.

- f. For all objects supporting intrinsic alarming, even if no alarm generation is required during installation, configure the following Properties as follows:
 - (1) Notification_Class to point to the non-Critical Notification Class Object in that device.
 - (2) Limit_Enable to enable both the HighLimitEnable and LowLimitEnable
 - (3) Notify_Type to Alarm
- g. Use of alarm generation types:
 - (1) Only use algorithmic alarm generation when intrinsic alarm generation is not supported by the device or object, or when the specific alarm conditions cannot be implemented using intrinsic alarm generation.
 - (2) Only use remote alarm generation when the alarm cannot be generated using intrinsic or local algorithmic alarm generation on the device containing the referenced property. If remote alarm generation is used, use the same DDC Hardware for all remote alarm generation within a single sequence.

3.1.3.3 Support for Future Alarm Generation

For every piece of DDC Hardware, support future alarm generation capabilities by supporting either intrinsic or additional algorithmic alarming. Provide one of the following:

- a. Support intrinsic alarming for every Object used by the application in that device.
- b. Support additional Event_Enrollment Objects. For DDC hardware controlling a single terminal unit, support at least one additional object. Otherwise, support at least 4 additional Objects. Support additional Event_Enrollment Objects via one of the following:
 - (1) Provide unused Event_Enrollment Objects on that device.
 - (2) Support the DM-OCD-B BIBB and the creation of sufficient Event_Enrollment Objects on that device.
 - (3) Provide one or more devices in the IP network that support the AE-N-E-B BIBB and have unused Event_Enrollment Objects.
 - (4) Provide one or more devices on the IP network that support the AE-N-E-B BIBB, the DM-OCD-B BIBB, and the creation of sufficient Event_Enrollment Objects.

The total number of Event_Enrollment Objects required by the project is the sum of the individual device requirements, and the distribution of Event_Enrollment Objects among devices is not further restricted. (Note this allows a single device to contain many Event_Enrollment Objects satisfying the requirements for multiple devices.)

3.1.3.4 Trend Log Configuration

- a. Configure trends in Trend Log or Trend Log Multiple Objects as indicated on the Points Schedule and as specified.
- b. Configure all trend logs (including any provided to support future trends) to save data on regular intervals using the BUFFER_FULL event to request trend upload from the front end.
- c. Configure Trend Log Objects with a minimum Buffer_Size property value of 1,000 and Trend Log Multiple Objects with a minimum Buffer_Size property value of 1,000 per point trended (for example, a Trend Log Multiple Object used to trend 3 points must have a Buffer_Size Property value of at least 3,000).
- d. Configure a Notification Class Object in devices doing trending (including devices supporting future trends) to handle the BUFFER_FULL event.
- e. When possible, trend each point using an Object in the device containing the point. When it is necessary to trend using a an Object in another device, all trends not on the same Device as the Object being trended must be on a single device (i.e. all Trend Log and Trend Log Multiple Objects used for remote trending within a sequence must be on the same device).
- f. For each trend log, including any trend logs provided to support future trending, configure the following properties as specified:
 - (1) Logging_Type: Set to Polling
 - (2) Stop_When_Full: Set to Wrap Around
 - (3) Buffer_Size: Set to 400 or greater.
 - (4) Notification_Threshold: Set to 90 percent of full
 - (5) Notification_Class: Set to the Notification Class Object in that device
 - (6) Event_Enable: Set to TRUE
 - (7) Log_Interval: Set to 15 minutes.
- g. Future Trending support. Provide support for future trending:
 - (1) Provide one or more devices on the Building Control Network Backbone IP network which support both the T-VMT-E-B and DM-OCD-B BIBBs for Trend Log Objects. Provide sufficient devices to support the creation of at least one additional Trend Log Object for every terminal unit plus 4 additional Trend Log Objects for every non-terminal unit.
 - (2) Provide one additional Trend Log Object for every terminal unit plus 4 additional Trend Log Objects for every non-terminal unit in one or more devices on the Building Control Network Backbone IP network that support the T-VMT-E-B BIBB for later use by the site.
 - (3) A combination of these two methods is permitted provided the total

required number of Trend Log Objects is met.

3.1.3.5 Overrides

Provide an override for each point shown on the Points Schedule as requiring an override.

Unless otherwise approved, provide Commandable Objects to support all Overrides . With specific approval from the Contracting Officer, Overrides for points which are not hardware outputs and which are in DDC hardware controlling a single terminal unit may support overrides via an additional Object provided for the override. No other means of implementing Overrides may be used.

- a. Where Commandable Objects are used, ensure that WriteProperty service requests with a Priority of 10 or less take precedence over the SEQUENCE VALUE and that WriteProperty service request with a priority of 11 or more have a lower precedence than the SEQUENCE VALUE.
- b. For devices implementing overrides via additional Objects, provide Objects which are NOT Written to as part of the normal Sequence of Operations and are Writable when Out_Of_Service is TRUE and Out_Of_Service is Writable. Use this point as an Override of the normal value when Out_Of_Service is TRUE and the normal value otherwise. Note these Objects may be modified as part of the sequence via local processes, but must not be modified by local processes when Out_Of_Service is TRUE.

3.1.4 BACnet Gateways

The requirements in this paragraph do not themselves permit the installation of hardware not meeting the other requirements of this section. Except for proprietary systems specifically indicated in Section 23 09 00, all control hardware installed under this project must meet the requirements of this specification, including the control hardware providing the network interface for a package unit or split system specified under another section. Only use gateways to connect to pre-existing control devices, and to proprietary systems specifically permitted by Section 23 09 00.

3.1.4.1 General Gateway Requirements

Provide BACnet Gateways to connect non-BACnet control hardware in accordance with the following:

- a. Configure gateways to map writable data points in the controlled equipment to Writable Properties of Standard Objects as indicated in the Points Schedule and as specified.
- b. Configure gateway to map readable data points in the controlled equipment to Readable Properties of Standard Objects as indicated in the Points Schedule and as specified.
- c. Configure gateway to support the DS-COV-B BIBB for all points mapped to BACnet Objects.
- d. Do not use non-BACnet control hardware for controlling built-up units or any other equipment that was not furnished with factory-installed controls.

- e. Do not use non-BACnet control hardware for system scheduling functions.
- f. Each gateway must communicate with and perform protocol translation for non-BACnet control hardware controlling one and only one package unit or a single non-BACnet system specifically permitted by Section 23 09 00.
- g. Connect one network port on the gateway to the Building Control Backbone IP Network or to a BACnet MS/TP network and the other port to the single piece of controlled equipment or the non-BACnet system specifically permitted by Section 23 09 00..
- h. For gateways to existing package units or simple split systems, non-BACnet network wiring connecting the gateway to the package unit must not exceed 10 feet in length and must connect to exactly two devices: the controlled equipment (packaged unit) or split system interface and the gateway.

-- End of Section --

SECTION 23 11 20

FACILITY GAS PIPING

PART 1 GENERAL

1.1 SUMMARY

This specification section applies to gas piping installed within buildings incidental underground piping under building, above ground steel piping and corrugated stainless steel tubing (CSST) both outside (up to 5 feet beyond exterior walls) and within buildings in compliance with NFPA 54 /AGA Z223.1, "National Fuel Gas Code" , "Fuel Gas Piping".

1.2 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 GAS ASSOCIATION (AGA)

AGA XR0603 (2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service

AGA Z223.1 (2012) National Fuel Gas Code

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.15/CSA 9.1 (2021) Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves

ANSI Z21.21/CSA 6.5 (2019) Automatic Valves for Gas Appliances

ANSI Z21.24/CSA 6.10 (2022) Connectors for Gas Appliances

ANSI Z21.41/CSA 6.9 (2014; R 2019) Quick-Disconnect Devices for Use with Gas Fuel Appliances

ANSI Z21.69/CSA 6.16 (2015; R 2020) Connectors for Movable Gas Appliances

ANSI Z21.80/CSA 6.22 (2019) Line Pressure Regulators

AMERICAN PETROLEUM INSTITUTE (API)

API 570 (2016; Addendum 1 2017; Addendum 2 2018; ERTA 1 2018) Piping Inspection Code: In-Service Inspection, Rating, Repair, and Alteration of Piping Systems

API RP 2009 (2002; R 2007; 7th Ed) Safe Welding, Cutting, and Hot Work Practices in Refineries, Gasoline Plants, and Petrochemical Plants

API Spec 6D	(June 2018, 4th Ed; Errata 1 July 2018; Errata 2 August 2018) Specification for Pipeline and Piping Valves
API Std 598	(2009) Valve Inspecting and Testing
API Std 607	(2016) Fire Test for Quarter-turn Valves and Valves Equipped with Non-metallic Seats

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 25-16	(2016) Earthquake-Activated Automatic Gas Shutoff Devices

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2020) Scheme for the Identification of Piping Systems
ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.33	(2012; R 2017) Manually Operated Metallic Gas Valves for Use in Gas Piping Systems Up to 125 psi, (Sizes NPS 1/2 - NPS 2)
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.8	(2018; Supplement 2018) Gas Transmission and Distribution Piping Systems
ASME B31.9	(2020) Building Services Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS WHB-2.9	(2004) Welding Handbook; Volume 2, Welding Processes, Part 1

ASTM INTERNATIONAL (ASTM)

ASTM 01.01	(2019) Steel - Piping, Tubing, Fittings

ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2020a) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A513/A513M	(2020a) Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
ASTM F2015	(2000; R 2013) Standard Specification for Lap Joint Flange Pipe End Applications
CSA GROUP (CSA)	
ANSI LC 1/CSA 6.26	(2019) Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing (CSST)
CGA 9.2-M88	(1988; R 2009) Manually Operated Shut-Off Valves for Gas Piping Systems
FM GLOBAL (FM)	
FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/
MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)	
MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 54	(2021) National Fuel Gas Code
NFPA 58	(2020; TIA 20-1; TIA 20-2; TIA 20-3) Liquefied Petroleum Gas Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
SOCIETY FOR PROTECTIVE COATINGS (SSPC)	
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning
U.S. DEPARTMENT OF DEFENSE (DOD)	
MIL-STD-101	(2014; Rev C) Color Code for Pipelines and

for Compressed Gas Cylinders

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 192

Transportation of Natural and Other Gas by
Pipeline: Minimum Federal Safety Standards

UNDERWRITERS LABORATORIES (UL)

UL FLAMMABLE & COMBUSTIBLE

(2012) Flammable and Combustible Liquids
and Gases Equipment Directory

1.3 SYSTEM DESCRIPTION

The gas piping system includes natural gas piping and appurtenances from point of connection with supply system, as indicated, to gas operated equipment within the facility. Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, in three separate packages.

1.3.1 Gas Facility System and Equipment Operation

Include shop drawings showing piping layout, locations of system valves, gas line markers and cathodic protection system; step-by-step procedures for system start up, operation and shutdown (index system components and equipment to the system drawings); isolation procedures including valve operation to shutdown or isolate each section of the system (index valves to the system maps and provide separate procedures for normal operation and emergency shutdown if required to be different). Submit Data package No. 4.

1.3.2 Gas Facility System Maintenance

Include maintenance procedures and frequency for system and equipment; identification of pipe materials and manufacturer by locations, pipe repair procedures, and jointing procedures at transitions to other piping material or material from a different manufacturer. Submit Data Package No.4.

1.3.3 Gas Facility Equipment Maintenance

Include identification of valves, shut-offs, disconnects, and other equipment by materials, manufacturer, vendor identification and location; maintenance procedures and recommended tool kits for valves and equipment; recommended repair methods (i.e., field repair, factory repair, or replacement) for each valve and piece of equipment; and preventive maintenance procedures, possible failure modes and troubleshooting guide. Submit Data Package No. 3.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Gas Piping System; G

SD-03 Product Data

Pipe and Fittings; G

Gas Equipment Connectors; G

Gas Piping System; G

Pipe Coating Materials; G

Pressure Regulators; G

Risers; G

Transition Fittings; G

Valves; G

Warning and Identification Tape; G

SD-06 Test Reports

Testing; G

Pressure Tests; G

Test with Gas; G

SD-07 Certificates

Welders Procedures and Qualifications; G

Assigned Number, Letter, or Symbol; G

SD-08 Manufacturer's Instructions

PE Pipe and Fittings; G

Pipe Coating Materials; G

SD-10 Operation and Maintenance Data

Gas Facility System and Equipment Operation; G

Gas Facility System Maintenance; G

Gas Facility Equipment Maintenance; G

1.5 QUALITY ASSURANCE

Submit manufacturer's descriptive data and installation instructions for approval for compression-type mechanical joints used in joining dissimilar

materials and for insulating joints. Mark all valves, flanges and fittings in accordance with [MSS SP-25](#).

1.5.1 Welding Qualifications

- a. Weld piping in accordance with qualified procedures using performance qualified welders and welding operators in accordance with [API RP 2009](#), [ASME BPVC SEC IX](#), and [ASME B31.9](#). Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by [ASME B31.9](#). Notify the Contracting Officer at least 24 hours in advance of tests, and perform at the work site if practicable.
- b. Submit a certified copy of [welders procedures and qualifications](#) metal and PE in conformance with [ASME B31.9](#) for each welder and welding operator. Submit the [assigned number, letter, or symbol](#) that will be used in identifying the work of each welder to the Contracting Officer. Weld all structural members in conformance with [AWS A5.8/A5.8M](#), and [AWS WHB-2.9](#).

1.5.2 Jointing Thermoplastic and Fiberglass Piping

Perform all jointing of piping using qualified joiners and qualified procedures in accordance with [AGA XR0603](#). Furnish the Contracting Officer with a copy of qualified procedures and list of and identification symbols of qualified joiners. Submit manufacturer's installation instructions and manufacturer's visual joint appearance chart, including all [PE pipe and fittings](#).

1.5.3 Shop Drawings

Submit drawings for complete [Gas Piping System](#), within 30 days of contract award, showing location, size and all branches of pipeline; location of all required shutoff valves; and instructions necessary for the installation of [gas equipment connectors](#) and supports.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Plastic Pipe

Handle, transport, and store plastic pipe and fittings carefully. Plug or cap [pipe and fittings](#) ends during transportation or storage to minimize dirt and moisture entry. Do not subject piping to abrasion or concentrated external loads. Discard PE pipe sections and fittings that have been damaged.

1.6.2 CSST Tubing

Handle, transport and store CSST tubing on the wooden spool or shipping container provided by the manufacturer. Insure tubing ends are capped during transportation and storage to minimize dirt and moisture entry. Discard any tubing segment and fitting that has been damaged.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that

essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Asbestos or products containing asbestos are not allowed. Submit catalog data and installation instructions for pipe, valves, all related system components, pipe coating materials and application procedures. Conform to NFPA 54 and with requirements specified herein. Provide supply piping to appliances or equipment at least as large as the inlets thereof.

2.2 GAS PIPING SYSTEM AND FITTINGS

2.2.1 Steel Pipe, Joints, and Fittings

2.2.2 Steel Tubing, Joints and Fittings

Provide steel tubing conforming to ASTM 01.01, and ASTM A513/A513M, with tubing joints made up with gas tubing fittings recommended by the tubing manufacturer.

2.2.3 Corrugated Stainless Steel Tubing, Fittings and Accessories

Provide corrugated stainless steel tubing conforming to ANSI LC 1/CSA 6.26 (austenitic stainless steel of series 300) with tubing joints made with special mechanical fittings as supplied by the tubing manufacturer.

2.2.3.1 Tubing

Austenitic stainless alloy of series 300 with polyethylene jacket/coating in accordance with ANSI LC 1/CSA 6.26 for sizes 3/8-inch through 2-inch

2.2.3.2 Mechanical Fittings

Copper alloy with one end matched to the corrugated tubing and one end with NPT threads in accordance with ASME B1.20.1

2.2.3.3 Striker Plates

Hardened steel designed to protect tubing from mechanical damage in accordance with ANSI LC 1/CSA 6.26

2.2.3.4 Manifolds

Malleable iron, steel or copper alloy with threaded connections/ports in accordance with ASME B1.20.1

2.2.4 Sealants for Steel Pipe Threaded Joints

Provide joint sealing compound as listed in UL FLAMMABLE & COMBUSTIBLE, Class 20 or less. For taping, use tetrafluoroethylene tape conforming to UL FLAMMABLE & COMBUSTIBLE.

2.2.5 Warning and Identification

Provide pipe flow markings, warning and identification tape, and metal tags as required.

2.2.6 Flange Gaskets

Provide gaskets of nonasbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type, containing aramid fibers bonded with styrene butadiene rubber (SBR)

or nitrile butadiene rubber (NBR) suitable for a maximum 600 degree F service, to be used for hydrocarbon service.

2.2.7 Pipe Threads

Provide pipe threads conforming to ASME B1.20.1.

2.2.8 Escutcheons

Provide chromium-plated steel or chromium-plated brass escutcheons, either one piece or split pattern, held in place by internal spring tension or set screw.

2.2.9 Gas Transition Fittings

c. Provide manually operated shut-off valve conforming to CGA 9.2-M88

2.2.10 Insulating Pipe Joints

2.2.10.1 Insulating Joint Material

Provide insulating joint material between flanged or threaded metallic pipe systems where shown to control galvanic or electrical action.

2.2.10.2 Threaded Pipe Joints

Provide threaded pipe joints of steel body nut type dielectric unions with insulating gaskets.

2.2.10.3 Flanged Pipe Joints

Provide joints for flanged pipe consisting of full face sandwich-type flange insulating gasket of the dielectric type, insulating sleeves for flange bolts, and insulating washers for flange nuts. Provide lap joint flange pipe ends conforming to ASTM F2015.

2.2.11 Flexible Connectors

- a. Provide flexible connectors for connecting gas utilization equipment to building gas piping conforming to ANSI Z21.24/CSA 6.10 or ANSI Z21.41/CSA 6.9 for quick disconnect devices, and flexible connectors for movable food service equipment conforming to ANSI Z21.69/CSA 6.16.
- b. Do not install the flexible connector through the appliance cabinet face. Provide rigid metallic pipe and fittings to extend the final connection beyond the cabinet, except when appliance is provided with an external connection point.

2.3 VALVES

Provide lockable shutoff or service isolation valves conforming to the following:

2.3.1 Valves 2 Inches and Smaller

Provide valves 2 inches and smaller conforming to ASME B16.33 of materials and manufacture compatible with system materials used.

2.3.2 Valves 2-1/2 Inches and Larger

Provide valves 2-1/2 inches and larger of carbon steel conforming to API Spec 6D, Class 150.

2.4 RISERS

Provide manufacturer's standard riser, transition from plastic to steel pipe with 7 to 12 mil thick epoxy coating. Use swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Provide remote bolt-on or bracket or wall-mounted riser supports .

2.5 PIPE HANGERS AND SUPPORTS

Provide pipe hangers and supports conforming to MSS SP-58.

2.6 LINE AND APPLIANCE REGULATORS AND SHUTOFF VALVES

Provide regulators conforming to , and ANSI Z21.80/CSA 6.22 for line pressure regulators. Provide shutoff valves conforming to ANSI Z21.15/CSA 9.1 for manually controlled gas shutoff valves and ANSI Z21.21/CSA 6.5 for automatic shutoff valves for gas appliances.

2.7 BOLTING (BOLTS AND NUTS)

Stainless steel bolting; ASTM A193/A193M, Grade B8M or B8MA, Type 316, for bolts; and ASTM A194/A194M, Grade 8M, Type 316, for nuts. Dimensions of bolts, studs, and nuts must conform with ASME B18.2.1 and ASME B18.2.2 with coarse threads conforming to ASME B1.1, with Class 2A fit for bolts and studs and Class 2B fit for nuts. Bolts or bolt-studs must extend through the nuts and may have reduced shanks of a diameter not less than the diameter at root of threads. Bolts must have American Standard regular square or heavy hexagon heads; nuts must be American Standard heavy semifinished hexagonal.

2.8 GASKETS

Fluorinated elastomer, compatible with flange faces.

2.9 IDENTIFICATION FOR ABOVEGROUND PIPING

MIL-STD-101 for legends and type and size of characters. For pipes 3/4 inch od and larger, provide printed legends to identify contents of pipes and arrows to show direction of flow. Color code label backgrounds to signify levels of hazard. Make labels of plastic sheet with pressure-sensitive adhesive suitable for the intended application. For pipes smaller than 3/4 inch od, provide brass identification tags 1 1/2 inches in diameter with legends in depressed black-filled characters.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy or areas of conflict before performing the work.

3.2 EXCAVATION AND BACKFILLING

Provide required excavation, backfilling, and compaction as specified in Section 31 00 00 EARTHWORK.

3.3 GAS PIPING SYSTEM

Provide a gas piping system from the point of delivery, defined as the outlet of the meter set assembly , to the connections to each gas utilization device that is in compliance with NFPA 54NFPA 58..

3.3.1 Protection and Cleaning of Materials and Components

Protect equipment, pipe, and tube openings by closing with caps or plugs during installation. At the completion of all work, thoroughly clean the entire system.

3.3.2 Workmanship and Defects

Piping, tubing and fittings must be clear and free of cutting burrs and defects in structure or threading and must be thoroughly brushed and chip-and scale-blown. Repair of defects in piping, tubing or fittings is not allowed; replace defective items when found.

3.4 PROTECTIVE COVERING

3.4.1 Underground Metallic Pipe

Protect buried metallic piping and tubing from corrosion by either: (1) applying protective coatings; (2) encasement in a water tight plastic conduit; or (3) encasement in a protective system designed and listed by the manufacturer for this application. When dissimilar metals are joined underground, use gastight insulating fittings.

3.4.2 Aboveground Metallic Piping Systems

3.4.2.1 Ferrous Surfaces

Touch up shop primed surfaces with ferrous metal primer. Solvent clean surfaces that have not been shop primed . Mechanically clean surfaces that contain loose rust, loose mill scale and other foreign substances by power wire brushing or commercial sand blasted conforming to SSPC SP 6/NACE No.3 and prime with ferrous metal primer . Finish primed surfaces with two coats of exterior oil paint or vinyl paint.

3.4.2.2 Nonferrous Surfaces

Except for aluminum alloy pipe, do not paint nonferrous surfaces. Paint surfaces of aluminum alloy pipe and fittings to protect against external corrosion where they contact masonry, plaster, insulation, or are subject to repeated wettings by such liquids as water, detergents or sewage. Solvent-clean the surfaces and treat with vinyl type wash coat. Apply a first coat of aluminum paint and a second coat of alkyd gloss enamel or silicone alkyd copolymer enamel.

3.5 INSTALLATION

Install the gas system in conformance with the manufacturer's recommendations and applicable provisions of NFPA 54 and AGA XR0603, and

as indicated. Perform all pipe cutting without damage to the pipe, with an approved type of mechanical cutter, unless otherwise authorized. Use wheel cutters where practicable. On steel pipe 6 inches and larger, an approved gas cutting and beveling machine may be used. Cut thermoplastic and fiberglass pipe in accordance with AGA XR0603.

3.5.1 Metallic Piping Installation

Bury underground piping a minimum of 18 inches below grade. Make changes in direction of piping with fittings only; mitering or notching pipe to form elbows and tees or other similar type construction is not permitted. Branch connection may be made with either tees or forged branch outlet fittings. Provide branch outlet fittings which are forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Do not use aluminum alloy pipe in exterior locations or underground.

3.5.2 Metallic Tubing Installation

Install metallic tubing using gas tubing fittings approved by the tubing manufacturer. CSST gas piping systems must be installed by contractors who have completed the manufacturer's training program as indicated on a certification card. Make branch connections with tees. Prepare all tubing ends with tools designed for that purpose. Do not use aluminum alloy tubing in exterior locations or underground. Maintain electrical continuity of gas piping system in accordance with NFPA 54 NFPA 58, paragraph entitled 'Electrical Bonding and Grounding'.

3.5.3 Thermoplastic and Fiberglass Piping, Tubing, and Fittings

Installation of thermoplastic and fiberglass piping, tubing, and fittings is permitted only outside and underground. Bury piping a minimum of 18 inches below grade. Install the piping to avoid excessive stresses due to thermal contraction, and use only where indicated. Installations must be made using qualified procedures, by qualified installers, and in compliance with AGA XR0603 and NFPA 54 NFPA 58, and must be inspected by a qualified inspector.

3.5.4 Connections Between Metallic and Plastic Piping

Connections between metallic and plastic piping are only allowed outside, underground, and with approved transition fittings.

3.5.5 Piping and Tubing Buried Under Buildings

Run underground piping and tubing installed beneath buildings in a steel pipe casing protected from corrosion with protective coatings or installed within a water tight plastic conduit or as part of a listed encasement system. Extend casing or encasement system at least 4 inches outside the building, and provide the pipe with spacers and end bushings to seal at both ends to prevent the entrance of water and/or the escape of gas. Extend a vent line from the annular space above grade outside to a point where gas will not be a hazard, and terminate in a rain/insect-resistant fitting.

3.5.6 Concealed Piping in Buildings

Do not use combinations of fittings (unions, tubing fittings, running threads, right- and left-hand couplings, bushings, and swing joints) to

conceal piping within buildings.

3.5.6.1 Piping and Tubing in Partitions

Locate concealed piping and tubing in hollow, rather than solid, partitions. Protect tubing passing through walls or partitions against physical damage both during and after construction, and provide appropriate safety markings and labels. Provide protection of concealed pipe and tubing in accordance with [ANSI LC 1/CSA 6.26](#).

3.5.6.2 Piping in Floors

Lay piping in solid floors in channels suitably covered to permit access to the piping with minimum damage to the building.

3.5.7 Aboveground Piping

Run aboveground piping as straight as practicable along the alignment and elevation indicated, with a minimum of joints, and separately supported from other piping system and equipment. Install exposed horizontal piping no farther than [6 inches](#) from nearest parallel wall and at an elevation which prevents standing, sitting, or placement of objects on the piping.

3.5.8 Final Gas Connections

Unless otherwise specified, make final connections with rigid metallic pipe and fittings. Provide accessible gas shutoff valve and coupling for each gas equipment item.

3.5.9 Seismic Requirements

Support and brace piping and attached valves to resist seismic loads in conformance with [ASCE 25-16](#). CSST tubing and fittings that are seismically qualified in accordance with the [FM APP GUIDE: Flexible Piping Systems for Flammable Gases](#) must meet the seismic requirements in accordance with the manufacturer's installation instructions.

3.6 PIPE JOINTS

Design and install pipe joints to effectively sustain the longitudinal pull-out forces caused by contraction of the piping or superimposed loads.

3.6.1 Threaded Metallic Joints

Provide threaded joints in metallic pipe with tapered threads evenly cut and made with UL approved graphite joint sealing compound for gas service or tetrafluoroethylene tape applied to the male threads only. Threaded joints up to [1-1/2 inches](#) in diameter may be made with approved tetrafluoroethylene tape. Threaded joints up to [2 inches](#) in diameter may be made with approved joint sealing compound. After cutting and before threading, ream pipe and remove all burrs. Caulking of threaded joints to stop or prevent leaks is not permitted.

3.6.2 Welded Metallic Joints

Conform beveling, alignment, heat treatment, and inspection of welds to [NFPA 54](#). Remove weld defects and make repairs to the weld, or remove the weld joints entirely and reweld. After filler metal has been removed from its original package, protect and store so that its characteristics or

welding properties are not affected adversely. Do not use electrodes that have been wetted or have lost any of their coating.

3.6.3 Thermoplastic and Fiberglass Joints

3.6.3.1 Thermoplastic and Fiberglass

Conform jointing procedures to [AGA XR0603](#). Do not make joints with solvent cement or heat of fusion between different kinds of plastics.

3.6.3.2 PE Fusion Welding Inspection

Visually inspect butt joints by comparing with, manufacturer's visual joint appearance chart. Inspect fusion joints for proper fused connection. Replace defective joints by cutting out defective joints or replacing fittings. Inspect, in conformance with [API 570](#), 100 percent of all joints and re-inspect all corrections. Arrange with the pipe manufacturer's representative in the presence of the Contracting Officer to make first time inspection.

3.6.4 Flared Metallic Tubing Joints

Make flared joints in metallic tubing with special tools recommended by the tubing manufacturer. Use flared joints only in systems constructed from nonferrous pipe and tubing, when experience or tests have demonstrated that the joint is suitable for the conditions, and when adequate provisions are made in the design to prevent separation of the joints. Do not use metallic ball sleeve compression-type tubing fittings for tubing joints.

3.6.5 Solder or Brazed Joints

Make all joints in metallic tubing and fittings with materials and procedures recommended by the tubing supplier. Braze joints with material having a melting point above [1000 degrees F](#), containing no phosphorous.

3.6.6 Joining Thermoplastic or Fiberglass to Metallic Piping or Tubing

When compression type mechanical joints are used, provide gasket material in the fittings compatible with the plastic piping and with the gas in the system. Use an internal tubular rigid stiffener in conjunction with the fitting, flush with end of the pipe or tubing, extending at least to the outside end of the compression fitting when installed. Remove all rough or sharp edges from stiffener. Do not force fit stiffener in the plastic. Split tubular stiffeners are not allowed.

3.6.7 Press Connections

Make press connections in accordance with manufacturer's installation instructions using tools approved by the manufacturer. Fully insert the tubing into the fitting and then mark at the shoulder of the fitting. Check the fitting alignment against the mark on the tubing to assure the tubing is fully inserted before the joint is pressed.

3.7 PIPE SLEEVES

Provide pipes passing through concrete or masonry walls or concrete floors or roofs with pipe sleeves fitted into place at the time of construction. Do not install sleeves in structural members except where indicated or

approved. Make all rectangular and square openings as detailed. Extend each sleeve through its respective wall, floor or roof, and cut flush with each surface, except in mechanical room floors not located on grade where clamping flanges or riser pipe clamps are used. Extend sleeves in mechanical room floors above grade at least 4 inches above finish floor. Unless otherwise indicated, use sleeves large enough to provide a minimum clearance of 1/4 inch all around the pipe. Provide steel pipe for sleeves in bearing walls, waterproofing membrane floors, and wet areas. Provide sleeves in nonbearing walls, floors, or ceilings of steel pipe, galvanized sheet metal with lock-type longitudinal seam, or moisture-resistant fiber or plastic. For penetrations of fire walls, fire partitions and floors which are not on grade, seal the annular space between the pipe and sleeve with fire-stopping material and sealant that meet the requirement of Section 07 84 00 FIRESTOPPING.

3.8 PIPES PENETRATING WATERPROOFING MEMBRANES

Install pipes penetrating waterproofing membranes as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.9 FIRE SEAL

Fire seal all penetrations of fire rated partitions, walls and floors in accordance with Section 07 84 00 FIRESTOPPING.

3.10 ESCUTCHEONS

Provide escutcheons for all finished surfaces where gas piping passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms.

3.11 SPECIAL REQUIREMENTS

Provide drips, grading of the lines, freeze protection, and branch outlet locations as shown and conforming to the requirements of NFPA 54.

3.12 BUILDING STRUCTURE

Do not weaken any building structure by the installation of any gas piping. Do not cut or notch beams, joists or columns. Attach piping supports to metal decking. Do not attach supports to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.13 PIPING SYSTEM SUPPORTS

Support gas piping systems in buildings with pipe hooks, metal pipe straps, bands or hangers suitable for the size of piping or tubing. Do not support any gas piping system by other piping. Conform spacing of supports in gas piping and tubing installations to the requirements of NFPA 54. Conform the selection and application of supports in gas piping and tubing installations to the requirements of MSS SP-58. In the support of multiple pipe runs on a common base member, use a clip or clamp where each pipe crosses the base support member. Spacing of the base support members is not to exceed the hanger and support spacing required for any of the individual pipes in the multiple pipe run. Rigidly connect the clips or clamps to the common base member. Provide a clearance of 1/8 inch between the pipe and clip or clamp for all piping which may be subjected to thermal expansion.

3.14 ELECTRICAL BONDING AND GROUNDING

Provide a gas piping system within the building that is electrically continuous and bonded to a grounding electrode as required by NFPA 54, NFPA 58, and NFPA 70.

3.15 SHUTOFF VALVE

Install the main gas shutoff valve controlling the gas piping system to be easily accessible for operation, as indicated, protected from physical damage, and marked with a metal tag to clearly identify the piping system controlled. Install valves approximately at locations indicated. Orient stems vertically, with operators on top, or horizontally. Provide stop valve on service branch at connection to main and shut-off valve on riser outside of building.

3.16 LINE AND APPLIANCE PRESSURE REGULATORS

Install line pressure regulators and appliance regulators in accordance with the manufacturer's requirements and in accordance with NFPA 54. Install each regulator in an accessible location and install shutoff valves ahead of each line and appliance regulator to allow for maintenance. Where vent limiting devices are not included in the regulators, install a vent pipe to the exterior of the building. Terminate all service regulator vents and relief vents in the outside air in rain and insect resistant fittings. Locate the open end of the vent where gas can escape freely into the atmosphere, away from any openings into the building and above areas subject to flooding.

3.17 GAS SERVICE INSTALLATION

Installations must be in accordance with 49 CFR 192 and ASME B31.8. Contractor must submit and use only tested and approved work procedures. Contractor must use only welders and jointers who have been recently qualified by training and test for joining and installing the gas pipe material used on this job. The finished product must be inspected by a person qualified to inspect joints made by the particular procedures used to make joints.

3.18 TESTING

Submit test procedures and reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Test entire gas piping system to ensure that it is gastight prior to putting into service. Prior to testing, purge the system, clean, and clear all foreign material. Test each joint with an approved gas detector, soap and water, or an equivalent nonflammable solution. Inspect and test each valve in conformance with API Std 598 and API Std 607. Complete testing before any work is covered, enclosed, or concealed, and perform with due regard for the safety of employees and the public during the test. Install bulkheads, anchorage and bracing suitably designed to resist test pressures if necessary, and as directed and or approved by the Contracting Officer. Do not use oxygen as a testing medium.

3.18.1 Pressure Tests

Submit test procedures and reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Before appliances are connected, test by filling the piping systems with air or an inert gas to withstand a minimum pressure of 3 pounds gauge for a period of not less than 10 minutes as specified in NFPA 54 without showing any drop in pressure. Do not use Oxygen for test. Measure pressure with a mercury manometer, slope gauge, or an equivalent device calibrated to be read in increments of not greater than 0.1 pound. Isolate the source of pressure before the pressure tests are made.

3.18.2 Test With Gas

Before turning on gas under pressure into any piping, close all openings from which gas can escape. Immediately after turning on the gas, check the piping system for leakage by using a laboratory-certified gas meter, an appliance orifice, a manometer, or equivalent device. Conform all testing to the requirements of NFPA 54. If leakage is recorded, shut off the gas supply, repair the leak, and repeat the tests until all leaks have been stopped.

3.18.3 Purging

After testing is completed, and before connecting any appliances, fully purge all gas piping. Do not purge piping into the combustion chamber of an appliance. Do not purge the open end of piping systems into confined spaces or areas where there are ignition sources unless the safety precautions recommended in NFPA 54 are followed.

3.18.4 Labor, Materials and Equipment

Furnish all labor, materials and equipment necessary for conducting the testing and purging.

3.19 PIPE COLOR CODE MARKING

Provide color code marking of piping as specified in Section 09 90 00 PAINTS AND COATINGS, conforming to ASME A13.1.

-- End of Section --

SECTION 23 21 23

HYDRONIC PUMPS

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 OF MECHANICAL ENGINEERS (ASME)

ASME B1.1 (2003; R 2018) Unified Inch Screw Threads
(UN and UNR Thread Form)

ASME B16.1 (2020) Gray Iron Pipe Flanges and Flanged
Fittings Classes 25, 125, and 250

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M (2003; R 2021) Standard Specification for
Gray Iron Castings

ASTM A123/A123M (2017) Standard Specification for Zinc
(Hot-Dip Galvanized) Coatings on Iron and
Steel Products

ASTM A307 (2021) Standard Specification for Carbon
Steel Bolts, Studs, and Threaded Rod 60
000 PSI Tensile Strength

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.2 (2014) Rotodynamic (Centrifugal) Pump for
Nomenclature and Definitions

HI 1.3 (2013) Rotodynamic (Centrifugal) Pump
Applications

HI 9.6.4 (2009) Rotodynamic Pumps for Vibration
Analysis and Allowable Values

HI ANSI/HI 2.1-2.2 (2014) Rotodynamic Vertical Pumps of
Radial, Mixed, and Axial Flow Types for
Nomenclature and Definitions

HI ANSI/HI 9.6.3 (2017) Rotodynamic Pumps - Guideline for
Operating Regions - B120

HI ANSI/HI 14.6 (2011) Rotodynamic Pumps for Hydraulic
Performance Acceptance Tests - A136

INTERNATIONAL CODE COUNCIL (ICC)

ICC IgCC (2018) International Green Construction

Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2016) Motors and Generators - Revision
1: 2018; Includes 2021 Updates to Parts
0, 1, 7, 12, 30, and 31

NEMA Z535.4 (2011; R 2017) Product Safety Signs and
Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA
20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 21 (1982; E 2004) White or Colored Silicone
Alkyd Paint (Type I, High Gloss and Type
II, Medium Gloss)

SSPC Paint 25 (1997; E 2004) Zinc Oxide, Alkyd, Linseed
Oil Primer for Use Over Hand Cleaned
Steel, Type I and Type II

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.219 Mechanical Power Transmission Apparatus

UNDERWRITERS LABORATORIES (UL)

UL 778 (2016; Reprint Jun 2021) UL Standard for
Safety Motor-Operated Water Pumps

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S"
classification. Submittals not having a "G" or "S" classification are for
information only. When used, a code following the "G" classification
identifies the office that will review the submittal for the Government.
Submit the following in accordance with Section 01 33 00 SUBMITTAL
PROCEDURES:

SD-02 Shop Drawings

System Coordination; G

SD-03 Product Data

Instructions; G

Equipment Data; G

Training Period; G

SD-06 Test Reports

Factory Tests

Field Quality Control

SD-07 Certificates

Manufacturer's Representative

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

Training; G

1.3 QUALITY ASSURANCE

1.3.1 Manufacturer Services

Provide the services of a [manufacturer's representative](#) experienced in the installation, adjustment, and operation of the equipment specified. The representative must supervise the installation, adjustment, testing of the equipment, and conduct training.

Submit the names and qualifications of the manufacturer's representative and training engineers and written certification from the manufacturer that the representative and trainers are technically qualified.

1.3.2 Standard Products

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate equipment that has been in satisfactory HVAC operation at least 2 years prior to issuance of this solicitation. Support equipment with a service organization that is reasonably convenient to the jobsite. Pumps [and motors](#) of the same types must each be the product of one manufacturer.

1.3.3 Conformance with Agency Requirements

Where materials or equipment are specified to be an approved type, attach the seal or label of approval from a nationally recognized testing agency, adequately equipped and competent to perform such services. A written certificate from the testing agency must accompany the materials or equipment and be submitted stating that the items have been tested and that they conform to the applicable requirements of the specifications and to the standards listed herein. The certificate must indicate the methods of testing used by the testing agency. In lieu of a certificate from a testing agency, published catalog specification data, accompanied by the manufacturer's certified statement to the effect that the items are in accordance with the applicable requirements of the specifications and the referenced standards, will be considered and may be acceptable as evidence that the items conform with agency requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect equipment, delivered and designated for storage, from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Hydronic pumps used for heating and air conditioning applications are defined by the type of impeller, number of impellers, type of casing, method of connection to the driver, and mounting position. Provide centrifugal water pumps of the types indicated and specified. Use an electric motor driving unit for each pump as indicated and specified.

2.1.1 Selection Criteria

Select pumps at a point within the maximum efficiency for a given impeller casing combination. Deviations within 3 percent of maximum efficiency are permissible, provided the lesser efficiency is not less than the scheduled efficiency in the construction design documents. Pumps having impeller diameters larger or smaller than manufacturer's published maximum and minimum impeller diameters for a given impeller casing combination will be rejected. Pump performance data, as shown in performance curves, must be based on factory tests using precision instrumentation and exacting procedures as detailed in [HI ANSI/HI 14.6](#).

2.1.2 System Coordination

Submit drawings containing complete wiring and piping schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show the proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation. Provide a complete listing of equipment, materials and miscellaneous components including mechanical seals, bearings, and couplings.

2.1.3 Safety Requirements

Fully enclose or guard couplings, projecting set-screws, keys, and other rotating parts, that pose an entangling hazards..

2.2 MATERIALS AND EQUIPMENT

2.2.1 Nameplates

Securely affix a standard nameplate to pumps and motors in a conspicuous place showing the manufacturer's name, address, type or style, model, serial number, and catalog number. In addition, for each pump show the capacity in [gpm](#) at rated speed in rpm and total head in [feet](#) of water. For each electric motor show at least the minimum information required by [NEMA MG 1](#). Show such other information as the manufacturer may consider necessary to complete identification on the nameplate. Pumps must be listed and labeled by UL, and comply with [UL 778](#) for pumps not using universal motors rated more than 250 volts such as circulating pumps.

2.2.2 Framed Instructions

Submit proposed diagrams, instructions, and other sheets, prior to posting. Post approved wiring and control diagrams showing the complete layout of the entire system, including equipment, piping valves, and control sequence, framed under glass or in approved laminated plastic, where directed. Provide 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, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. Post the framed instructions before acceptance testing of the systems.

2.2.3 Pump Characteristic

Construct hydronic water pumps in accordance with **HI 1.1-1.2** and **HI ANSI/HI 2.1-2.2**. The pumps must be capable of discharging quantities at total discharge heads measured at the discharge flange, between the following limits:

Operate pumps at optimum efficiencies to produce the most economical pumping system under the conditions encountered and size to make optimum match with the system head curve as shown. Pumps must furnish not less than 150 percent of rated capacity at a total discharge head of not less than 65 percent of total rated head. The shutoff total head must not be greater than 120 percent of total rated head. Operate pumps at specified system fluid temperatures without vapor binding and cavitation. Operate pumps to **HI ANSI/HI 9.6.3** standard for Preferred Operating Region (POR).

2.2.4 Pump Drivers

Provide electric motors as indicated for each pump and in compliance with Section **26 20 00** INTERIOR DISTRIBUTION SYSTEM .

2.2.5 Equipment Data

Submit manufacturer's descriptive data and technical literature, performance charts and curves for all impeller sizes for a given casing, catalog cuts, and installation instructions. Provide 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. Include a complete list of parts and supplies, with current unit prices and local source of supply with contact information.

Submit catalog information, certified pumps curves, rated capacities, final impeller dimensions, and accessories provided for the product indicated. Indicate operating point of each pump on curves. Furnish pump curves for each pump and combination of pumps designed to operate in parallel. The pump curve must show as a minimum; bhp, flow, total dynamic head, efficiency, NPSH, impeller diameter and system curve (individually and in combination for each pump operating in a parallel application). Select pumps operating in parallel operation to cross the system curve when operating individually.

2.3 HYDRONIC PUMPS

Provide centrifugal, multi-stage type, designed for HVAC service. **Refer to drawings for pump designation and service.**

2.3.1 Base-Mounted, Flexible Coupled, End suction

Provide pumps with capacities as indicated; base mounted, separately-coupled, end suction designed with volute housing mounted to the frame to allow for pump service without relocating the motor or disturbing piping connections. Bearings and seals must be serviceable without disturbing piping. Pump must be factory hydrostatically tested in

accordance with Hydraulic Institute standards and thoroughly cleaned.

2.3.1.1 Casing

Provide radially split pump casing [ASTM A48/A48M](#) Class 30 cast iron suitable for 175 psig working pressure with integral cast iron flanges drilled for [ASME B16.1](#) ANSI Class 125 flanges, with an integrally-cast pedestal support foot. The pump volute must include gauge tapings at suction and discharge nozzles along with vent and drain tapings at top and bottom.

2.3.1.2 Pump Shaft

Carbon steel pump shaft with a replaceable stainless steel shaft sleeve completely covering the wetted area of the shaft under the seal.

2.3.1.3 Bearing

Incorporate maintenance free, permanently lubricated and sealed bearings in the pump bearing frame.

2.3.1.4 Seal Assembly

Equip with an integrally flushed mechanical seal assembly or a positive pressure external seal flushing line. Provide a mechanical seal with ceramic seal seat and carbon seal ring. Seal assembly must be rated up to 225 degrees F.

2.3.1.5 Baseplate

Baseplate must be of steel construction fully enclosed at sides and ends with welded cross members and fully open grouting area for field grouting. Minimum base plate stiffness must conform to [HI 1.3](#) for horizontal baseplate design standards.

2.3.1.6 Coupler

Provide a flexible-type coupler between the pump and motor, capable of absorbing torsional vibration and variable speed operation between the pump and motor. The coupler must allow replacement with no need to move the hubs. Coupler must have natural rubber or neoprene type element materials with a maximum misalignment capability of 4 degrees angular and 0.125 inches parallel. Provide donut shaped elastomer element with preassembled flanges mechanically clamped to reinforced element and preassembled spacer center assembly. Secure flexible donut shaped element of coupler in place with radial clamp ring screws. Couplers must be rated for required maximum rpm, horsepower and torque. The coupler must be shielded by a coupler guard securely fastened to the base. Provide coupler guard in compliance with current national safety standards including [29 CFR 1910.219](#) and [NEMA Z535.4](#). Guards cannot have gaps greater than 0.250 inches, must be safety orange in color, and have an [NEMA Z535.4](#) compliant warning label.

2.3.1.7 Impeller

Hydraulically and dynamically balance to [HI 9.6.4](#) balance grade G6.3, closed, overhung, single suction, fabricate from cast bronze, key to shaft and secured by a locking capscrew.

2.3.1.8 Motor

Electric Motors must meet NEMA MG 1 and be the horsepower, speed, and voltage indicated. Motor enclosure must be open drip proof. Motor must have heavy duty grease lubricated ball bearings completely adequate for the maximum load for which the motor is designed. Motor must be non-overloading at any point on the pump curve and premium efficiency. Provide motor efficiencies as shown in the ICC IgCC standard.

2.3.2 Cooling Coil Condensate Pump Units

Provide pumps with capacities as indicated. Cooling Coil Condensate Pump Unit must be a packaged unit including a corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory installed check valve and a 72 inch minimum, electrical power cord with plug for 120V/1PH/60HZ electrical service.

2.3.2.1 Motor

Electric motor must comply with NEMA MG 1 and be the size, voltage and enclosure indicated. Provide heavy duty grease lubricated ball bearings completely adequate for the maximum load for which the motor is designed.

2.4 ELECTRICAL WORK

Provide electrical motor driven equipment specified herein complete with motors, motor starters, and controls. Provide electric equipment and wiring in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics must be as indicated. Provide motor starters complete with properly sized thermal overload protection in each phase and other appurtenances necessary for the motor control specified. Each motor must be of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor when operating at proper electrical system voltage and frequency. Manual or automatic control and protective or signal devices required for the operation herein specified and any control wiring required for controls and devices but not indicated must be provided under this section of the specifications.

2.5 ELECTRICAL EQUIPMENT

Provide electrical equipment in conformance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical motor driven equipment herein specified complete with motors, motor starters, and controls. Motor controls, equipment, and wiring must be in accordance with NFPA 70.

2.5.1 Electric Motors

Drive each electric motor-driven pump by a continuous-duty electric motor with enclosure type for specific service as defined in paragraph HYDRONIC PUMPS. Motor must have a 1.5 service factor. Provide synchronous motors having normal-starting-torque and low-starting-current characteristics, and of sufficient size so that the nameplate horsepower rating will not be exceeded throughout the entire published pump characteristic curve. Integral size motors must be the premium efficiency type in accordance with NEMA MG 1. Pump electric motor efficiencies must meet or exceed the requirements of the ICC IgCC standard. Motor bearings must provide smooth operations under the conditions encountered for the life of the motor. Provide adequate thrust bearing in the motor to carry the weight of all

rotating parts plus the hydraulic thrust and be capable of withstanding upthrust imposed during pump starting and under variable pumping head conditions specified. Motors must be rated 460 volts, 3 phase, 60 Hz and such rating must be stamped on the nameplate. Provide motors in conformance with NEMA MG 1.

2.5.2 Control Equipment

Automatically controlled pumps must have three-position "MANUAL-OFF-AUTOMATIC" selector switch in cover. Provide additional controls or protective devices as indicated. Install a pump low-water cutoff on the suction pipe and must shut the pump off when the water level in the well reaches the level shown.

2.5.3 Variable Speed Control

The variable speed motor controllers must meet the requirements of UFGS 26 29 23 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.

2.6 EQUIPMENT APPURTENANCES

2.6.1 Attachments

Furnish all necessary bolts, nuts, washers, bolt sleeves, and other types of attachments with the equipment for the installation of the equipment. Bolts conform to the requirements of ASTM A307 and hexagonal nuts of the same quality as the bolts used. Threads must be clean-cut and conform to ASME B1.1. Bolts, nuts, and washers specified to be galvanized or not otherwise indicated or specified, must be zinc coated after being threaded, by the hot-dip process conforming to ASTM A123/A123M as appropriate. Bolts, nuts, and washers specified or indicated to be stainless steel must be Type 316.

2.6.2 Equipment Guards

Provide equipment driven by open shafts, belts, chains, or gears with all-metal guards enclosing the drive mechanism. Secure guards in position with steel braces or straps that permit easy removal for servicing the equipment. Coupler guards must comply with current national safety standards including 29 CFR 1910.219 and NEMA Z535.4. Provide guards with gaps no greater than 0.250 inches, safety orange in color, and have an NEMA Z535.4 compliant warning label.

2.6.3 Tools

Furnish a complete set of all special tools which may be necessary for the adjustment, operation, maintenance, and disassembly of all equipment. Special tools are considered to be those tools which because of their limited use are not normally available, but which are necessary for the particular equipment. Special tools must be high-grade, smooth, forged, alloy, tool steel. Furnish one pressure grease gun for each type of grease required. Deliver all tools at the same time as the equipment to which they pertain. Properly store and safeguard such tools until completion of the work, at which time deliver them to the Contracting Officer.

2.7 FINISHES

All motors, pump casings, and similar parts of equipment must be

thoroughly cleaned, primed, and given two finish coats of paint at the factory in accordance with the recommendations of the manufacturer. Give ferrous surfaces not to be painted a shop coat of grease or other suitable rust-resistant coating.

2.8 FACTORY TESTS

Pumps must be tested by the manufacturer or a nationally recognized testing agency in compliance with **HI 1.3**. Submit certified test results.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Install each pump and motor in accordance with the written instructions of the manufacturer. Provide access space around the device for servicing no less than the minimum recommended by the manufacturer.

3.2.1 Base Mounted, Long-Coupled Pumps

Set the pump baseplate as follows.

- a. Place two sets of shims or wedges for each foundation bolt. Lower baseplate onto foundation bolts and level baseplate both lengthwise and across by adding or removing shims or mount wedges. A maximum difference of **0.125 inches** lengthwise and **0.059 inches** across is allowable.
- b. Mount pump and driver on baseplate if not already mounted at factory. Pump and driver shafts must have initial cold (pump and driver at ambient temperature) alignment check and final hot (pump and driver at operating temperature) alignment check. Perform cold alignment check before baseplate is grouted, after baseplate is grouted, and after piping is connected. Perform final alignment check when pump and driver are at operating temperature. Move or shim only the driver to make adjustments to prevent strain on the piping installations. Initial alignment may be performed with scales, straight edges and calipers. Final alignment must be done with dial gauges or laser alignment devices. Final alignment misalignment may not exceed coupling manufacturer's maximum parallel and angular misalignment values. When using variable frequency drives, reduce the manufacturer's misalignment values by 50 percent. Remove flexible coupling when performing alignment.
- c. Support the connecting piping to ensure that there are no piping loads at the pump flange connections and connecting piping is not forced into position. Use concrete for equipment foundations as specified in Section **03 30 00** CAST-IN-PLACE CONCRETE. Provide concrete foundations that are integral with and of the same class as that of the building floor unless otherwise indicated. Use concrete having a compressive strength of at least **2,500 psi** in foundations that are entirely separated from the surrounding floor. Install a premolded filler strip between the foundation and floor slab as shown. Furnish

foundation bolts, as required, for proper positioning during the placement of the concrete.

3.3 FIELD QUALITY CONTROL

After installation of the pumping units and appurtenances, including coupling guard, is complete, carry out operating tests to assure that the pumping installation operates properly. Give each pumping unit a running field test in the presence of the Contracting Officer for a minimum of 2 hours. Operate each pumping unit at its rated capacity or such other point on its head-capacity curve selected by the Contracting Officer. Provide an accurate and acceptable method of measuring the discharge flow. Tests must assure that the units and appurtenances have been installed correctly, that there is no objectionable heating, vibration, or noise from any parts, and that all manual and automatic controls function properly. If any deficiencies are revealed during any tests, correct such deficiencies and reconduct the tests.

Submit 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 must indicate the final position of controls.

3.4 FIELD PAINTING

Do not paint stainless steel, galvanized steel, and nonferrous surfaces.

3.4.1 Touch-up painting

Factory painted items requiring touching up in the field must be thoroughly cleaned of all foreign material, and primed and topcoated with the manufacturer's standard factory finish.

3.4.2 Exposed Ferrous Surfaces

Paint exposed ferrous surfaces with two coats of enamel paint conforming to [SSPC Paint 21](#). Solvent clean factory primed surfaces before painting. Surfaces that have not been factory primed must be prepared and primed with one coat of [SSPC Paint 25](#) or in accordance with the enamel paint manufacturer's recommendations.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Operation and Maintenance Manuals

Submit one complete set at the time the tests procedure is submitted; remaining sets before the contract is completed. Permanently bind each in a hard cover. Inscribe the following identification on the covers: the words "OPERATING AND MAINTENANCE INSTRUCTIONS," name and location of the building, name of the Contractor, and contract number. Place flysheets before instructions covering each subject. Use [8-1/2 by 11 inches](#) paper for instruction sheets, with large sheets of drawings folded in.

Include, but do not limit to, the following in the Instructions:

- a. System layout showing piping, valves, and controls.
- b. Approved wiring and control diagrams including variable frequency

drives.

- c. A control sequence describing startup, operation, and shutdown.
- d. Operating and maintenance instructions for each piece of equipment, including task list for routine maintenance, routine inspections, intermediate inspections, and annual inspections; lubrication instructions; and troubleshooting guide.
- e. Manufacturer's bulletins, cuts, and descriptive data; and parts list and recommended spare parts.

3.5.2 Training

Upon completion of the work, and at a time designated by the Contracting Officer, provide the services of one or more competent engineers for a [training period](#) of not less than 2 hours to instruct a representative of the Government in the contents of the operation and maintenance manuals for the equipment furnished under these specifications. These field instructions must cover all the items contained in the bound instructions. Submit the training course curriculum and training instructions 14 days prior to the start of training.

-- End of Section --

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SECTION 23 23 00

REFRIGERANT PIPING

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, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 710 I-P (2009) Performance Rating of Liquid-Line Driers

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15 & 34 (2013) ASHRAE Standard 34-2016 Safety Standard for Refrigeration Systems/ASHRAE Standard 34-2016 Designation and Safety Classification of Refrigerants-ASHRAE Standard 34-2016

ASHRAE 90.1 - IP (2019; Errata 1 2019; Errata 2-6 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 7-8 2021; Interpretation 1-4 2020; Interpretation 5-8 2021; Addenda AS-CB 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.22 (2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASME B16.26 (2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes

ASME B31.1 (2020) Power Piping

ASME B31.5 (2020) Refrigeration Piping and Heat Transfer Components

ASME BPVC SEC IX (2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M (2019) Specification for Filler Metals for Brazing and Braze Welding

AWS A5.31/A5.31M (2012) Specification for Fluxes for

Brazing and Braze Welding

AWS BRH

(2007; 5th Ed) Brazing Handbook

AWS D1.1/D1.1M

(2020; Errata 1 2021) Structural Welding
Code - Steel

AWS Z49.1

(2021) Safety in Welding and Cutting and
Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M

(2020) Standard Specification for Pipe,
Steel, Black and Hot-Dipped, Zinc-Coated,
Welded and Seamless

ASTM A653/A653M

(2020) Standard Specification for Steel
Sheet, Zinc-Coated (Galvanized) or
Zinc-Iron Alloy-Coated (Galvannealed) by
the Hot-Dip Process

ASTM B32

(2020) Standard Specification for Solder
Metal

ASTM B62

(2017) Standard Specification for
Composition Bronze or Ounce Metal Castings

ASTM B75/B75M

(2020) Standard Specification for Seamless
Copper Tube

ASTM B117

(2019) Standard Practice for Operating
Salt Spray (Fog) Apparatus

ASTM B280

(2020) Standard Specification for Seamless
Copper Tube for Air Conditioning and
Refrigeration Field Service

ASTM B813

(2016) Standard Specification for Liquid
and Paste Fluxes for Soldering of Copper
and Copper Alloy Tube

ASTM D520

(2000; R 2011) Zinc Dust Pigment

ASTM D3308

(2012; R 2017) Standard Specification for
PTFE Resin Skived Tape

ASTM E84

(2020) Standard Test Method for Surface
Burning Characteristics of Building
Materials

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS
INDUSTRY (MSS)

MSS SP-58

(2018) Pipe Hangers and Supports -
Materials, Design and Manufacture,
Selection, Application, and Installation

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Refrigerant Piping System; G

SD-03 Product Data

Refrigerant Piping System

Spare Parts

Qualifications

Refrigerant Piping Tests

Verification of Dimensions

SD-06 Test Reports

Refrigerant Piping Tests

SD-07 Certificates

Service Organization

SD-10 Operation and Maintenance Data

Maintenance; G

Operation and Maintenance Manuals; G

Demonstrations; G

1.3 QUALITY ASSURANCE

1.3.1 Qualifications

Submit 2 copies of qualified procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations. Weld piping in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders must 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. Notify the Contracting Officer 24 hours in advance of tests to be performed at the work site, if practical. The welder or welding operator must apply the personally assigned symbol near each weld made, as a permanent record. .

1.3.2 Contract Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. 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.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect stored items 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 is the Contractor's responsibility. Replace any materials found to be damaged at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

1.5 MAINTENANCE

1.5.1 General

Submit Data Package 2 plus operation and maintenance data complying with the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

1.5.2 Extra Materials

Submit 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. 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 in the data.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

- a. Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship and that have been in satisfactory commercial or industrial use for 2 years prior to bid opening.
- b. The 2 year use must 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, 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.
- c. Products must be supported by a service organization. System components must be environmentally suitable for the indicated locations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their

addresses and qualifications. The service organizations must 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.

- d. Exposed equipment moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.
- e. Provide the manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component. Highlight the data to show information such as, but not limited to, material, size, options, performance charts, and curves in adequate detail to demonstrate compliance with contract requirements. Include the manufacturer's recommended installation instructions and procedures in the data provided. Provide data for the following components as a minimum:
 - (1) Piping and Fittings
 - (2) Valves
 - (3) Piping Accessories
 - (4) Pipe Hangers, Inserts, and Supports

2.2 ELECTRICAL WORK

Electrical equipment and wiring must be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Field wiring must be in accordance with manufacturer's instructions.

2.3 REFRIGERANT PIPING SYSTEM

Provide refrigerant piping, valves, fittings, and accessories in accordance with ASHRAE 15 & 34 and ASME B31.5, except as specified herein. Refrigerant piping, valves, fittings, and accessories must 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 must be cleaned, dehydrated, and sealed (capped or plugged) prior to shipment from the manufacturer's plant. Submit drawings, at least 5 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings must consist of:

- a. Piping layouts which identify all valves and fittings.
- b. Plans and elevations which identify clearances required for maintenance and operation.

2.4 PIPE, FITTINGS AND END CONNECTIONS (JOINTS)

2.4.1 Copper Tubing

Provide copper tubing conforming to ASTM B280 annealed or hard drawn as required. Copper tubing must bear the product identification markings in accordance with ASTM B280, "ACR" must be present on copper tubing. Copper tubing must be soft annealed where bending is required and hard drawn

where no bending is required. Soft annealed copper tubing must not be used in sizes larger than **1-3/8 inches**. Joints must be brazed except that joints on lines **7/8 inch** and smaller may be flared. Cast copper alloy fittings for flared copper tube must conform to **ASME B16.26** and **ASTM B62**. Wrought copper and bronze solder-joint pressure fittings must conform to **ASME B16.22** and **ASTM B75/B75M**. Joints and fittings for brazed joint must be wrought-copper or forged-brass sweat fittings. Cast sweat-type joints and fittings are not 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.

2.4.2 Solder

Solder must conform to **ASTM B32**, grade Sb5, tin-antimony alloy for service pressures up to **150 psig**. Solder flux must be liquid or paste form, non-corrosive and conform to **ASTM B813**.

2.4.3 Brazing Filler Metal

Filler metal must conform to **AWS A5.8/A5.8M**, Type BAg-5 with AWS Type FB3-A or Type FB3-C flux, except Type BCuP-3, BCuP-4, or BCuP-5 may be used for brazing copper-to-copper joints. BAlSi-4 with AWS Type FB1-A flux may be used when joining copper piping to aluminum components.

2.4.4 Brazing Flux

Brazing flux must conform to **AWS A5.31/A5.31M**, Type FB3-A or Type FB3-C when using Type BAg-5 filler metal. Type FB1-A is to be used with Type BAlSi-4 filler metal.

2.4.5 Press Fittings

Press fittings are not acceptable for use in refrigerant piping systems.

2.5 PIPING ACCESSORIES

2.5.1 Filter Driers

Driers must conform to **AHRI 710 I-P**. Sizes **5/8 inch** and larger must be the full flow, replaceable core type. Sizes **1/2 inch** and smaller must be the sealed type. Cores must be of suitable desiccant that will not plug, cake, dust, channel, or break down, and must remove water, acid, and foreign material from the refrigerant. Construct filter driers so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure must be **1,500 psi**.

2.5.2 Pipe Hangers, Inserts, and Supports

Provide pipe hangers, inserts, guides, and supports conforming to **MSS SP-58**.

2.5.3 Escutcheons

Escutcheons must be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.6 FABRICATION

2.6.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish, except that items located outside of buildings must have weather resistant finishes that will withstand 500 hours exposure to the salt spray test specified in [ASTM B117](#) using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond [1/8 inch](#) on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to [ASTM D520](#), Type I.

2.6.2 Factory Applied Insulation

Factory installed insulation must be in accordance with [ASHRAE 90.1 - IP](#). Refrigerant pumps and exposed chilled water lines on absorption chillers must be insulated with not less than [1/2 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 must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes must be determined by [ASTM E84](#). Test insulation in the same density and installed thickness as the material to be used in the actual construction. Test material supplied by a manufacturer with a jacket as a composite material. Provide jackets, facings, and adhesives that have a flame spread index less than 25 and a smoke developed index less than 50 when tested in accordance with [ASTM E84](#).

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform a [verification of dimensions](#) in the field. Submit 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 before performing any work.

3.2 INSTALLATION

Pipe and fitting installation must conform to the requirements of [ASME B31.1](#). Cut pipe accurately to measurements established at the jobsite, and work 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 is not permitted without written approval. Cut pipe or tubing square, remove by reaming, and permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

3.2.1 Directional Changes

Make changes in direction with fittings, except that bending of pipe [4](#)

inches and smaller is 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 is not permitted. The centerline radius of bends must not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted.

3.2.2 Functional Requirements

Install piping 1/2 inch/10 feet of pipe in the direction of flow to ensure adequate oil drainage. Properly cap or plug open ends of refrigerant lines or equipment during installation to keep moisture, dirt, or other foreign material out of the system. Piping must remain capped until installation. Equipment piping must be in accordance with the equipment manufacturer's recommendations and the contract drawings. Equipment and piping arrangements must fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance.

3.2.3 Fittings and End Connections

3.2.3.1 Threaded Connections

Make threaded connections with tapered threads and make tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint compound applied to the male threads only. Do not show more than three threads after the joint is made.

3.2.3.2 Brazed Connections

Perform brazing in accordance with AWS BRH, except as modified herein. During brazing, fill the pipe and fittings with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, clean both the outside of the tube and the inside of the fitting with a wire fitting brush until the entire joint surface is bright and clean. Do not use brazing flux on copper-to-copper connections. Remove surplus brazing material at all joints. Make steel tubing joints in accordance with the manufacturer's recommendations. Paint joints in steel tubing with the same material as the baked-on coating within 8 hours after joints are made. Protect tubing against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Support piping prior to brazing and do not spring or force.

3.2.3.3 Welded Connections

Fusion-weld joints in steel refrigerant piping. Make branch connections with welding tees or forged welding branch outlets. Thoroughly clean pipe of all scale and foreign matter before the piping is assembled. During welding, fill the pipe and fittings with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld must conform to ASME B31.1. Remove and reweld weld defects at no additional cost to the Government. Store and dry electrodes in accordance with AWS D1.1/D1.1M or as recommended by the manufacturer. Do not use electrodes that have been wetted or that have lost any of their coating

3.2.3.4 Flared Connections

When flared connections are used, use a suitable lubricant between the

back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.2.3.5 Flanged Connections

When steel refrigerant piping is used, provide union or flange joints 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 must be assembled square end tight with matched flanges, gaskets, and bolts. Provide gaskets that are suitable for use with the refrigerants to be handled.

3.2.4 Filter Dryer

Provide a liquid line filter dryer on each refrigerant circuit located such that all liquid refrigerant passes through a filter dryer. Size dryers in accordance with the manufacturer's recommendations for the system in which it is installed. Install dryers such that it can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Install dryers in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

3.2.5 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports must conform to [MSS SP-58](#), except as modified herein. Do not use pipe hanger types 5, 12, and 26. Fabricate hangers used to support piping [2 inches](#) and larger to permit adequate adjustment after erection while still supporting the load. Support piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, by variable spring hangers and supports or by constant support hangers.

3.2.5.1 Hangers

Do not use Type 3 on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.2.5.2 Inserts

Secure Type 18 inserts 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.

3.2.5.3 C-Clamps

Torque Type 19 and 23 C-clamps in accordance with [MSS SP-58](#) and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.2.5.4 Angle Attachments

Furnish Type 20 attachments used on angles and channels with an added malleable-iron heel plate or adapter.

3.2.5.5 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, must be

used on all pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Use Type 40 shields on all piping less than 4 inches and all piping 4 inches and larger carrying medium less than 60 degrees F. Use a high-density insulation insert of cellular glass under the Type 40 shield for piping 2 inches and larger.

3.2.5.6 Horizontal Pipe Supports

Space horizontal pipe supports as specified in MSS SP-58 and install a support no more than 1 foot from the pipe fitting joint at each change in direction of the piping. Space pipe supports no more than 5 feet apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 50 pounds must have the excess hanger loads suspended from panel points.

3.2.5.7 Vertical Pipe Supports

Support vertical pipe at each floor, except at slab-on-grade, and at intervals of not more than 15 feet not more than 8 feet from end of risers, and at vent terminations.

3.2.5.8 Pipe Guides

Provide Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides where required to allow longitudinal pipe movement. Provide lateral restraints as required. Provide slide materials that are suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.2.5.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4 inches and larger, use a Type 39 saddle. On piping under 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.2.5.10 High Temperature Guides with Cradles

Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide must include a pipe cradle, welded to the guide structure and strapped securely to the pipe. Separate the pipe from the slide material by at least 4 inches, or by an amount adequate for the insulation, whichever is greater.

3.2.5.11 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, use a clip or clamp where each pipe crosses the base support member. Spacing of the base support members must not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.2.5.12 Structural Attachments

Attachment to building structure concrete and masonry must be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors must be applied with a safety factor not less than 5. Do not attach supports to metal decking. Construct masonry anchors for overhead applications of ferrous materials only. Provide structural steel brackets

required to support piping, headers, and equipment, but not shown, under this section.

3.2.6 Building Surface Penetrations

Do not install sleeves in structural members except where indicated or approved. Provide galvanized sheet metal sleeves in non-load bearing surfaces conforming to **ASTM A653/A653M**, Coating Class G-90, **20 gauge**. Provide uncoated carbon steel pipe sleeves in load bearing surfaces conforming to **ASTM A53/A53M**, Schedule 30. Apply sealants to moisture and oil-free surfaces and elastomers to not less than **1/2 inch** depth. Do not install sleeves in structural members.

3.2.6.1 Refrigerated Space

Fit refrigerated space building surface penetrations 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. Construct sleeves with integral collar or fit cold side with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, fill voids with latex mixed mortar cast to shape of sleeve and assemble flange/external collar type sleeve with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Flash integral cast-in collar type sleeve with not less than **4 inches** of cold side vapor barrier overlap of sleeve surface. Normally seal noninsulated penetrating round surfaces to sleeve bore with mechanically expandable seals in vapor tight manner and insulate remaining warm and cold side sleeve depth with not less than **4 inches** of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Apply vapor barrier sealant to finish warm side insulation surface. Insulate warm side of penetrating surface beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Seal wires in refrigerated space surface penetrating conduit with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.2.6.2 General Service Areas

Extend each sleeve through its respective wall, floor, or roof, and cut flush with each surface. Provide pipes passing through concrete or masonry wall or concrete floors or roofs with pipe sleeves fitted into place at the time of construction. Provide sleeves that allow a minimum of **1/4 inch** all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, seal the annular space between pipe and sleeve or between jacket over-insulation and sleeve in accordance with Section **07 92 00 JOINT SEALANTS**.

3.2.6.3 Waterproof Penetrations

Install pipes passing through roof or floor waterproofing membrane through a **17 ounce** copper sleeve, or a **0.032 inch** thick aluminum sleeve, each within an integral skirt or flange. Form flashing sleeve, and extend skirt or flange greater than **8 inches** from the pipe and set over the roof or floor membrane in a troweled coating of bituminous cement. Extend the flashing sleeve up the pipe a minimum of **2 inches** above the roof or floor penetration. Seal the annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered

insulation as indicated. Seal penetrations by either one of the following methods.

3.2.6.3.1 Waterproofing Clamping Flange

Pipes up to and including 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. Clamp waterproofing membrane into place and place sealant in the caulking recess.

3.2.6.3.2 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. Provide seals consisting 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. Loosely assemble links 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, tighten the bolt to cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Size each seal assembly as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals must provide sleeves of the proper diameters.

3.2.6.4 Fire-Rated Penetrations

Seal penetration of fire-rated walls, partitions, and floors as specified in Section 07 84 00 FIRESTOPPING.

3.2.6.5 Escutcheons

Provide escutcheons for finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Where sleeves project slightly from floors, use special deep-type escutcheons. Secure escutcheon to pipe or pipe covering.

3.2.7 Access Panels

Provide access panels for all concealed valves, vents, controls, and items requiring inspection or maintenance. Provide access panels of sufficient size and locate so that the concealed items may be serviced and maintained or completely removed and replaced. Provide access panels as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.2.8 Field Applied Insulation

Field installed insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.2.9 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.2.9.1 Color Coding

Color coding for piping identification is specified in Section 09 90 00 PAINTS AND COATINGS.

3.2.9.2 Color Coding Scheme

Provide a color coding scheme for locating hidden piping in accordance with the existing facility scheme.

3.2.10 Identification Tags

Provide identification tags made of brass, engraved laminated plastic or engraved anodized aluminum indicating service and item number on all valves and dampers. Tags must be 1-3/8 inch minimum diameter and marking must be stamped or engraved. Indentations must be black for reading clarity. Attach tags to valves with No. 12 AWG copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.3 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 are considered contaminated systems. Restore contaminated systems to clean condition including disassembly, component replacement, evacuation, flushing, purging, and re-charging, using currently approved refrigerant and refrigeration manufacturer's procedures. Restore contaminated systems at no additional cost to the Government as determined by the Contracting Officer. Do not use water in any procedure or test.

3.4 TRAINING COURSE

- a. Submit 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. Conduct a training course for 2 members of the operating staff as designated by the Contracting Officer. The training period must consist of a total 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests.
- b. Cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations in the field posted instructions..
- c. Submit 6 complete copies of an operation manual in bound 8 1/2 by 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. Include the manufacturer's name, model number, and parts list in the booklets. Include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features in the manuals.
- d. Submit 6 complete copies of maintenance manual in bound 8 1/2 x 11 inch booklets listing routine maintenance procedures, possible breakdowns

and repairs, and a trouble shooting guide. Include piping layouts and simplified wiring and control diagrams of the system as installed in the manuals.

3.5 REFRIGERANT PIPING TESTS

After all components of the refrigerant system have been installed and connected, subject the entire refrigeration system to pneumatic, evacuation, and startup tests as described herein. Submit a schedule, at least 2 weeks prior to the start of related testing, for each test. Identify the proposed date, time, and location for each test. Conduct tests in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Provide all material, equipment, instruments, and personnel required for the test. Provide the services of a qualified technician, as required, to perform all tests and procedures indicated herein. Coordinate field tests with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Submit 6 copies of the tests report in bound 8 1/2 by 11 inch booklets documenting all phases of the tests performed. Include initial test summaries, all repairs/adjustments made, and the final test results in the report.

3.5.1 Preliminary Procedures

Prior to pneumatic testing, isolate 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, from the test pressure, or remove from the system. Remove safety relief valves and rupture discs that are not part of factory sealed systems, and cap or plug openings.

3.5.2 Pneumatic Test

Provide pressure control and excess pressure protection at the source of test pressure. Valves must be wide open, except those leading to the atmosphere. Test gas must be dry nitrogen, with minus 70 degree F dewpoint and less than 5 ppm oil. Apply test pressure in two stages before any refrigerant pipe is insulated or covered. In accordance with ASME B31.5, a preliminary test not to exceed 25 psi must be applied as a means of locating major leaks. Every joint being tested must be coated with a thick soap or color indicating solution. The second stage test pressure must be at least 110 percent of the design pressure, but cannot exceed 130 percent of the design pressure of any component in the system. For large systems that are not completely visible, the pressure in the system must be gradually increased to one-half of the test pressure after which the pressure must be increased in steps of one-tenth of the test pressure, until the required test pressure has been reached. The test pressure must be continuously maintained for at least 24 hours, after which it can be reduced to the leak test pressure. A correction factor of 0.3 psi will be allowed for each degree F change between test space initial and final ambient temperature, plus for increase and minus for a decrease. The leak test pressure must be the design pressure, or a pressure specified in the engineering design. To repair leaks, the joint must be taken apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, re-melting, or back-welding/brazing are not acceptable. Following repair, the entire system must be retested using the pneumatic tests described above. Reassemble the entire system once the pneumatic tests are satisfactorily completed.

3.5.3 Evacuation Test

Following satisfactory completion of the pneumatic tests, relieve the pressure and evacuate the entire system to an absolute pressure of 300 micrometers. During evacuation of the system, the ambient temperature must be higher than 35 degrees F. Do not evacuate no more than one system at one time by one vacuum pump. Once the desired vacuum has been reached, close the vacuum line and allow the system to stand for 1 hour. If the pressure rises over 500 micrometers after the 1 hour period, evacuate the system again down to 300 micrometers and let set for another 1 hour period. Do not charge the system 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 rises above 500 micrometers, continue to repeat the evacuation procedures until all residual moisture has been removed. During evacuation, record pressures by a thermocouple-type, electronic-type, or a calibrated-micrometer type gauge.

3.5.4 System Charging and Startup Test

Following satisfactory completion of the evacuation tests, charge the system with the required amount of refrigerant by raising pressure to normal operating pressure and in accordance with manufacturer's procedures. Following charging, the system must operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. Test the entire system tested for leaks. Test fluorocarbon systems with halide torch or electronic leak detectors.

3.5.5 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system must be immediately isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. The refrigerant must not be discharged into the atmosphere.

3.5.6 Contractor's Responsibility

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 must 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 will the allowable leak rate exceed the leak rates allowed in Section 608 of the Clean Air Act: 30 percent of the full charge per year for industrial refrigeration, 20 percent of the full charge per year for commercial refrigeration, and 10 percent of the full charge per year for comfort cooling. Any system leaks within the first year must 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.

-- End of Section --

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SECTION 23 25 00

CHEMICAL TREATMENT OF WATER FOR MECHANICAL SYSTEMS

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 OF MECHANICAL ENGINEERS (ASME)

ASME B40.100 (2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM D596 (2001; R 2018) Standard Guide for Reporting Results of Analysis of Water

ASTM D1384 (2005; R 2019) Corrosion Test for Engine Coolants in Glassware

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Water Treatment System; G

Spare Parts

Field Instructions

Tests; G

Training Course; G

SD-06 Test Reports

Condenser Water QA Tests

SD-10 Operation and Maintenance Data

Water Treatment System

1.3 MAINTENANCE MATERIAL SUBMITTALS

Submit **spare parts** data for each different item of material and equipment specified, after approval of the detail drawings, not later than **2** months prior to the date of beneficial occupancy. Include a complete list of parts and supplies, with source of supply, with the data.

1.4 QUALITY CONTROL

1.4.1 Safety

Ensure 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 are insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired. Provide catwalk, ladder, and guardrail where indicated and in accordance with Section **05 50 13 MISCELLANEOUS METAL FABRICATIONS** .

1.4.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. 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.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Summary

This section covers the provisions and installation procedures necessary for a complete and totally functional water system(s) chemical treatment. Provide and install the system with all necessary System Components, Accessories, Piping Components, and Supplemental Components/Services.

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2.1.2 Standard Products

- a. Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship and that have been in satisfactory commercial or industrial use for two years' prior to bid opening.
- b. Include in the two-year use all applications of equipment and materials under similar circumstances and of similar size. Ensure the

two years' experience has been 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 two-year field service record are 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.

- c. All products are required to be supported by a service organization. Submit a certified list of qualified permanent service organizations for support of the equipment, including their addresses and qualifications. These service organizations are required to be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.
- d. The selected service organization provides the chemicals required, the concentrations required, and the water treatment equipment sizes and flow rates required. The company provides all chemicals required for the condenser and chilled water systems and fills the systems with chemicals to the levels specified. The chemical is required to meet the requirements of this specification as well as the recommendations from the manufacturers of the condenser and cooling tower. Acid treatment chemicals are not allowed to be used.

2.2 EQUIPMENT

2.2.1 Nameplates

Provide a nameplate for each major component of equipment that includes the manufacturer's name, address, type or style, and catalog or serial number securely attached to the item of equipment. Provide nameplates for:

- a. Pump(s)
- b. Pump Motor(s)
- c. Water Treatment Controller(s)

2.2.2 Electrical Work

Ensure all electrical equipment, motors, motor efficiencies, and wiring complies with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical motor driven equipment specified complete with motors, motor starters, and controls. Provide electrical characteristics and enclosure types as shown, and unless otherwise indicated, provide all motors of 1 horsepower and above with open, drip-proof, or totally enclosed fan cooled enclosures, high efficiency type. Perform field wiring in accordance with manufacturer's instructions. Each motor is required to conform to NEMA MG 1 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Provide continuous duty motors with the enclosure specified. Provide motor starters complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Furnish motors with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Furnish motor starters with NEMA 3R enclosures. Provide 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.

2.2.3 Gauges

Provide gauges that conform to ASME B40.100, Class 1, 2, or 3, Style X, Type I or III as required, 4-1/2 inches in diameter with phenolic or metal case.

2.3 COMPONENTS

2.3.1 Condenser Water Treatment Systems

The use of chemical-treatment products containing hexavalent chromium (Cr) is prohibited. Treat the water to be used in the condenser water systems to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Chemicals are required to meet all required federal, state, and local environmental regulations for the treatment of condenser-side heat exchangers, cooling towers and direct discharge to the sanitary sewer.

Provisions should be made to effectively dose, monitor and control a water treatment program to include (1) inhibitor and biocide injection (2) water sampling, (3) corrosion coupon sampling, and (4) effective bleed and control points.

2.3.1.1 Condenser Water Limits

Meet the following condenser water limits, unless dictated differently by the cooling tower or chiller manufacturer's recommendations:

Treatment type	Phosphonate/Polymer
Puckorius Index	4 minimum
Langelier Index	4 maximum
Total Dissolved Solids	5000 ppm maximum
Calcium Hardness	1200 ppm maximum
Silica	150 ppm maximum
pH	7.5 - 8.5

For treated condenser/cooling tower water, minimize blowdown until the first of one of the top 5 limits is reached. Specific requirements for treatment chemicals and levels are listed below in paragraphs dealing with small and large systems.

2.3.1.2 Glycol Solution

Coordinate minimum glycol concentration with manufacturer to avoid corrosion inhibitor degradation. Test the glycol in accordance with ASTM D1384 with less than 0.5 mils penetration per year for all system metals. Provide glycol that contains corrosion inhibitors. Silicate based inhibitors are not acceptable. Ensure the solution is compatible with pump seals, other elements of the system, and water treatment

chemicals used within the system.

2.3.1.3 Chemical Treatment for Small Systems

For cooling systems with a capacity of 50 tons or less, provide the following chemical treatment. For corrosion control provide 15 to 20 pounds polyphosphate in nylon mesh bag in cooling tower sump. If biocide is needed, use either 1-bromo-3-chloro-5.5-dimethylhydantoin or gluteraldehyde as recommended by manufacturer.

2.3.1.4 Chemical Treatment for Large Systems

For cooling systems with capacities greater than 50 tons provide one of the three following chemical treatments with the limits indicated. The zinc and molybdate in the last two treatments help to meet the maximum corrosion requirements in waters that tend to be more corrosive. Maintain biocides to control bacteria below 10,000 colony forming units per milliliter.

a. Phosphonate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
TT	1-2 ppm
Biocides	as required

b. Zinc-Phosphonate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
Zinc	1-2 ppm
TT	1-2 ppm
Biocides	as required

c. Zinc-Molybdate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
Molybdate	10-15 ppm
Zinc	2-3 ppm

TT	1-2 ppm
Biocides	as required

2.3.1.4.1 General Requirements

Provide a **water treatment system** capable of automatically feeding chemicals and bleeding the system to prevent corrosion, scale, and biological formations. Submit 6 complete copies, at least 5 weeks prior to the purchase of the water treatment system, of the proposed water treatment plan including a layout; control scheme; a list of existing make-up water chemistry; a list of treatment chemicals to be added; the proportion of chemicals to be added; the final treated water control levels; and a description of health, safety and environmental concerns for handling the chemicals plus any special ventilation requirements. Automatic chemical feed systems automatically feed chemicals into the condenser water based on makeup water rate. Use electrical signals from a water meter on the makeup water line to control the output of chemical feed pumps. Set the system initially manually based on the water analysis of the make-up water. Submit 6 complete copies of operating and maintenance manuals for the step-by-step water treatment procedures. Include in the manuals all testing procedures used in determining water quality.

2.3.1.4.2 Chemical Feed Pumps and Tanks

- a. Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. Furnish chemical feed pumps of the positive displacement diaphragm type. Furnish all pump cylinders, plungers, ball check valves, and check valve bodies made of corrosion resistant materials suitable for the chemicals being pumped. Ensure the cylinders of the provided pumps are replaceable for increased or reduced pressure or capacity ranges.
- b. Provide pumps with a flow rate adjustable from 0 to 100 percent while in operation. The volumetric accuracy of the pumps is required to be within one percent over the range indicated. Ensure pump capacities are adjustable by positioning crank pin with micrometer setscrews. Divide stroke length scale in percentage graduations engraved on scale. Ensure the discharge pressure of pumps is not less than 1.5 times the line pressure at the point of connection. Provide the pumps with a pressure relief valve and a check valve mounted in the pump discharge. Control the pump by an external controller/timer receiving signals from the makeup water meter.
- c. Provide drive motors rated at 110 volt, single phase with drip-proof enclosures. Provide two chemical tanks constructed of materials compatible with the chemicals to be stored in the tank with a hinged cover and mounted on legs. Ensure tanks have filling and drain connections and gauge glasses. Furnish each tank with one pump, mounted and piped with pipe materials and fittings suitable for working pressure and compatible with the chemicals in the tank it is in contact with, with suction strainer and stainless steel screen, and with **1/2 inch** relief valve with steel body and stainless steel trim. Provide a tank bottom that is dished concave to a radius equal to the diameter of the tank. Provide motor-driven agitator. Size the tanks to have sufficient capacity to require recharging only once per 14

days during normal operation.

2.3.1.4.3 Chemical Injection Assembly

Provide an injection assembly at each chemical feed point. Locate the injection assembly downstream of recirculating pumps and upstream of the condenser. Construct the injection assemblies of stainless steel. Locate the discharge of the assemblies in the condenser water piping as recommended by the manufacturer. Include with each assembly a shutoff valve and check valve at the point of entrance into the condenser water line.

2.3.1.4.4 Water Meter

Provide water meters with an electric contacting register and remote accumulative counter. Install the meter within the make-up water line, as indicated.

2.3.1.4.5 Timers

Provide timers which are of the automatic reset, adjustable type, and are electrically operated. Ensure the timers are designed to work with the contacting head water meters. Include the water meter cable with the timer. Ensure timers control operation of the chemical feed pumps and are suitable for a 120 volt current. Locate the timers within the water treatment control panel.

2.3.1.4.6 Bleed (Blowdown) Line

Control the flow through the bleed line by a conductivity meter and probe installed to measure the conductivity of the condenser water. Provide a high and low set point on the conductivity meter above which the meter opens a solenoid valve on the bleed line. Locate the bleed line attachment to the condenser water piping downstream of the recirculating pumps and upstream of the chemical injection point. Extend the bleed line to the nearest drain for continuous discharge.

2.3.1.4.7 Control Panel

Provide a NEMA 12 control panel enclosure suitable for surface mounting. Construct the panel of stainless steel with a hinged door and lock. Include a laminated plastic nameplate identifying each of the following functions:

- (1) Main power switch and indicating light
- (2) MAN-OFF-AUTO selector switch
- (3) Indicating lamp for bleed-off valve
- (4) Indicating lamp for each chemical feed pump
- (5) Set point reading for each timer

2.3.1.4.8 Chemical Piping

Construct the piping and fittings of schedule 80 PVC suitable for the water treatment chemicals.

2.3.1.4.9 Sequence of Operation

Add chemicals based upon sensing the make-up water flow rate and activating appropriate timers. Provide a separate timer for each

chemical. Control the blow down based upon the conductivity of the condenser water. Control the injection of the chemical required for biological control manually set for proper chemical feed. The water treatment company is required to determine and set a timer set points, blow down rates, and chemical pump flow rates.

2.3.1.4.10 Test Kits

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals.

2.3.2 Chilled Water System

Provide a 2 gallon shot feeder on the chilled water piping as indicated. Furnish the feeder with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.3.2.1 Chilled Water Treatment

Treat chilled water with either a borax/nitrite type treatment or a molybdate type treatment. Maintain borax/nitrite treatment at pH of 8.5 to 9.5. Maintain molybdate treatment at pH of 8.0 to 9.0.

2.3.2.2 Chilled Water Test Kits

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals (e.g. pH and nitrite or molybdate).

2.3.3 Low and Medium Temperature Hot Water Boilers and Heat Exchangers

Low and medium temperature hot water boilers are defined as those operating below 350 degrees F, (250 degrees F for Low Temperature).

2.3.3.1 Chemical Feeder

Provide a 5 gallon shot feeder on the hot water piping as indicated. Base the size and capacity of feeder upon local requirements and water analysis. Furnish the feeder with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.3.3.2 Low and Medium Temperature Hot Water Treatment

Treat hot water with either a borax/nitrite type treatment or a molybdate type treatment. Both types of treatment are acceptable to use with glycol. Maintain borax/nitrite treatment at the limits of 600 to 1000 ppm nitrite, 40 - 50 ppm copper corrosion inhibitor (TT or MBT) and pH of 8.5 to 9.5. Maintain molybdate treatment at the limits of 100 to 125 ppm molybdate, 40 - 50 ppm copper corrosion inhibitor (TT or MBT) and pH of 8.0 to 9.0.

2.3.3.3 Dual Temperature Systems

Dual hot/chilled water systems treated with borax/nitrite are required to also be treated with a biocide.

2.3.3.4 Test Kit Requirements

Provide one test kit of each type required to determine the water quality

as outlined within the operation and maintenance manuals (e.g. pH and nitrite or molybdate).

2.3.4 Test Kit

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals (e.g. pH, hardness and sulfite).

2.3.5 Supplemental Components/Services

Ensure drain and makeup water piping complies with the requirements of Section 22 00 00 PLUMBING, GENERAL PURPOSE. Connect drains to sanitary sewer systems by means of an indirect waste connection.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming 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.

3.2 INSTALLATION

Provide all chemicals, equipment and labor necessary to bring all system waters in conformance with the specified requirements. Perform all work in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements.

3.2.1 Piping

Fabricate all connections between dissimilar metals using dielectric unions.

3.3 FIELD QUALITY CONTROL

3.3.1 Tests

If the waters of the mechanical systems are not in conformance with the specified requirements or in accordance with manufacturer's recommendations, the contractor is required to direct the water treatment company to take corrective action to achieve compliance. Perform daily operational tests in the directed frequencies to maintain required control to prevent corrosion, scaling and damage to equipment during operation. Submit test schedules, at least 2 weeks prior to the start of related testing, for the condenser/chilled/boiler/condensate/feedwater water quality tests. Identify the date, time, frequency and collection location for each test within the schedules.

3.3.2 Condenser Water Quality Tests

3.3.2.1 Tests for Large Systems (daily)

Daily, for cooling systems with a capacity larger than 50 tons, ensuring the following items are recorded.

pH	_____
Total Alkalinity (as CaCO ₃)	_____ ppm (mg/L)
Conductivity	_____ micromho/cm
Phosphate	_____ ppm (mg/L)
Zinc, if used (Zn)	_____ ppm (mg/L)
Molybdate, if used (Mo)	_____ ppm (mg/L)

3.3.3 Chilled Water Testing (monthly)

Perform the following tests on chilled water on a monthly basis.

pH	_____
Nitrite or Molybdate	_____ ppm (mg/L)
Conductivity	_____ micromho/cm

3.3.4 Hot Water Boiler Water Quality Testing

3.3.4.1 Low and Medium Temperature Systems (monthly)

Complete and record monthly testing for the following parameters.

pH	_____
Nitrite or Molybdate	_____ ppm (mg/L)

3.3.5 Quality Assurance Testing

Conduct QA testing periodically by an independent water treatment lab/consultant to verify to managers that the mechanical and water treatment systems are being maintained properly. Provide the QA evaluation reports to the government COR.

3.3.5.1 Condenser Water QA Tests

Submit test reports in bound 8-1/2 by 11 inch booklets. Within the reports, identify the chemical composition of the condenser water. Also include in the reports a comparison of the manufacturer's or chemical vendor's recommended operating conditions for the cooling tower and condenser in relation to the actual condition of the condenser water. Document any required corrective actions undertaken within the report.

For cooling systems with capacities greater than 50 ton), analyze the condenser water a minimum of once a month for a period of one year by the water treatment company. Ensure the analysis includes the following information recorded in accordance with ASTM D596.

Date of Sample	_____
Temperatures (before & after condenser)	_____ & _____ degrees C
pH	_____
Silica (SiO ₂)	_____ ppm (mg/L)
Iron (total, as Fe(2)O(3))	_____ ppm (mg/L)
Copper (Cu)	_____ ppm (mg/L)
Calcium Hardness(CaCO ₃)	_____ ppm (mg/L)
Total Hardness (as CaCO ₃)	_____ ppm (mg/L)
Chloride (Cl)	_____ ppm (mg/L)
Total Alkalinity (as CaCO ₃)	_____ ppm (mg/L)
Conductivity	_____ micromho/cm
Total Dissolved Solids	_____ ppm (mg/L)
Phosphonate (as P04)	_____ ppm (mg/L)
Zinc (if used) (Zn)	_____ ppm (mg/L)
Molybdate (if used) (Mo)	_____ ppm (mg/L)
Tolyltriazole (TT)	_____ ppm (mg/L)
Biocide	_____ ppm (mg/L)
Bacteria colony count	_____ colonies/mL
Makeup water pH	_____ ppm (mg/L)
Makeup water Iron	_____ ppm (mg/L)
Makeup water Silica	_____ ppm (mg/L)
Makeup water Calcium Hardness	_____ ppm (mg/L)
Makeup water Total Hardness	_____ ppm (mg/L)
Makeup water Total Alkalinity	_____ ppm (mg/L)
Makeup water Chloride (Cl)	_____ ppm (mg/L)
Makeup water Conductivity	_____ micromho/cm
Written evaluation summary	

3.3.5.2 Chilled Water Quality Assurance Testing (quarterly)

Perform the following tests quarterly on chilled water.

pH	_____
Nitrite or Molybdate	_____ ppm (mg/L)
Conductivity	_____ micromho/cm
Iron (total, as Fe(2)O(3))	_____ ppm (mg/L)
Written evaluation summary	

3.3.5.3 Hot Water Boiler Water Quality Assurance Testing

- a. Complete quarterly testing of Low and Medium Temperature Systems and record the following parameters.

pH	_____
Nitrite or Molybdate	_____ ppm (mg/L)
Iron (total, as Fe(2)O(3))	_____ ppm (mg/L)
Written evaluation summary	

3.4 CLOSEOUT ACTIVITIES

3.4.1 Training Course

Submit a schedule, at least 2 weeks prior to the date of the proposed training course that identifies the date, time, and location for the training. Conduct a training course for the operating staff as designated by the Contracting Officer. Conduct the training to include a total of 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. Submit [field 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. Include within the condensed operation instructions all preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. Frame the posted instructions under glass or laminated plastic and post where indicated by the Contracting Officer. Ensure the field instructions cover all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

3.5 INSPECTIONS

3.5.1 Inspection General Requirements

Thirty days after project completion, inspect the cooling tower and condenser for problems due to corrosion, scale, and biological growth. If

the cooling tower and condenser are found not to conform to the manufacturer's recommended conditions, and the water treatment company recommendations have been followed; instruct the water treatment company to provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations.

3.5.2 Boiler/Piping Test

Thirty days after project completion, inspect the boiler piping for problems due to corrosion and scale. If the boiler is found not to conform to the manufacturer's recommendations, and the water treatment company recommendations have been followed, instruct the water treatment company to provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations. If corrosion is found within the condensate piping, proper repairs are required to be made by the water treatment company at no additional cost.

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SECTION 23 30 00

HVAC AIR DISTRIBUTION

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 MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 201	(2002; R 2011) Fans and Systems
AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2014) Methods for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 500-D	(2018) Laboratory Methods of Testing Dampers for Rating

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 430	(2009) Central-Station Air-Handling Units
AHRI 880 I-P	(2011) Performance Rating of Air Terminals
AHRI 885	(2008; Addendum 2011) Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets
AHRI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING
ENGINEERS (ASHRAE)

ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62.1	(2010) Ventilation for Acceptable Indoor Air Quality
ASHRAE 70	(2006; R 2021) Method of Testing the Performance of Air Outlets and Inlets
ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-6 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 7-8 2021; Interpretation 1-4 2020; Interpretation 5-8 2021; Addenda AS-CB 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A924/A924M	(2020) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B280	(2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B766	(1986; R 2015) Standard Specification for Electrodeposited Coatings of Cadmium
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D520	(2000; R 2011) Zinc Dust Pigment

ASTM D1654 (2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D3359 (2017) Standard Test Methods for Rating Adhesion by Tape Test

ASTM E2016 (2020) Standard Specification for Industrial Woven Wire Cloth

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350 (2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NEMA MG 10 (2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors

NEMA MG 11 (1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A (2021) Standard for the Installation of Air Conditioning and Ventilating Systems

NFPA 701 (2019) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1819 (2002) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th Edition

SMACNA 1966 (2020) HVAC Duct Construction Standards Metal and Flexible, 4th Edition

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168 (2017) Adhesive and Sealant Applications

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 82 Protection of Stratospheric Ozone

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 181	(2013; Reprint Dec 2021) UL Standard for Safety Factory-Made Air Ducts and Air Connectors
UL 555	(2006; Reprint Aug 2016) UL Standard for Safety Fire Dampers
UL 586	(2009; Reprint Dec 2017) UL Standard for Safety High-Efficiency Particulate, Air Filter Units
UL 705	(2017; Reprint Aug 2021) UL Standard for Safety Power Ventilators
UL 900	(2015) Standard for Air Filter Units
UL 1995	(2015) UL Standard for Safety Heating and Cooling Equipment
UL Bld Mat Dir	(updated continuously online) Building Materials Directory
UL Electrical Construction	(2012) Electrical Construction Equipment Directory
UL Fire Resistance	(2014) Fire Resistance Directory

1.2 SYSTEM DESCRIPTION

Furnish ductwork, piping offsets, fittings, and accessories as required to provide a complete installation. Coordinate the work of the different trades to avoid interference between piping, equipment, structural, and electrical work. Provide complete, in place, all necessary offsets in piping and ductwork, and all fittings, and other components, required to install the work as indicated and specified.

1.2.1 Mechanical Equipment Identification

The number of charts and diagrams must be equal to or greater than the number of mechanical equipment rooms. Where more than one chart or diagram per space is required, mount these in edge pivoted, swinging leaf, extruded aluminum frame holders which open to 170 degrees.

1.2.1.1 Charts

Provide chart listing of equipment by designation numbers and capacities such as flow rates, pressure and temperature differences, heating and cooling capacities, horsepower, pipe sizes, and voltage and current characteristics.

1.2.1.2 Diagrams

Submit proposed diagrams, at least 2 weeks prior to start of related testing. provide neat mechanical drawings provided with extruded aluminum frame under 1/8-inch glass or laminated plastic, 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. After approval, post these items where directed.

1.2.2 Service Labeling

Label equipment, including fans, air handlers, terminal units, etc. with labels made of self-sticking, plastic film designed for permanent installation. Provide labels in accordance with the typical examples below:

SERVICE	LABEL AND TAG DESIGNATION
Air handling unit Number	AHU - n; n = 1 through 5
Control and instrument air	CONTROL AND INSTR.
Exhaust Fan Number	EF - 1
VAV Box Number	VAV - n; n = 1 through 30

Identify similar services with different temperatures or pressures. Where pressures could exceed 125 pounds per square inch, gage, include the maximum system pressure in the label. Label and arrow piping in accordance with the following:

- Each point of entry and exit of pipe passing through walls.
- Each change in direction, i.e., elbows, tees.
- In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard.
- In long straight runs, locate labels at distances within eyesight of each other not to exceed 75 feet. All labels must be visible and legible from the primary service and operating area.

For Bare or Insulated Pipes	
for Outside Diameters of	Lettering
1/2 thru 1-3/8 inch	1/2 inch
1-1/2 thru 2-3/8 inch	3/4 inch
2-1/2 inch and larger	1-1/4 inch

1.2.3 Color Coding

Color coding of all piping systems must be in accordance with the existing facility standards.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G

SD-03 Product Data

Insulated Nonmetallic Flexible Duct Runouts

Duct Connectors

Duct Access Doors; G

Fire Dampers

Manual Balancing Dampers; G

Diffusers

Registers and Grilles

LouversIn-Line Centrifugal FansCentrifugal Type Power Roof Ventilators

Air Handling Units; G

Variable Volume, Single Duct Terminal Units; G

Reheat Units; G

Test Procedures

Diagrams; G

Indoor Air Quality for Duct Sealants; S

SD-06 Test Reports

Performance Tests; G

SD-07 Certificates

Ozone Depleting Substances Technician Certification

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions

Operation and Maintenance Training

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

Fire Dampers; G

Manual Balancing Dampers; G

In-Line Centrifugal Fans; G
Centrifugal Type Power Roof Ventilators;
G

Air Handling Units; G

Variable Volume, Single Duct Terminal Units; G

Reheat Units; G

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.4 QUALITY ASSURANCE

Except as otherwise specified, approval of materials and equipment is based on manufacturer's published data.

- a. Where materials and equipment are specified to conform to the standards of the Underwriters Laboratories, the label of or listing with reexamination in **UL Bld Mat Dir**, and **UL 6** is acceptable as sufficient evidence that the items conform to Underwriters Laboratories requirements. In lieu of such label or listing, submit a written certificate from any nationally recognized testing agency, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified requirements. Outline methods of testing used by the specified agencies.
- b. Where materials or equipment are specified to be constructed or

tested, or both, in accordance with the standards of the ASTM International (ASTM), the ASME International (ASME), or other standards, a manufacturer's certificate of compliance of each item is acceptable as proof of compliance.

- c. Conformance to such agency requirements does not relieve the item from compliance with other requirements of these specifications.
- d. Where products are specified to meet or exceed the specified energy efficiency requirement of FEMP-designated or ENERGY STAR covered product categories, equipment selected must have as a minimum the efficiency rating identified under "Energy-Efficient Products" at <http://femp.energy.gov/procurement>.

1.4.1 Prevention of Corrosion

Protect metallic materials against corrosion. Provide rust-inhibiting treatment and standard finish for the equipment enclosures. Do not use aluminum in contact with earth, and where connected to dissimilar metal. Protect aluminum by approved fittings, barrier material, or treatment. Provide hot-dip galvanized ferrous parts such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous parts not of corrosion-resistant steel or nonferrous materials in accordance with [ASTM A123/A123M](#) for exterior locations and cadmium-plated in conformance with [ASTM B766](#) for interior locations.

1.4.2 Asbestos Prohibition

Do not use asbestos and asbestos-containing products.

1.4.3 Ozone Depleting Substances Technician Certification

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in [40 CFR 82](#), Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.4.4 Detail Drawings

Submit detail 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. Include any information required to demonstrate that the system has been coordinated and functions properly as a unit on the drawings and show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Submit drawings showing bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Submit function designation of the equipment and any other requirements specified throughout this Section with the shop drawings.

1.4.5 Test Procedures

Conduct performance tests as required in Section [23 05 93](#) Testing, Adjusting and Balancing for HVAC and Section [23 09 00](#) Instrumentation and

Control for HVAC.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect stored equipment at the jobsite from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all pipes until installed.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide components and equipment that are "standard products" of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. "Standard products" is defined as being in satisfactory commercial or industrial use for 2 years before bid opening, including applications of components and equipment under similar circumstances and of similar size, satisfactorily completed by a product that is sold on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record are 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. Provide equipment items that are supported by a service organization. In product categories covered by ENERGY STAR or the Federal Energy Management Program, provide equipment that is listed on the ENERGY STAR Qualified Products List or that meets or exceeds the FEMP-designated Efficiency Requirements.

2.2 IDENTIFICATION PLATES

In addition to standard manufacturer's identification plates, provide engraved laminated phenolic identification plates for each piece of mechanical equipment. Identification plates are to designate the function of the equipment. Submit designation with the shop drawings. Provide identification plates that are layers, black-white-black, engraved to show white letters on black background. Letters must be upper case. Identification plates that are 1-1/2-inches high and smaller must be 1/16-inch thick, with engraved lettering 1/8-inch high; identification plates larger than 1-1/2-inches high must be 1/8-inch thick, with engraved lettering of suitable height. Identification plates 1-1/2-inches high and larger must have beveled edges. Install identification plates using a compatible adhesive.

2.3 EQUIPMENT GUARDS AND ACCESS

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact according to OSHA requirements. Properly guard or cover with insulation of a type specified, high temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard. The requirements for catwalks, operating platforms, ladders, and guardrails are specified in Section 08 31 00 ACCESS DOORS AND PANELS.

2.4 ELECTRICAL WORK

- a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section

26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown. For packaged equipment, include manufacturer provided controllers with the required monitors and timed restart.

- b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11. Provide premium efficiency type integral size motors in accordance with NEMA MG 1.
- c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Select premium efficiency polyphase motors in accordance with NEMA MG 10.
- d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Provide motors rated for continuous duty with the enclosure specified. Provide motor duty that allows for maximum frequency start-stop operation and minimum encountered interval between start and stop. Provide motor torque capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Fit motor bearings with grease supply fittings and grease relief to outside of the enclosure.
- e. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers are allowed to accomplish the same function. Use solid-state variable-speed controllers for motors rated 10 hp or less and adjustable frequency drives for larger motors. Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.

2.5 ANCHOR BOLTS

Provide anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts to be of the size and number recommended by the equipment manufacturer and located by means of suitable templates. Installation of anchor bolts must not degrade the surrounding concrete.

2.6 PAINTING

Paint equipment units in accordance with approved equipment manufacturer's standards unless specified otherwise. Field retouch only if approved. Otherwise, return equipment to the factory for refinishing.

2.7 INDOOR AIR QUALITY

Provide equipment and components that comply with the requirements of ASHRAE 62.1 unless more stringent requirements are specified herein.

2.8 DUCT SYSTEMS

2.8.1 Metal Ductwork

Provide metal ductwork construction, including all fittings and components, that complies with [SMACNA 1966](#), as supplemented and modified by this specification .

- b. Provide radius type elbows 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 are allowed.
- c. Provide ductwork that meets the requirements of Seal Class A. Provide ductwork in VAV systems upstream of the VAV boxes that meets the requirements of Seal Class A.
- e. Provide sealants that conform to fire hazard classification specified in Section [23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS](#) and are suitable for the range of air distribution and ambient temperatures to which it is exposed. Do not use pressure sensitive tape as a sealant. Provide duct sealant products that meet either emissions requirements of [CDPH SECTION 01350](#) (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of [SCAQMD Rule 1168](#) (HVAC duct sealants are classified as "Other" within the [SCAQMD Rule 1168](#) sealants table). Provide validation of [indoor air quality for duct sealants](#).
- f. Make spiral lock seam duct, and flat oval with duct sealant and lock with not less than 3 equally spaced drive screws or other approved methods indicated in [SMACNA 1966](#). Apply the sealant to the exposed male part of the fitting collar so that the sealer is on the inside of the joint and fully protected by the metal of the duct fitting. Apply one brush coat of the sealant over the outside of the joint to at least [2 inch](#) band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar are not acceptable.
- g. Fabricate outdoor air intake ducts and plenums with watertight soldered or brazed joints and seams.

2.8.1.1 Insulated Nonmetallic Flexible Duct Runouts

Use flexible duct runouts only where indicated. Runout length is indicated on the drawings, and is not to exceed [5 feet](#). Provide runouts that are preinsulated, factory fabricated, and that comply with [NFPA 90A](#) and [UL 181](#). Provide either field or factory applied vapor barrier. Provide not less than [20 ounce](#) glass fabric [duct connectors](#) coated on both sides with neoprene. Where coil induction or high velocity units are supplied with vertical air inlets, use a streamlined, vaned and mitered elbow transition piece for connection to the flexible duct or hose. Provide a die-stamped elbow and not a flexible connector as the last elbow to these units other than the vertical air inlet type. Insulated flexible connectors are allowed as runouts. Provide insulated material and vapor barrier that conform to the requirements of Section [23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS](#). Do not expose the insulation material surface to the air stream.

2.8.1.2 General Service Duct Connectors

Provide a flexible duct connector approximately 6 inches in width where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, secure the flexible material by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, install the flexible material locked to metal collars using normal duct construction methods. Provide a composite connector system that complies with NFPA 701 and is classified as "flame-retardent fabrics" in UL Bld Mat Dir.

2.8.2 Duct Access Doors

Provide hinged access doors conforming to SMACNA 1966 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. Provide access doors upstream and downstream of air flow measuring primaries and heating and cooling coils. Provide doors that are a minimum 15 by 18 inches, unless otherwise shown. Where duct size does not accommodate this size door, make the doors as large as practicable. Equip doors 24 by 24 inches or larger with fasteners operable from inside and outside the duct. Use insulated type doors in insulated ducts.

2.8.3 Fire Dampers

Use 1.5 hour rated fire dampers unless otherwise indicated. Provide fire dampers that conform to the requirements of NFPA 90A and UL 555. Perform the fire damper test as outlined in NFPA 90A. Provide a pressure relief door upstream of the fire damper. If the ductwork connected to the fire damper is to be insulated then provide a factory installed pressure relief damper. Provide automatic operating fire dampers with a dynamic rating suitable for the maximum air velocity and pressure differential to which it is subjected. Provide fire dampers approved for the specific application, and install according to their listing. Equip fire dampers with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, does not impair the operation of the damper. Equip sleeves or frames with perimeter mounting angles attached on both sides of the wall or floor opening. Construct ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies in conformance with UL Fire Resistance. Provide curtain type with damper blades out of the air stream fire dampers. Install dampers that do not reduce the duct or the air transfer opening cross-sectional area. Install dampers 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, comply with the installation details given in SMACNA 1819 and in manufacturer's instructions for fire dampers. Perform acceptance testing of fire dampers according to paragraph Fire Damper Acceptance Test and NFPA 90A.

2.8.4 Manual Balancing Dampers

Furnish manual balancing dampers with accessible operating mechanisms. Use chromium plated operators (with all exposed edges rounded) in finished portions of the building. Provide manual volume control dampers that are operated by locking-type quadrant operators. Install dampers that are 2 gauges heavier than the duct in which installed. Unless otherwise indicated, provide opposed blade type multileaf dampers with maximum blade

width of 12 inches. Provide access doors or panels for all concealed damper operators and locking setscrews. Provide stand-off mounting brackets, bases, or adapters not less than the thickness of the insulation when the locking-type quadrant operators for dampers are installed on ducts to be thermally insulated, to provide clearance between the duct surface and the operator. Provide stand-off mounting items that are integral with the operator or standard accessory of the damper manufacturer.

2.8.5 Air Supply And Exhaust Air Dampers

Provide outdoor air supply and exhaust air dampers that have a maximum leakage rate when tested in accordance with AMCA 500-D as required by ASHRAE 90.1 - IP, including maximum Damper Leakage for:

- a. Climate Zones 1,2,6,7,8 the maximum damper leakage at 1.0 inch w.g. for motorized dampers is 4 cfm per square foot of damper area and non-motorized dampers are not allowed.
- b. All other Climate Zones the maximum damper leakage at 1.0 inch w.g. is 10 cfm per square foot and for non-motorized dampers is 20 cfm per square foot of damper area.

Dampers smaller than 24 inches in either direction may have leakage of 40 cfm per square foot.

2.8.6 Plenums and Casings for Field-Fabricated Units

2.8.6.1 Plenum and Casings

Fabricate and erect plenums and casings as shown in SMACNA 1966, as applicable. Construct system casing of not less than 16 gauge galvanized sheet steel. Furnish cooling coil drain pans with 1 inch threaded outlet to collect condensation from the cooling coils. Fabricate drain pans from not lighter than 16 gauge steel, galvanized after fabrication or of 18 gauge corrosion-resisting sheet steel conforming to ASTM A167, Type 304, welded and stiffened. Thermally insulate drain pans exposed to the atmosphere to prevent condensation. Coat insulation with a flame resistant waterproofing material. Provide separate drain pans for each vertical coil section, and a separate drain line for each pan. Size pans to ensure capture of entrained moisture on the downstream-air side of the coil. Seal openings in the casing, such as for piping connections, to prevent air leakage. Size the water seal for the drain to maintain a pressure of at least 2 inch water gauge greater than the maximum negative pressure in the coil space.

2.8.6.2 Casing

Terminate casings at the curb line and bolt each to the curb using galvanized angle, as indicated in SMACNA 1966.

2.8.6.3 Access Doors

Provide access doors in each section of the casing. Weld doorframes in place, gasket each door with neoprene, hinge with minimum of two brass hinges, and fasten with a minimum of two brass tension fasteners operable from inside and outside of the casing. Where possible, make doors 36 by 18 inches and locate them 18 inches above the floor. Where the space available does not accommodate doors of this size, use doors as large as

the space accommodates. Swing doors so that fan suction or pressure holds doors in closed position, airtight. Provide a push-button station, located inside the casing, to stop the supply.

2.8.6.4 Factory-Fabricated Insulated Sheet Metal Panels

Factory-fabricated components are allowed for field-assembled units, provided all requirements specified for field-fabricated plenums and casings are met. Provide panels of modular design, pretested for structural strength, thermal control, condensation control, and acoustical control. Seal and insulate panel joints. Provide and gasket access doors to prevent air leakage. Provide panel construction that is not less than 20 gauge galvanized sheet steel, assembled with fasteners treated against corrosion. Provide standard length panels that deflect not more than 1/2 inch under operation. Construct details, including joint sealing, not specifically covered, as indicated in SMACNA 1966. Construct the plenums and casings to withstand the specified internal pressure of the air systems.

2.8.7 Diffusers, Registers, and Grilles

Provide factory-fabricated units of aluminum that distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 50 fpm in occupied zone, or dead spots anywhere in the conditioned area. Provide outlets for diffusion, spread, throw, and noise level as required for specified performance. Certify performance according to ASHRAE 70. Provide sound rated and certified inlets and outlets according to ASHRAE 70. Provide sound power level as indicated. Provide diffusers and registers with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device is acceptable. Provide opposed blade type volume dampers for all diffusers and registers, except linear slot diffusers. Provide linear slot diffusers with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 7 feet above the floor, protect them by a grille or screen according to NFPA 90A.

2.8.7.1 Diffusers

Provide diffuser types indicated. Furnish ceiling mounted units with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Provide diffusers with air deflectors of the type indicated. Provide air handling troffers or combination light and ceiling diffusers conforming to the requirements of UL Electrical Construction for the interchangeable use as cooled or heated air supply diffusers or return air units. Install ceiling mounted units with rims tight against ceiling. Provide sponge rubber gaskets between ceiling and surface mounted diffusers for air leakage control. Provide suitable trim for flush mounted diffusers. For connecting the duct to diffuser, provide duct collar that is airtight and does not interfere with volume controller. Provide return or exhaust units that are similar to supply diffusers.

2.8.7.2 Registers and Grilles

Provide units that are four-way directional-control type, except provide return and exhaust registers that are fixed horizontal or vertical louver type similar in appearance to the supply register face. Furnish registers with sponge-rubber gasket between flanges and wall or ceiling. Install

wall supply registers at least 6 inches below the ceiling unless otherwise indicated. Locate return and exhaust registers 6 inches above the floor unless otherwise indicated. Achieve four-way directional control by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Provide grilles as specified for registers, without volume control damper.

2.8.8 Louvers

Provide louvers for installation in exterior walls that are associated with the air supply and distribution system as specified in Section 08 91 00 METAL WALL LOUVERS.

2.8.9 Bird Screens and Frames

Provide bird screens that conform to ASTM E2016, No. 2 mesh, aluminum or stainless steel. Provide "medium-light" rated aluminum screens. Provide "light" rated stainless steel screens. Provide removable type frames fabricated from either stainless steel or extruded aluminum.

2.9 AIR SYSTEMS EQUIPMENT

2.9.1 Fans

Test and rate fans according to AMCA 210. Calculate system effect on air moving devices in accordance with AMCA 201 where installed ductwork differs from that indicated on drawings. Install air moving devices to minimize fan system effect. Where system effect is unavoidable, determine the most effective way to accommodate the inefficiencies caused by system effect on the installed air moving device. The sound power level of the fans must not exceed 85 dBA when tested according to AMCA 300 and rated in accordance with AMCA 301. Provide all fans with an AMCA seal. Connect fans to the motors either directly or indirectly with V-belt drive. Use V-belt drives designed for not less than 150 percent of the connected driving capacity. Provide variable pitch motor sheaves for 15 hp and below, and fixed pitch as defined by AHRI Guideline D (A fixed-pitch sheave is provided on both the fan shaft and the motor shaft. This is a non-adjustable speed drive.). Select variable pitch sheaves to drive the fan at a speed which can produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, provide a replaceable sheave when needed to achieve system air balance. Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans 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. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Provide sound power level as indicated. Obtain the sound power level values according to AMCA 300. Provide standard AMCA arrangement, rotation, and discharge as indicated. Provide power ventilators that conform to UL 705 and have a UL label.

2.9.1.1 In-Line Centrifugal Fans

Provide in-line fans with centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and

adjustable motor mounts. Mount fans in a welded tubular casing. Provide a fan that axially flows the air in and out. Streamline inlets with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Enclose and isolate fan bearings and drive shafts from the air stream. Provide precision, self aligning ball or roller type fan bearings that are sealed against dust and dirt and are permanently lubricated. Provide L50 rated bearing life at not less than 200,000 hours as defined by [ABMA 9](#) and [ABMA 11](#). Provide motors with opendriproof enclosure.

2.9.1.2 Centrifugal Type Power Roof Ventilators

Provide centrifugal type fans with backward inclined, non-overloading wheel. Provide hinged or removable and weatherproof motor compartment housing, constructed of heavy gauge aluminum. Provide fans with disconnect switch ([where indicated](#)), dampers [as indicated on plans](#), and roof curb. Provide driproof type motor enclosure. Use only lubricated bearings. If there is a conflict between NFPA 96 and UL 705 the most stringent wording must be adhered to.

2.9.2 Coils

Provide fin-and-tube type coils constructed of seamless copper tubes and aluminum fins mechanically bonded or soldered to the tubes. Provide casing and tube support sheets that are not lighter than [16 gauge](#) galvanized steel, formed to provide structural strength. When required, provide multiple tube supports to prevent tube sag. Mount coils for counterflow service. Rate and certify coils to meet the requirements of [AHRI 410](#).

2.9.2.1 Direct-Expansion Coils

Provide suitable direct-expansion coils for the refrigerant involved. Provide refrigerant piping that conforms to [ASTM B280](#) and clean, dehydrate and seal. Provide seamless copper tubing suction headers or seamless or resistance welded steel tube suction headers with copper connections. Provide supply headers that consist of a distributor which distributes the refrigerant through seamless copper tubing equally to all circuits in the coil. Provide circuited tubes to ensure minimum pressure drop and maximum heat transfer. Provide circuiting that permits refrigerant flow from inlet to suction outlet without causing oil slugging or restricting refrigerant flow in coil. Provide field installed coils which are completely dehydrated and sealed at the factory upon completion of pressure tests. Pressure test coils in accordance with [UL 1995](#).

2.9.2.2 Water Coils

Install water coils with a pitch of not less than [1/8 inch/foot](#) of the tube length toward the drain end. Use headers constructed of cast iron, welded steel or copper. Furnish each coil with a plugged vent and drain connection extending through the unit casing. Provide removable water coils with drain pans. Pressure test coils in accordance with [UL 1995](#).

2.9.3 Air Filters

List air filters according to requirements of [UL 900](#), except list high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method under the Label Service to meet the requirements of [UL 586](#).

2.9.3.1 Extended Surface Pleated Panel Filters

Provide 2 inch depth, sectional, disposable type filters of the size indicated with a MERV of 8 when tested according to ASHRAE 52.2. Provide initial resistance at 500 fpm that does not exceed 0.36 inches water gauge. Provide UL Class 2 filters, and nonwoven cotton and synthetic fiber mat media. Attach a wire support grid bonded to the media to a moisture resistant fiberboard frame. Bond all four edges of the filter media to the inside of the frame to prevent air bypass and increase rigidity.

2.9.3.2 Replaceable Media Filters

Provide the dry-media type replaceable media filters, of the size required to suit the application. Provide filtering media that is not less than 2 inches thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Enclose pad in a holding frame of not less than 16 gauge galvanized steel, equipped with quick-opening mechanism for changing filter media. Base the air flow capacity of the filter on net filter face velocity not exceeding 300 fpm, with initial resistance of 0.13 inches water gauge. Provide MERV that is not less than what is indicated on the drawings when tested according to ASHRAE 52.2.

2.9.3.3 Holding Frames

Fabricate frames from not lighter than 16 gauge sheet steel with rust-inhibitor coating. Equip each holding frame with suitable filter holding devices. Provide gasketed holding frame seats. Make all joints airtight.

2.9.3.4 Filter Gauges

Provide dial type filter gauges, diaphragm actuated draft for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Provide gauges that are at least 3-7/8 inches in diameter, with white dials with black figures, and graduations with a minimum range of 1 inch of water beyond the specified final resistance for the filter bank on which each gauge is applied. Provide each gauge with a screw operated zero adjustment and two static pressure taps with integral compression fittings, two molded plastic vent valves, two 5 foot minimum lengths of 1/4 inch diameter aluminum tubing, and all hardware and accessories for gauge mounting.

2.10 AIR HANDLING UNITS

2.10.1 Factory-Fabricated Air Handling Units

Provide single-zone draw-through type units as indicated. Units must include fans, coils, airtight insulated casing, prefilters, adjustable V-belt drives, belt guards for externally mounted motors, access sections where indicated, combination sectional filter-mixing box, vibration-isolators, and appurtenances required for specified operation. Provide vibration isolators as indicated. Physical dimensions of each air handling unit must be suitable to fit space allotted to the unit with the capacity indicated. Provide air handling unit that is rated in accordance with AHRI 430 and AHRI certified for cooling.

2.10.1.1 Casings

Provide the following:

- a. Casing sections 2 inch double wall type, constructed of a minimum 18 gauge galvanized steel, or 18 gauge corrosion-resisting sheet steel conforming to ASTM A167, Type 304. Inner casing of double-wall units that are a minimum 20 gauge solid galvanized steel or corrosion-resisting sheet steel conforming to ASTM A167, Type 304. Design and construct casing with an integral insulated structural galvanized steel frame such that exterior panels are non-load bearing.
- b. Individually removable exterior panels with standard tools. Removal must not affect the structural integrity of the unit. Furnish casings with access sections, according to paragraph AIR HANDLING UNITS, inspection doors, and access doors, all capable of opening a minimum of 90 degrees, as indicated.
- c. Insulated, fully gasketed, double-wall type inspection and access doors, of a minimum 18 gauge outer and 20 gauge inner panels made of either galvanized steel or corrosion-resisting sheet steel conforming to ASTM A167, Type 304. Provide rigid doors with heavy duty hinges and latches. Inspection doors must be a minimum 12 inches wide by 12 inches high. Access doors must be a minimum 24 inches wide, the full height of the unit casing or a minimum of 6 foot, whichever is less.
- d. Double-wall insulated type drain pan (thickness equal to exterior casing) constructed of 16 gauge galvanized steel, conforming to ASHRAE 62.1. Construct drain pans 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 must not flow across the face of lower coils. Provide intermediate drain pans or condensate collection channels and downspouts, as required to carry condensate to the unit drain pan out of the air stream and without moisture carryover. Construct drain pan to allow for easy visual inspection, including underneath the coil without removal of the coil and to allow complete and easy physical cleaning of the pan underneath the coil without removal of the coil. Provide coils that are individually removable from the casing.
- f. Factory applied fibrous glass insulation that conforms to ASTM C1071, except that the minimum thickness and density requirements do not apply, and that meets the requirements of NFPA 90A. Make air handling unit casing insulation uniform over the entire casing. Foil-faced insulation is not an acceptable substitute for use on double-wall access doors and inspections doors and casing sections.
- h. A latched and hinged inspection door, in the fan and coil sections. Plus additional inspection doors, access doors and access sections where indicated.

2.10.1.2 Heating and Cooling Coils

Provide coils as specified in paragraph AIR SYSTEMS EQUIPMENT.

2.10.1.3 Air Filters

Provide air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

2.10.1.4 Fans

Provide the following:

- a. Fans that are double-inlet, centrifugal type with each fan in a separate scroll. Dynamically balance fans and shafts prior to installation into air handling unit, then after it has been installed in the air handling unit, statically and dynamically balance the entire fan assembly. Mount fans on steel shafts, accurately ground and finished.
- b. Fan bearings that are sealed against dust and dirt and are precision self-aligning ball or roller type, with L50 rated bearing life at not less than 200,000 hours as defined by [ABMA 9](#) and [ABMA 11](#). Provide bearings that are permanently lubricated or lubricated type with lubrication fittings readily accessible at the drive side of the unit. Support bearings by structural shapes, or die formed sheet structural members, or support plates securely attached to the unit casing. Do not fasten bearings directly to the unit sheet metal casing. Furnish fans and scrolls with coating indicated.
- c. Fans that are 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. Furnish belt guards that are the three-sided enclosed type with solid or expanded metal face. Design belt drives for not less than a 1.3 service factor based on motor nameplate rating.
- d. Where fixed sheaves are required, the use of variable pitch sheaves is allowed during air balance, but replace them with an appropriate fixed sheave after air balance is completed. Select variable pitch sheaves to drive the fan at a speed that produces the specified capacity when set at the approximate midpoint of the sheave adjustment. Furnish motors for V-belt drives with adjustable bases, and with totally enclosed enclosures.
- e. Motor starters of reduced-voltage-start type with general-purpose enclosure. Select unit fan or fans to produce the required capacity at the fan static pressure.

2.10.1.5 Access Sections and Filter/Mixing Boxes

Provide access sections where indicated and furnish with access doors as shown. Construct access sections and filter/mixing boxes in a manner identical to the remainder of the unit casing and equip with access doors. Design mixing boxes to minimize air stratification and to promote thorough mixing of the air streams.

2.11 TERMINAL UNITS

2.11.1 Variable Air Volume (VAV) and Dual Duct Terminal Units

- a. Provide VAV and dual duct terminal units that are the type, size, and capacity shown, mounted in the ceiling or wall cavity, plus units that are suitable for single or dual duct system applications. Provide actuators and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. [For each VAV terminal unit, provide a temperature sensor in the unit discharge ductwork.](#)

- b. Provide unit enclosures that are constructed of galvanized steel not lighter than 22 gauge or aluminum sheet not lighter than 18 gauge. Provide single or multiple discharge outlets as required. Units with flow limiters are not acceptable. Provide unit air volume that is factory preset and readily field adjustable without special tools.
- c. Attach a flow chart to each unit. Base acoustic performance of the terminal units upon units tested according to AHRI 880 I-P with the calculations prepared in accordance with AHRI 885. Provide sound power level as indicated. Show discharge sound power for minimum and 1-1/2 inches water gauge inlet static pressure. Provide acoustical lining according to NFPA 90A.

2.11.1.1 Variable Volume, Single Duct Terminal Units

Provide variable volume, single duct, terminal units with a calibrated air volume sensing device, air valve or damper, actuator, and accessory relays. Provide units that 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 3/4 to 6 inch water gauge. Provide units with an internal resistance not exceeding 0.4 inch water gauge at maximum flow range. Provide external differential pressure taps separate from the control pressure taps for air flow measurement with a 0 to 1 inch water gauge range.

2.11.1.2 Reheat Units

2.11.1.2.1 Hot Water Coils

Provide fin-and-tube type hot-water coils constructed of seamless copper tubes and copper or aluminum fins mechanically bonded or soldered to the tubes. Provide headers that are constructed of cast iron, welded steel or copper. Provide casing and tube support sheets that are 16 gauge, galvanized steel, formed to provide structural strength. Provide tubes that are correctly circuited for proper water velocity without excessive pressure drop and are drainable where required or indicated. At the factory, test each coil at not less than 250 psi air pressure and provide coils suitable for 200 psi working pressure. Install drainable coils in the air handling units with a pitch of not less than 1/8 inch per foot of tube length toward the drain end. Coils must conform to the provisions of AHRI 410.

2.12 FACTORY PAINTING

Factory paint new equipment, which are not of galvanized construction. Paint with a corrosion resisting paint finish according to ASTM A123/A123M or ASTM A924/A924M. Clean, phosphatize and coat internal and external ferrous metal surfaces with a paint finish which has been tested according to ASTM B117, ASTM D1654, and ASTM D3359. Submit 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. Provide rating of failure at the scribe mark that is not less than 6, average creepage not greater than 1/8 inch. Provide rating of the inscribed area that is not less than 10, no failure. On units constructed of galvanized steel that have been welded, provide a final shop docket of zinc-rich protective paint on exterior surfaces of welds or welds that have burned through from the interior according to ASTM D520 Type I.

Field paint factory painting that has been damaged prior to acceptance by

the Contracting Officer in compliance with the requirements of paragraph
FIELD PAINTING OF MECHANICAL EQUIPMENT.

2.13 SUPPLEMENTAL COMPONENTS/SERVICES

2.13.1 Chilled, Condenser, or Dual Service Water Piping

The requirements for chilled, condenser, or dual service water piping and accessories are specified in Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS

2.13.2 Refrigerant Piping

The requirements for refrigerant piping are specified in Section 23 23 00 REFRIGERANT PIPING.

2.13.3 Water or Steam Heating System Accessories

The requirements for water or steam heating accessories such as expansion tanks and steam traps are specified in Section 23 52 00 HEATING BOILERS.

2.13.4 Condensate Drain Lines

Provide and install condensate drainage for each item of equipment that generates condensate in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS except as modified herein.

2.13.5 Insulation

The requirements for shop and field applied insulation are specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.13.6 Controls

The requirements for controls are specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS and Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

- a. Install materials and equipment in accordance with the requirements of the contract drawings and approved [manufacturer's installation instructions](#). Accomplish installation by workers skilled in this type of work. Perform installation so that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors.
- b. No installation is permitted to block or otherwise impede access to any existing machine or system. Install all hinged doors to swing open a minimum of 120 degrees. Provide an area in front of all access doors that clears a minimum of 3 feet. In front of all access doors to electrical circuits, clear the area the minimum distance to

energized circuits as specified in OSHA Standards, part 1910.333 (Electrical-Safety Related work practices) and an additional 3 feet.

- c. Except as otherwise indicated, install emergency switches and alarms in conspicuous locations. Mount all indicators, to include gauges, meters, and alarms in order to be easily visible by people in the area.

3.2.1 Condensate Drain Lines

Provide water seals in the condensate drain from all units. Provide a depth of each seal of 2 inches plus the number of inches, measured in water gauge, of the total static pressure rating of the unit to which the drain is connected. Provide water seals that are constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Provide pipe cap or plug cleanouts where indicated. Connect drains indicated to connect to the sanitary waste system using an indirect waste fitting. Insulate air conditioner drain lines as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.2 Equipment and Installation

Provide frames and supports for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Floor mount or ceiling hang air handling units as indicated. Anchor and fasten as detailed. Set floor-mounted equipment on not less than 6 inch concrete pads or curbs doweled in place unless otherwise indicated. Make concrete foundations heavy enough to minimize the intensity of the vibrations transmitted to the piping, duct work and the surrounding structure, as recommended in writing by the equipment manufacturer. In lieu of a concrete pad foundation, build a concrete pedestal block with isolators placed between the pedestal block and the floor. Make the concrete foundation or concrete pedestal block a mass not less than three times the weight of the components to be supported. Provide the lines connected to the pump mounted on pedestal blocks with flexible connectors. Submit foundation drawings as specified in paragraph DETAIL DRAWINGS. Provide concrete for foundations as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2.3 Access Panels

Install access panels for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance of sufficient size, and locate them so that the concealed items are easily serviced and maintained or completely removed and replaced. Provide access panels as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.2.4 Flexible Duct

Install pre-insulated flexible duct in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Provide hangers, when required to suspend the duct, of the type recommended by the duct manufacturer and set at the intervals recommended.

3.2.5 Metal Ductwork

Install according to SMACNA 1966 unless otherwise indicated. Install duct supports for sheet metal ductwork according to SMACNA 1966, unless otherwise specified. Do not use friction beam clamps indicated in SMACNA 1966. Anchor risers on high velocity ducts in the center of the

vertical run to allow ends of riser to move due to thermal expansion. Erect supports on the risers that allow free vertical movement of the duct. Attach supports only to structural framing members and concrete slabs. Do not anchor supports 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, provide suitable intermediate metal framing. Where C-clamps are used, provide retainer clips.

3.2.6 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, perform temporary dust control protection. Protect the distribution system (supply and return) with temporary seal-offs at all inlets and outlets at the end of each day's work. Keep temporary protection in place until system is ready for startup.

3.2.7 Insulation

Provide thickness and application of insulation materials for ductwork, piping, and equipment according to Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Externally insulate outdoor air intake ducts and plenums .

3.2.8 Duct Test Holes

Provide holes with closures or threaded holes with plugs in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Plug insulated duct at the duct surface, patched over with insulation and then marked to indicate location of test hole if needed for future use.

3.2.9 Power Roof Ventilator Mounting

Provide foamed 1/2 inch thick, closed-cell, flexible elastomer insulation to cover width of roof curb mounting flange. Where wood nailers are used, predrill holes for fasteners.

3.2.10 Power Transmission Components Adjustment

Test V-belts and sheaves for proper alignment and tension prior to operation and after 72 hours of operation at final speed. Uniformly load belts on drive side to prevent bouncing. Make alignment of direct driven couplings to within 50 percent of manufacturer's maximum allowable range of misalignment.

3.3 EQUIPMENT PADS

Provide equipment pads to the dimensions shown or, if not shown, to conform to the shape of each piece of equipment served with a minimum 3-inch margin around the equipment and supports. Allow equipment bases and foundations, when constructed of concrete or grout, to cure a minimum of 28 calendar days before being loaded.

3.4 CUTTING AND PATCHING

Install work in such a manner and at such time that a minimum of cutting and patching of the building structure is required. Make holes in exposed locations, in or through existing floors, by drilling and smooth by

sanding. Use of a jackhammer is permitted only where specifically approved. Make holes through masonry walls to accommodate sleeves with an iron pipe masonry core saw.

3.5 CLEANING

Thoroughly clean surfaces of piping and equipment that have become covered with dirt, plaster, or other material during handling and construction before such surfaces are prepared for final finish painting or are enclosed within the building structure. Before final acceptance, clean mechanical equipment, including piping, ducting, and fixtures, and free from dirt, grease, and finger marks. When the work area is in an occupied space such as office, laboratory or warehouse protect all furniture and equipment from dirt and debris. Incorporate housekeeping for field construction work which leaves all furniture and equipment in the affected area free of construction generated dust and debris; and, all floor surfaces vacuum-swept clean.

3.6 PENETRATIONS

Provide sleeves and prepared openings for duct mains, branches, and other penetrating items, and install during the construction of the surface to be penetrated. Cut sleeves flush with each surface. Place sleeves for round duct **15 inches** and smaller. Build framed, prepared openings for round duct larger than **15 inches** and square, rectangular or oval ducts. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Provide **one inch** clearance between penetrating and penetrated surfaces except at grilles, registers, and diffusers. Pack spaces between sleeve or opening and duct or duct insulation with mineral fiber conforming with **ASTM C553**, Type 1, Class B-2.

3.6.1 Sleeves

Fabricate sleeves, except as otherwise specified or indicated, from **20 gauge** thick mill galvanized sheet metal. Where sleeves are installed in bearing walls or partitions, provide black steel pipe conforming with **ASTM A53/A53M**, Schedule 20.

3.6.2 Framed Prepared Openings

Fabricate framed prepared openings from **20 gauge** galvanized steel, unless otherwise indicated.

3.6.3 Insulation

Provide duct insulation in accordance with Section **23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS** continuous through sleeves and prepared openings except firewall penetrations. Terminate duct insulation at fire dampers and flexible connections. For duct handling air at or below **60 degrees F**, provide insulation continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air.

3.6.4 Closure Collars

Provide closure collars of a minimum **4 inches** wide, unless otherwise indicated, for exposed ducts and items on each side of penetrated surface, except where equipment is installed. Install collar tight against the surface and fit snugly around the duct or insulation. Grind sharp edges smooth to prevent damage to penetrating surface. Fabricate collars for

round ducts 15 inches in diameter or less from 20 gauge galvanized steel. Fabricate collars for square and rectangular ducts, or round ducts with minimum dimension over 15 inches from 18 gauge galvanized steel. Fabricate collars for square and rectangular ducts with a maximum side of 15 inches or less from 20 gauge galvanized steel. Install collars with fasteners a maximum of 6 inches on center. Attach to collars a minimum of 4 fasteners where the opening is 12 inches in diameter or less, and a minimum of 8 fasteners where the opening is 20 inches in diameter or less.

3.6.5 Firestopping

Where ducts pass through fire-rated walls, fire partitions, and fire rated chase walls, seal the penetration with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING.

3.7 FIELD PAINTING OF MECHANICAL EQUIPMENT

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except clean to bare metal on metal surfaces subject to temperatures in excess of 120 degrees F. Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Provide aluminum or light gray finish coat.

3.7.1 Temperatures less than 120 degrees F

Immediately after cleaning, apply one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat to metal surfaces subject to temperatures less than 120 degrees F.

3.7.2 Temperatures between 120 and 400 degrees F

Apply two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of two mils to metal surfaces subject to temperatures between 120 and 400 degrees F.

3.7.3 Finish Painting

The requirements for finish painting of items only primed at the factory, and surfaces not specifically noted otherwise, are specified in Section 09 90 00 PAINTS AND COATINGS.

3.8 IDENTIFICATION SYSTEMS

Provide identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number on all valves and dampers. Provide tags that are 1-3/8 inch minimum diameter with stamped or engraved markings. Make indentations black for reading clarity. Attach tags to valves with No. 12 AWG 0.0808-inch diameter corrosion-resistant steel wire, copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.9 TESTING, ADJUSTING, AND BALANCING

The requirements for testing, adjusting, and balancing are specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC. Begin testing, adjusting, and balancing only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.10 PERFORMANCE TESTS

Conduct performance tests as required in Section 23 05 93 Testing, Adjusting and Balancing for HVAC and Section 23 09 00 Instrumentation and Control for HVAC.

3.11 CLEANING AND ADJUSTING

Provide a temporary bypass for water coils to prevent flushing water from passing through coils. Inside of room fan-coil units air terminal units, thoroughly clean ducts, plenums, and casing of debris and blow free of small particles of rubbish and dust and then vacuum clean before installing outlet faces. Wipe equipment clean, with no traces of oil, dust, dirt, or paint spots. Provide temporary filters prior to startup of all fans that are operated during construction, and provide new filters after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. Perform and document that proper "Indoor Air Quality During Construction" procedures have been followed; provide documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. Maintain system in this clean condition until final acceptance. Properly lubricate bearings with oil or grease as recommended by the manufacturer. Tighten belts to proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions. Maintain all equipment installed under the contract until close out documentation is received, the project is completed and the building has been documented as beneficially occupied.

3.12 OPERATION AND MAINTENANCE

3.12.1 Operation and Maintenance Manuals

Submit six manuals at least 2 weeks prior to field training. Submit data complying with the requirements specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit Data Package 3 for the items/units listed under SD-10 Operation and Maintenance Data

3.12.2 Operation And Maintenance Training

Conduct a training course for the members of the operating staff as designated by the Contracting Officer. Make the training period consist of a total of 4 hours of normal working time and start it after all work specified herein is functionally completed and the Performance Tests have been approved. Conduct field instruction that covers all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations. Submit the proposed On-site Training schedule concurrently with the Operation and Maintenance Manuals and at least 14 days prior to conducting the training course.

-- End of Section --

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SECTION 23 52 00

HEATING BOILERS

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 MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 801 (2001; R 2008) Industrial Process/Power
Generation Fans: Specification Guidelines

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.13/CSA 4.9 (2017; Errata 2018) Gas-Fired Low Pressure
Steam and Hot Water Boilers

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING
ENGINEERS (ASHRAE)

ASHRAE 52.2 (2012) Method of Testing General
Ventilation Air-Cleaning Devices for
Removal Efficiency by Particle Size

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1 (2013; R 2018) Pipe Threads, General
Purpose (Inch)

ASME B16.3 (2021) Malleable Iron Threaded Fittings,
Classes 150 and 300

ASME B16.4 (2021) Gray Iron Threaded Fittings;
Classes 125 and 250

ASME B16.5 (2020) Pipe Flanges and Flanged Fittings
NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B16.9 (2018) Factory-Made Wrought Butt welding
Fittings

ASME B16.11 (2016) Forged Fittings, Socket-Welding and
Threaded

ASME B16.15 (2018) Cast Copper Alloy Threaded Fittings
Classes 125 and 250

ASME B16.18 (2021) Cast Copper Alloy Solder Joint
Pressure Fittings

ASME B16.20 (2017) Metallic Gaskets for Pipe Flanges

ASME B16.22	(2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2020) Power Piping
ASME B31.5	(2020) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IV	(2017) BPVC Section IV-Rules for Construction of Heating Boilers
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME CSD-1	(2021) Control and Safety Devices for Automatically Fired Boilers

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2015) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.2/B2.2M	(2016) Specification for Brazing Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A515/A515M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM B828	(2016) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM D596	(2001; R 2018) Standard Guide for Reporting Results of Analysis of Water
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(2016; 14/17) Copper Tube Handbook

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds (2015) (10th Ed) EJMA Standards

HYDRONICS INSTITUTE DIVISION OF AHRI (HYI)

HYI-005 (2008) I=B=R Ratings for Boilers,
Baseboard Radiation and Finned Tube
(Commercial)

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS
INDUSTRY (MSS)

MSS SP-25 (2018) Standard Marking System for Valves,
Fittings, Flanges and Unions

MSS SP-58 (2018) Pipe Hangers and Supports -
Materials, Design and Manufacture,
Selection, Application, and Installation

MSS SP-70 (2011) Gray Iron Gate Valves, Flanged and
Threaded Ends

MSS SP-71 (2018) Gray Iron Swing Check Valves,
Flanged and Threaded Ends

MSS SP-72 (2010a) Ball Valves with Flanged or
Butt-Welding Ends for General Service

MSS SP-78 (2011) Cast Iron Plug Valves, Flanged and
Threaded Ends

MSS SP-80 (2019) Bronze Gate, Globe, Angle and Check
Valves

MSS SP-85 (2011) Gray Iron Globe & Angle Valves
Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2020) Enclosures for Electrical Equipment
(1000 Volts Maximum)

NEMA MG 1 (2016) Motors and Generators - Revision
1: 2018; Includes 2021 Updates to Parts
0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54 (2021) National Fuel Gas Code

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA
20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star (1992; R 2006) Energy Star Energy
Efficiency Labeling System (FEMP)

UNDERWRITERS LABORATORIES (UL)

UL 795	(2016; Reprint Sep 2020) UL Standard for Safety Commercial-Industrial Gas Heating Equipment
UL 1738	(2020; Reprint Aug 2021) UL Standard for Safety Venting Systems for Gas-Burning Appliances, Categories II, III and IV
UL FLAMMABLE & COMBUSTIBLE	(2012) Flammable and Combustible Liquids and Gases Equipment Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Materials and Equipment

Spare Parts

Water Treatment System

Boiler Water Treatment Fuel System Tests

Welding

Field Instructions

Tests

SD-06 Test Reports

Fuel System Tests

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions; G

1.3 QUALITY ASSURANCE

Submit a copy of qualified welding procedures and a list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations. 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. Notify the Contracting Officer 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.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings and no later than 2 months prior to the date of beneficial occupancy. Submit 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. Include on the drawings any information required to demonstrate that the system has been coordinated and will properly function as a unit and to show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Include in the data 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.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that 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. Submit manufacturer's catalog data included with the detail drawings for the following:

- a. Radiant floor heating system including tubing, joints, and manifold for radiant floor heating systems.
- b. Data showing model, size, options, etc., that are intended for consideration. Data submitted shall be adequate to demonstrate compliance with contract requirements. Data shall include manufacturer's written installation instructions and manufacturer's recommendations for operation and maintenance clearances for the following:
 - (1) Boilers
 - (2) Fittings and Accessories

2.1.2 Asbestos Prohibition

Asbestos and asbestos-containing products will not be allowed.

2.1.3 Nameplates

Secure a plate to each major component of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number. Also, display an **Energy Star** label as applicable. Each pressure vessel shall have an approved ASME stamp.

2.1.4 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.

2.2 BOILERS

Each boiler shall have the output capacity in **British thermal units per hour (Btuh)** as indicated when fired with the specified fuels. The boiler shall be furnished complete with the oil burning equipment, boiler fittings and trim, automatic controls, forced 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 condensing type and designed for water service as specified herein. The boiler capacity shall be based on the ratings shown in **HYI-005** or as certified by the American Boiler Manufacturers Association, or American Gas Association.

2.2.1 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.

2.3 FUEL BURNING EQUIPMENT

Boiler shall be designed to burn gas . Each boiler shall comply with Federal, state, and local emission regulations.

2.3.1 Burners

2.3.1.1 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. 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 400,000 Btuh per combustion chamber shall conform to UL 795. Gas fired units less than 12,500,000 Btuh input shall conform to ANSI Z21.13/CSA 4.9.

2.3.2 Draft Fans

Fans conforming to AMCA 801 forced-draft shall be furnished as an integral part of boiler design. 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. Forced draft fan bearings shall be air cooled.

2.3.2.1 Draft Fan Control

Forced-draft centrifugal fans shall have inlet vane controls or shall have variable speed control. Inlet vanes shall be suitable for use with combustion control equipment. Axial propeller fans shall have variable propeller pitch control.

2.3.2.2 Draft Fan Drives

Fans shall be driven by electric motors. Electric motor shall be suitable for installation in a Class II, Division 1, Group F, hazardous location conforming to NFPA 70.

2.3.3 Draft Damper

Boilers shall be provided with manual 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.

2.3.4 Ductwork

Air ducts connecting the forced-draft fan units with the plenum chamber shall be designed to convey air with a minimum of pressure loss due to friction. Ductwork shall be galvanized sheet metal conforming to ASTM A653/A653M. Ducts shall be straight and smooth on the inside with laps made in direction of air flow. Ducts shall have cross-break with enough center height to assure rigidity in the duct section, shall be

angle iron braced, and shall be completely free of vibration. Access and inspection doors shall be provided as indicated and required, with a minimum of one in each section between dampers or items of equipment. Ducts shall be constructed with long radius elbows having a centerline radius 1-1/2 times the duct width, or where the space does not permit the use of long radius elbows, short radius or square elbows with factory-fabricated turning vanes may be used. Duct joints shall be substantially airtight and shall have adequate strength for the service, with 1-1/2 x 1-1/2 x 1/8 inch angles used where required for strength or rigidity. Duct wall thickness shall be 16 gauge (0.0598 inch) for ducts 60 inches or less and 12 gauge (0.1046 inch) for ducts larger than 60 inches in maximum dimension. Additional ductwork shall be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.4 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 equipment shall operate electronically. 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.

2.4.1 Electrical controls

Electrical control devices shall be rated at 120 volts and shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.4.2 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 boiler return piping. 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.

2.4.3 Boiler Combustion Controls and Positioners

- a. Gas boiler units shall be provided with modulating combustion controls with gas pilot or spark ignition. Modulating controls shall be provided with a means for manually controlling the firing rate.
- b. 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. 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.

2.4.4 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 26 20 00 INTERIOR DISTRIBUTION SYSTEM. A 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 cutoff.
- e. High temperature cutoff.

2.4.4.1 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 ASME CSD-1.

2.4.4.2 Water Flow Interlock

Hot water boiler limit controls shall be provided to include protection for 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.

2.5 COLD WATER CONNECTIONS

Connections shall be provided which includes consecutively in line a

strainer, reduced pressure principle backflow preventers, and water pressure regulator in that order in the direction of the flow. The reduced pressure principle backflow preventers shall be provided as indicated and in compliance with Section 22 00 00 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 5 psi in excess of the static head on the system and shall operate within a 2 psi tolerance regardless of cold water supply piping pressure and without objectionable noise under any condition of operation.

2.6 AIR HANDLING UNITS

Air handling units and associated equipment shall be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.7 FITTINGS AND ACCESSORIES

Boiler fittings and accessories shall be installed with each boiler in accordance with ASME BPVC SEC IV, unless otherwise specified.

2.7.1 Direct Vents

Direct venting shall be used for condensing type boilers. 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 vent shall be provided for each boiler.

2.7.1.1 Combustion Air Intake Vent

The combustion air intake piping shall be constructed of Schedule 40 PVC in accordance with ASTM D1784. The vent shall be suitable for the temperature at the boiler combustion air intake connection point. Each intake shall be provided complete with bird screen.

2.7.1.2 Exhaust Vent

The exhaust vent piping shall be constructed of Schedule 40 CPVC or stainless steel conforming to UL 1738 and the boiler manufacturer's recommendations. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. The exhaust vent shall be suitable for the maximum anticipated boiler exhaust temperature and shall withstand the corrosive effects of the condensate. A 0.3125 inch diameter hole shall be provided in the stack not greater than 6 inches from the boiler 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 exhaust stack shall be provided complete with bird screen.

2.7.2 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 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 250 degrees F.

2.7.3 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 125 psi. The capacity of the air separation tank indicated is minimum.

2.7.4 Filters

Filters shall conform to ASHRAE 52.2.

2.7.5 Steel Sheets

2.7.5.1 Galvanized Steel

Galvanized steel shall be ASTM A653/A653M.

2.7.5.2 Uncoated Steel

Uncoated steel shall be composition, condition, and finish best suited to the intended use.

2.7.6 Gaskets

Gaskets shall be nonasbestos material in accordance with ASME B16.20, full face or self-centering type. The gaskets shall be of the spiral wound type with graphite filler material.

2.7.7 Steel Pipe and Fittings

2.7.7.1 Steel Pipe

Steel pipe shall be ASTM A53/A53M, Type E or S, Grade A or B, black steel, standard weight.

2.7.7.2 Steel Pipe Fittings

Fittings shall have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

2.7.7.3 Steel Flanges

Flanged fittings including flanges, bolts, nuts, bolt patterns, etc. shall be in accordance with ASME B16.5 class 150 and shall have the manufacturer's trademark affixed in accordance with MSS SP-25. Flange material shall conform to ASTM A105/A105M. Flanges for high temperature water systems shall be serrated or raised-face type. Blind flange

material shall conform to ASTM A516/A516M cold service and ASTM A515/A515M for hot service. Bolts shall be high strength or intermediate strength with material conforming to ASTM A193/A193M.

2.7.7.4 Welded Fittings

Welded fittings shall conform to ASTM A234/A234M with WPA marking. Buttwelded fittings shall conform to ASME B16.9, and socket-welded fittings shall conform to ASME B16.11.

2.7.7.5 Cast-Iron Fittings

Fittings shall be ASME B16.4, Class 125, type required to match connecting piping.

2.7.7.6 Malleable-Iron Fittings

Fittings shall be ASME B16.3, type as required to match connecting piping.

2.7.7.7 Unions

Unions shall be ASME B16.39, Class 150.

2.7.7.8 Threads

Pipe threads shall conform to ASME B1.20.1.

2.7.8 Copper Tubing and Fittings

2.7.8.1 Copper Tubing

Tubing shall be ASTM B88, Type K or L. Adapters for copper tubing shall be brass or bronze for brazed fittings.

2.7.8.2 Solder-Joint Pressure Fittings

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B75/B75M. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18 and ASTM B828.

2.7.8.3 Flared Fittings

Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B62.

2.7.8.4 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.

2.7.8.5 Threaded Fittings

Cast bronze threaded fittings shall conform to ASME B16.15.

2.7.8.6 Brazing Material

Brazing material shall conform to AWS A5.8/A5.8M.

2.7.8.7 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/A5.8M](#).

2.7.8.8 Solder Material

Solder metal shall conform to [ASTM B32](#) 95-5 tin-antimony.

2.7.8.9 Solder Flux

Flux shall be either liquid or paste form, non-corrosive and conform to [ASTM B813](#).

2.7.9 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 include dielectric unions to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

2.7.10 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for [125 psi](#) or [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.

2.7.11 Pipe Supports

Pipe supports shall conform to [MSS SP-58](#).

2.7.12 Pipe Expansion

2.7.12.1 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.

2.7.12.2 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 working pressure not less than 125 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 5 feet from expansion joint, except in lines 4 inches or smaller guides shall be installed not more than 2 feet from the joint. Service outlets shall be provided where indicated.

2.7.12.2.1 Bellows-Type joint

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 150 psig.

2.7.12.2.2 Flexible Ball Joint

Flexible ball joints shall be constructed of alloys as appropriate for the service intended. The joints shall be threaded, grooved, 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.

2.7.12.2.3 Slip Type Expansion Joint

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.

2.7.13 Valves

Valves shall be Class 125 and shall be suitable for the application. Grooved ends in accordance with AWWA C606 may be used for water service only. Valves in nonboiler external piping shall meet the material, fabrication and operating requirements of ASME B31.1. The connection type of all valves shall match the same type of connection required for the piping on which installed.

2.7.13.1 Gate Valves

Gate valves 2-1/2 inches and smaller shall conform to MSS SP-80 bronze

rising stem, threaded, soldered, or flanged ends. Gate valves 3 inches and larger shall conform to MSS SP-70 cast iron bronze trim, outside screw and yoke, flanged, or threaded ends.

2.7.13.2 Globe Valves

Globe valves 2-1/2 inches and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Globe valves 3 inches and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

2.7.13.3 Check Valves

Check valves 2-1/2 inches and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Check valves 3 inches and larger shall conform to MSS SP-71, cast iron, bronze trim, flanged, or threaded ends.

2.7.13.4 Angle Valves

Angle valves 2-1/2 inches and smaller shall conform to MSS SP-80 bronze, threaded, soldered, or flanged ends. Angle valves 3 inches and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

2.7.13.5 Ball Valves

Ball valves 1/2 inch and larger shall conform to MSS SP-72, ductile iron or bronze, threaded, soldered, or flanged ends.

2.7.13.6 Plug Valves

Plug valves 2 inch and larger shall conform to MSS SP-78. Plug valves smaller than 2 inch shall conform to ASME B16.34.

2.7.13.7 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 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.

2.7.13.8 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 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 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. 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.

2.7.13.9 Butterfly Valves

Butterfly valves shall be 2-flange type or lug wafer type, and shall be bubbletight at 150 psig. Valve bodies shall be cast iron, malleable iron, or steel. ASTM A167, 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 8 inches shall have throttling handles with a minimum of seven locking positions. Valves 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.

2.7.13.10 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 ASTM A53/A53M.

2.7.13.11 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 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 hot water service shall be pitched away from the valve seat.

2.7.14 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 125 psig service and 200 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 22 gauge thick corrosion-resistant steel with small perforations numbering not less than 400/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.

2.7.15 Pressure Gauges

Gauges shall conform to ASME B40.100 and shall be provided with throttling type needle valve or a pulsation dampener and shutoff valve. Minimum dial size shall be 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 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 (psi)	Pressure Range (psi)
76-150	0-200
16-75	0-100
2-15	0-30 (retard)

2.7.16 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 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 9 inch scale. The operating range of the thermometers shall be 32-212 degrees F. The thermometers shall be provided with readings in degrees F.

2.7.17 Air Vents

2.7.17.1 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.

2.7.17.2 Automatic Air Vents

Automatic air vents shall be 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.

2.8 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 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Motors which are not an integral part of a packaged boiler and which are integral in size shall be the premium efficiency type in accordance with NEMA MG 1. 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 enclosures. 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.

2.8.1 Motor Ratings

Motors shall be suitable for the voltage and frequency provided. Motors 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.

2.8.2 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 10 hp ratings. Adjustable frequency drives shall be used for larger motors.

2.9 INSULATION

Shop and field-applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.10 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.

2.10.1 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.

2.11 BOILER WATER TREATMENT

Submit six complete copies of the proposed water treatment plan. The plan shall include a layout, control scheme, a list of the existing water conditions including the items listed in this paragraph, a list of all chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals. The [water treatment system](#) shall be capable of feeding chemicals and bleeding the system to prevent corrosion and scale within the boiler and piping distribution system. Submit 6 complete copies of operating and maintenance manuals for the step-by-step water treatment procedures, including procedures for testing the water quality. The water shall be treated to maintain the conditions recommended by the boiler manufacturer. Chemicals shall meet required federal, state, and local environmental regulations for the treatment of boilers and discharge to the sanitary sewer. The services of a company regularly engaged in the treatment of boilers shall be used to determine the correct chemicals and concentrations required for water treatment. The company shall maintain the chemical treatment and provide all chemicals required for a period of 1 year from the date of occupancy. Filming amines and proprietary chemicals shall not be used. The water treatment chemicals shall remain stable throughout the operating temperature range of the system and shall be compatible with pump seals and other elements of the system.

2.11.1 MakeUp Water Analysis

The makeup water conditions reported as prescribed in [ASTM D596](#) are as follows:

Date of Sample	
Temperature	degrees F
Silica (SiO2)	ppm (mg/1)
Insoluble	ppm (mg/1)
Iron and Aluminum Oxides	ppm (mg/1)
Calcium (Ca)	ppm (mg/1)
Magnesium (Mg)	ppm (mg/1)
Sodium and Potassium (Na and K)	ppm (mg/1)
Carbonate (HCO3)	ppm (mg/1)
Sulfate (SO4)	ppm (mg/1)
Chloride (Cl)	ppm (mg/1)
Nitrate (NO3)	ppm (mg/1)

Turbidity	ntu
pH	
Residual Chlorine	ppm (mg/1)
Total Alkalinity	epm (meq/1)
Noncarbonate Hardness	epm (meq/1)
Total Hardness	epm (meq/1)
Dissolved Solids	ppm (mg/1)
Fluorine	ppm (mg/1)
Conductivity	micro-mho/cm

2.11.2 Boiler Water Limits

The boiler manufacturer shall be consulted for the determination of the boiler water chemical composition limits. The boiler water limits shall be as follows unless dictated differently by the boiler manufacturer's recommendations:

Causticity	20-200 ppm
Total Alkalinity (CAC03)	900-1200 ppm
Phosphate	30-60 ppm
Tanin	Medium
Dissolved Solids	3000-5000 ppm
Suspended Solids	300 ppm Max
Sodium Sulfite	20-40 ppm Max
Silica	Less than 150 ppm
Dissolved Oxygen	Less than 7 ppm
Iron	10 ppm
pH (Condensate)	7 - 8
Sodium Sulfite	20-40 ppm
Hardness	Less than 2 ppm

pH	9.3 - 9.9

2.11.3 Chemical Feed Pumps

One pump shall be provided for each chemical feed tank. The chemical feed pumps shall be positive displacement diaphragm type. The capacity of the pumps shall be adjustable from 0 to 100 percent while in operation. The discharge pressure of the pumps shall be not less than 1.5 times the pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge.

2.11.4 Tanks

The tanks shall be constructed of stainless steel with a hinged cover. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation. A level indicating device shall be included with each tank. An electric agitator shall be provided for each tank.

2.11.5 Injection Assemblies

An injection assembly shall be provided at each chemical injection point located along the boiler piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the water line.

2.11.6 Water Meter

The water meter shall be provided with an electric contacting register and remote accumulative counter. The meter shall be installed within the makeup water line, as indicated.

2.11.7 Water Treatment Control Panel

The control panel shall be a NEMA 12, single door, wall-mounted box conforming with NEMA 250. The panel shall be constructed of stainless steel with a hinged door and lock. The panel shall contain, as a minimum, the following functions identified with a laminated plastic nameplate:

- a. Main power switch and indicating light
- b. MAN-OFF-AUTO selector switch
- c. Indicating lamp for blow down
- d. Indicating lamp for each chemical feed pump
- e. Indicating lamp for the water softener

2.11.8 Sequence of Operation

The flow rate of chemical addition shall be based upon metering the makeup water. The boiler shall be provided with automatic blowdown based upon conductivity or boiler load. The required rate of chemical feed and boiler blowdown shall be determined by the water treatment company.

2.11.9 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.

2.11.10 Chemical Piping

The piping and fittings shall be constructed of schedule 80 PVC .

2.11.11 Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided.

2.11.12 Glycol Feed System

Design the Glycol feed system to automatically maintain the desired glycol content of the closed water recirculation system(s). Each system shall consist of the following components:

2.11.12.1 Supply Tank and Stand

Include a 50 gallon cross lined polyethylene tank and steel support stand. The tank shall have a cover and bottom outlet fitting for pump suction. Equip the tank stand with a pump mounting platform and support for the control panel and level switch.

2.11.12.2 Glycol Pump

Rotary gear type of bronze construction with a capacity of 1.8 gpm at 40 psi. The pump shall have a 1/3 horsepower, 1/115V/60hz motor and internal pressure relief. Provide the pump with a discharge check valve and shutoff valve.

2.11.12.3 Pressure Switch

The pressure switch shall be adjustable over the range of 3 - 15 psi with a 6 psi differential and have contacts rated for 115V.

2.11.12.4 Level Switch

Equipped with N/O and N/C contacts to activate upon sensing a low level condition.

2.11.12.5 Control Panel

The control panel shall be installed in a NEMA 1 enclosure with terminal strip and shall include a red low level alarm light, low level alarm bell and silence button, full voltage motor starter for the glycol pump, and a Hand-Off-Auto selector switch.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the

field, and advise the Contracting Officer of any discrepancy before performing any work or ordering any materials.

3.2 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 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.

3.3 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 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 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 2-1/2 inches or less in diameter and with flanges for pipe 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.

3.3.1 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 230 degrees F.

3.3.2 Vent Piping and Fittings

Vent piping shall be black steel. Fittings shall be black malleable iron or cast iron to suit piping.

3.3.3 Gauge Piping

Piping shall be copper tubing.

3.3.4 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 1 inch and smaller shall be threaded; fittings 1-1/4 inches and up to but not including 3 inches shall be either threaded, grooved, or welded; and fittings 3 inches and larger shall be either flanged, grooved, or welded. Pipe and fittings 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 2-1/2 inches or smaller in diameter and with flanges for pipe 3 inches or larger in diameter. Joints between sections of copper tubing or pipe shall be flared, soldered, or brazed.

3.3.4.1 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.

3.3.4.2 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 1/16 inch and no more than 1/8 inch.

3.3.4.3 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/B2.2M and CDA A4015 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.

3.3.4.4 Soldered Joints

Soldered joints shall be made with flux and are only acceptable for lines **2 inches** and smaller. Soldered joints shall conform to **ASME B31.5** and **CDA A4015**.

3.3.4.5 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.

3.3.5 Flanges and Unions

Flanges shall be faced true, provided with **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.

3.3.6 Branch Connections

3.3.6.1 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 **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.

3.3.6.2 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 undrilled risers or radiator connections with a grade of not less than **1 inch in 10 feet**. Connections to ensure unrestricted circulation, eliminate air

pockets, and permit the complete drainage of the system.

3.3.7 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 [CDA A4015](#). 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 [2 inches](#) or smaller. Soldered joints shall conform to [ASME B31.5](#) and shall be in accordance with [CDA A4015](#).

3.3.8 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.

3.3.9 Supports

Hangers used to support piping [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. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.3.9.1 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to [MSS SP-58](#), except as modified herein.

3.3.9.1.1 Types 5, 12, and 26

Use of Types 5, 12, and 26 is prohibited.

3.3.9.1.2 Type 3

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.

3.3.9.1.3 Type 18

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.

3.3.9.1.4 Type 19 and 23 C-Clamps

Torque Type 19 and 23 C-clamps in accordance with [MSS SP-58](#) and have both locknuts and retaining devices furnished by the manufacturer. Field fabricated C-clamp bodies or retaining devices are not acceptable.

3.3.9.1.5 Type 20 Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.3.9.1.6 Type 24

Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.3.9.1.7 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in [MSS SP-58](#) and a support shall be installed not over [1 foot](#) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over [5 feet](#) apart at valves.

3.3.9.1.8 Vertical Pipe Support

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than [15 feet](#), not more than [8 feet](#) from end of risers, and at vent terminations.

3.3.9.1.9 Type 35 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.

- a. Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping [4 inches](#) and larger, a Type 39 saddle may be welded to the pipe and freely rested on a steel plate. On piping under [4 inches](#), a Type 40 protection shield may be attached to the pipe or insulation and freely rested on a steel slide plate.
- b. 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 4 inches or by an amount adequate for the insulation, whichever is greater.

3.3.9.1.10 Horizontal Insulated Pipe

Except for Type 3, pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation.

3.3.9.1.11 Piping in Trenches

Support piping in trenches as indicated.

3.3.9.1.12 Structural Steel Attachments

Structural steel attachments and brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Pipe hanger loads suspended from steel joist between panel points shall not exceed 50 pounds. Loads exceeding 50 pounds shall be suspended from panel points.

3.3.9.2 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 1/8 inch shall be provided between the pipe insulation and the clip or clamp for piping which may be subjected to thermal expansion.

3.3.10 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.

3.3.11 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.

3.3.12 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 6 inches for proper flashing or finishing. Unless otherwise indicated, sleeves shall be sized to provide a minimum clearance of 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 07 92 00 JOINT SEALANTS. 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 0.006 inch thick aluminum, if corrugated, and 0.016 inch thick aluminum, if smooth.
- b. Secure metal jackets with aluminum or stainless steel bands not less than 3/8 inch wide and not more than 8 inches apart. When penetrating roofs and before fitting the metal jacket into place, a 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 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 2 inches above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 12 inches above material to a minimum distance of 2 inches above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 12 inches above the floor; when passing through walls above grade, the jacket shall extend at least 4 inches beyond each side of the wall.

3.3.12.1 Pipes Passing Through Waterproofing Membranes

In addition to the pipe sleeves referred to above, pipes passing through waterproofing membranes shall be provided with a 4 pound lead flashing or a 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 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 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 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.

3.3.12.2 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.

3.3.12.3 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 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.

3.3.12.4 Fire Seal

Where pipes pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.3.13 Balancing Valves

Balancing valves shall be installed as indicated.

3.3.14 Thermometer Wells

Provide a thermometer well in each return line for each circuit in multicircuit systems.

3.3.15 Air Vents

Install air vents 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.

3.3.16 Escutcheons

Provide escutcheons 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.

3.3.17 Drains

A drain connection with a 1 inch gate valve or 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.

3.3.18 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.

3.3.19 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 1/4 inch/ft toward the boiler's flue gas condensate collection point.

3.4 GAS FUEL SYSTEM

Gas piping, fittings, valves, regulators, tests, cleaning, and adjustments shall be in accordance with the Section 23 11 20 FACILITY GAS PIPING. Submit proposed test schedules for the heating system and fuel system tests, at least 2 weeks prior to the start of related testing. NFPA 54 shall be complied with unless otherwise specified. Burners, pilots, and all accessories shall be listed in UL FLAMMABLE & COMBUSTIBLE. 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.

3.5 COLOR CODE MARKING AND FIELD PAINTING

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS. Ferrous metal not specified to be coated at the factory shall be cleaned, prepared, and painted as specified in Section 09 90 00 PAINTS AND COATINGS. Exposed pipe covering shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. Aluminum sheath over insulation shall not be painted.

3.6 MANUFACTURER'S SERVICES

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified to supervise the installing, adjusting, and testing of the equipment.

3.7 TEST OF BACKFLOW PREVENTION ASSEMBLIES

Backflow prevention assemblies shall be tested in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.8 CLEANING

3.8.1 Boilers and Piping

After the hydrostatic tests have been made and before the system is balanced and operating tests are performed, the boilers and piping shall be thoroughly cleaned by filling the system with a solution consisting of either 1 pound of caustic soda or 1 pound of trisodium phosphate per 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 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 FIELD TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 4 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests.

- a. The field instructions shall cover all of the items contained in the approved operation and maintenance manuals, as well as demonstrations of routine maintenance operations and boiler safety devices.
- b. Submit 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.
- c. Submit six complete operation and maintenance instructions 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.
- d. Notify the Contracting Officer at least 14 days prior to date of proposed conduction of the training course.

3.10 FUEL SYSTEM TESTS

Submit test reports for the fuel system tests, upon completion of testing complete with results.

3.10.1 Gas System Test

The gas fuel system shall be tested in accordance with the test procedures outlined in NFPA 54.

-- End of Section --

SECTION 23 64 10

WATER CHILLERS, VAPOR COMPRESSION TYPE

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, HEATING AND REFRIGERATION INSTITUTE (AHRI)

- AHRI 450 (2007) Water-Cooled Refrigerant
Condensers, Remote Type
- AHRI 480 (2007) Refrigerant-Cooled Liquid Coolers,
Remote Type
- AHRI 550/590 I-P (2015; ERTA 2016) Performance Rating Of
Water-Chilling and Heat Pump Water-Heating
Packages Using the Vapor Compression Cycle

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

- ABMA 9 (2015) Load Ratings and Fatigue Life for
Ball Bearings
- ABMA 11 (2014) Load Ratings and Fatigue Life for
Roller Bearings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING
ENGINEERS (ASHRAE)

- ANSI/ASHRAE 15 & 34 (2013) ANSI/ASHRAE Standard 15-Safety
Standard for Refrigeration Systems and
ANSI/ASHRAE Standard 34-Designation and
Safety Classification of Refrigerants
- ASHRAE 90.1 - IP (2019; Errata 1 2019; Errata 2-6 2020;
Addenda BY-CP 2020; Addenda AF-DB 2020;
Addenda A-G 2020; Addenda F-Y 2021;
Errata 7-8 2021; Interpretation 1-4 2020;
Interpretation 5-8 2021; Addenda AS-CB
2022) Energy Standard for Buildings Except
Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

- ASME BPVC SEC VIII D1 (2019) BPVC Section VIII-Rules for
Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

- AWS Z49.1 (2021) Safety in Welding and Cutting and
Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F104	(2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 82	Protection of Stratospheric Ozone

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Water Chiller; G

Verification of Dimensions

System Performance Tests

Demonstrations

Refrigerant

Water Chiller - Field Acceptance Test Plan

SD-06 Test Reports

Field Acceptance Testing

Water Chiller - Field Acceptance Test Report

System Performance Tests

SD-07 Certificates

Refrigeration System; G

Ozone Depleting Substances Technician Certification

SD-08 Manufacturer's Instructions

Water Chiller - Installation Instructions; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.3 CERTIFICATIONS

1.3.1 Ozone Depleting Substances Technician Certification

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in [40 CFR 82](#), Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

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 must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with [AWS Z49.1](#).

1.5 DELIVERY, STORAGE, AND HANDLING

Stored items must 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 will be the Contractor's responsibility. Any materials found to be damaged must be replaced at the Contractor's expense. During installation, piping and similar openings must be capped to keep out dirt and other foreign matter.

1.6 PROJECT REQUIREMENTS

1.6.1 Verification of Dimensions

The Contractor must 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.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment will be standard Commercial cataloged products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. These products must have a two year record of satisfactory field service prior to bid opening. The two year record of service must include applications of equipment and materials under similar circumstances and of similar size. Products having less than a two year record of satisfactory field service will be acceptable if a certified record of satisfactory field service for not less than 6000 hours can be shown. The 6000 hour service record must not include any manufacturer's prototype or factory testing. Satisfactory field service must have been completed by a product that has been, and presently is being sold or offered for sale on the commercial market through the following copyrighted means: advertisements, manufacturer's catalogs, or brochures.

2.2 MANUFACTURER'S STANDARD NAMEPLATES

Major equipment including chillers, compressors, compressor drivers, condensers, water coolers, receivers, refrigerant leak detectors, heat exchanges, fans, and motors must 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 must be durable and legible throughout equipment life. Plates must be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

- a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.
- b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.
- c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.
- d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors must be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must 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. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor enclosure type may be either TEAO or TEFC.

- e. Use adjustable frequency drives for all variable-speed motor applications. Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.
- f. Provide inverter duty premium efficiency motors for use with variable frequency drives.

2.4 SPLIT-SYSTEM WATER CHILLER, VAPOR COMPRESSION TYPE

Total chiller system must be certified for performance per AHRI 550/590 I-P. If chiller is not in scope of AHRI 550/590 I-P then chiller must be rated in accordance with AHRI 550/590 I-P. Individual chiller components must be constructed and rated in accordance with the applicable AHRI standards. Chiller system must conform to ANSI/ASHRAE 15 & 34. The chiller must be ASHRAE 90.1 - IP compliant and meet 10 CFR Part 433, 434 and 435 efficiency performance standards for federal construction. The manufacturer must provide certification of compliance. Chiller must 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 must be sealed and charged with a nitrogen holding charge. Unit assembly must be completed in strict accordance with manufacturer's recommendations. Chiller must operate within capacity range and speed recommended by the manufacturer. Parts weighing 50 pounds or more which must be removed for inspection, cleaning, or repair, must have lifting eyes or lugs. Chiller must include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller's water cooler must be provided with marine water boxes with grooved mechanical connections. Chillers must operate at partial load conditions without increased vibration over normal vibration at full load, and must be capable of continuous operation down to minimum capacity. As a minimum, chiller must 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. Receiver

2.4.1 Compressor-Chiller Unit

As a minimum, the compressor-chiller unit must 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. Water cooler (evaporator)

2.4.2 Condensing Unit

As a minimum, the condensing unit must 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. Air or water cooled condenser

2.4.3 Remote Water Cooler (Evaporator)

2.4.3.1 Shell and Tube Type

Cooler must be constructed and rated in accordance with AHRI 480. Cooler must be of the shell-and-coil or shell-and-tube type design. Cooler's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Cooler's water side must be designed and factory pressure tested for not less than 300 psi. Cooler shell must be constructed of seamless or welded steel. Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable. Tubes must be installed into carbon mild steel tube sheets by rolling. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Cooler must be skid-mounted. Refrigerant circuit must be complete with liquid solenoid valve and expansion device capable of modulating to the minimum step of capacity unloading. For the water side of water cooler, performance must be based on a fluid velocity not less than 3 fps and not more than 12 fps and a fouling factor per AHRI 550/590 I-P.

2.4.3.2 Braze Plate Type

Cooler must be rated in accordance with AHRI 480. Cooler must be of the braze plate design. Cooler's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Cooler's water side must be designed and factory pressure tested for not less than 300 psi. Cooler shell must be constructed of stainless steel plates brazed together with copper. Refrigerant circuit must be complete with liquid solenoid valve and expansion device capable of modulating to the minimum step of capacity unloading. For the water side of water cooler, performance must be based on a fluid velocity not less than 3 fps and not more than 12 fps and a fouling factor per AHRI 550/590 I-P.

2.4.4 Remote Water-Cooled Condenser

Condenser must be a factory-fabricated and assembled unit constructed and rated in accordance with AHRI 450. Condenser may be of either the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side must be designed and factory pressure tested for not less than 300 psi. Condensers must be complete with pressure relief valve or rupture disk, water drain connections, refrigerant charging valve, refrigerant valves, liquid-level indicating devices, and stand or saddle. Low pressure refrigerant condenser must be

provided with a purge valve located at the highest point in the condenser to purge non-condensibles trapped in the condenser. Condenser shell must be constructed of seamless or welded steel. Tubes may be either seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable, except for the coaxial tubes. Tubes must be installed into carbon mild steel tube sheets by rolling. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Condenser performance must be based on water velocities not less than 3 fps nor more than 12 fps and a fouling factor per AHRI 550/590 I-P. 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. As a minimum, the condenser must include the following components as defined in paragraph CHILLER COMPONENTS.

- a. Liquid-level indicating devices.
- b. Companion flanges, bolts, and gaskets for flanged water connections.

2.5 CHILLER COMPONENTS

2.5.1 Refrigerant and Oil

Refrigerants must be one of the fluorocarbon gases. Refrigerants must have number designations and safety classifications in accordance with ANSI/ASHRAE 15 & 34. CFC-based refrigerants are prohibited. Refrigerants must have an Ozone Depletion Potential (ODP) no greater than 0.0, with the exception of R-123. Provide SDS sheets for all refrigerants.

2.5.2 Structural Base

Chiller and individual chiller components must be provided with a factory-mounted structural steel base (welded or bolted) or support legs. Chiller and individual chiller components must be isolated from the building structure by means of molded neoprene isolation pads.

2.5.3 Chiller Refrigerant Circuit

Chiller refrigerant circuit must be completely piped and factory leak tested in accordance with ANSI/ASHRAE 15 & 34. For multicompressor units, not less than 2 independent refrigerant circuits must be provided. Circuit must include as a minimum a combination filter and drier, combination sight glass and moisture indicator, an electronic or thermostatic expansion valve with external equalizer or float valve, charging ports, compressor service valves for field-serviceable compressors, and superheat adjustment.

2.5.4 Controls Package

Provide chillers with a complete factory-mounted , microprocessor based operating and safety control system. Controls package must contain as a minimum a digital display, an on-auto-off switch, variable frequency motor controller, power wiring, and control wiring. Controls package must provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and interfaces as defined below.

2.5.4.1 Operating Controls

Chiller must 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 must automatically re-cycle the chiller on power interruption.
- f. Startup and head pressure controls to allow system operation at all ambient temperatures down to 32 degrees F.

2.5.4.2 Monitoring Capabilities

During normal operations, the control system must be capable of monitoring and displaying the following operating parameters. Access and operation of display must not require opening or removing any panels or doors.

- a. Entering and leaving chilled water temperatures
- b. Entering and leaving chilled water pressure
- c. Entering and leaving condenser water pressure
- d. Self diagnostic
- e. Operation status
- f. Operating hours
- g. Number of starts
- h. Compressor status (on or off)
- i. Compressor load (percent)
- j. Refrigerant discharge and suction pressures
- m. Oil pressure
- n. Condenser water entering and leaving temperatures
- o. Number of purge cycles over the last 7 days

2.5.4.3 Configurable Setpoints

The control system must be capable of being configured directly at the unit's interface panel. No parameters may be capable of being changed without first entering a security access code. The programmable setpoints must include the following as a minimum:

- a. Leaving Chilled Water Temperature
- b. Leaving Condenser Water Temperature
- c. Time Clock/Calendar Date

2.5.4.4 Safety Controls with Manual Reset

Chiller must 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

2.5.4.5 Safety Controls with Automatic Reset

Chiller must 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

2.5.4.6 Remote Alarm

During the initiation of a safety shutdown, a chiller's control system must be capable of activating a remote alarm bell. In coordination with the chiller, the Contractor must provide an alarm circuit (including transformer if applicable) and a minimum 4 inch diameter alarm bell. Alarm circuit must activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell must not sound for a chiller that uses low-pressure cutout as an operating control.

2.5.4.7 Utility Monitoring and Control System Interface

Provide a Utility Monitoring and Control System (UMCS) interface meeting the requirements of Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and the requirements of Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. The interface must provide all system operating conditions, capacity controls, and safety shutdown conditions as network points. In addition, the following points must be overridable via the network interface:

- a. Unit Start/Stop
- b. Leaving Chilled Water Temperature Setpoint
- c. Leaving Condenser Water Temperature Setpoint

2.5.5 Compressor(s)

2.5.5.1 Rotary Screw Compressor(s)

Compressors must operate stably for indefinite time periods to at least 25 percent capacity reduction without gas bypass external to the compressor. Provision must be made to insure proper lubrication of bearings and shaft seals on shutdown with or without electric power supply. Rotary screw compressors must include:

- a. An open or hermetic, positive displacement, oil-injected design directly driven by the compressor driver. Allow access to internal compressor components for repairs, inspection, and replacement of parts.
- b. Rotors must be solid steel, possessing sufficient rigidity for proper operation.
- c. A maximum rotor operating speed no greater than 3600 RPM. Provide cast iron rotor housing.
- d. Casings of cast iron, precision machined for minimal clearance about periphery of rotors with minimal clearance at rotor tops and rotor ends.
- e. A lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.
- f. Bearing housing must be conservatively loaded and rated for an L(10) life of not less than 200,000 hours. Shaft main bearings of the sleeve type with heavy duty bushings or rolling element type in accordance with ABMA 9 or ABMA 11.
- 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. Use a Variable Frequency Drive (VFD) to modulate 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 must be provided.

2.5.6 Compressor Driver, Electric Motor

Components such as motors, starters, variable speed drives and wiring must be in accordance with paragraph ELECTRICAL WORK. Variable frequency drive must be unit mounted as indicated with variable frequency drive type, wiring, and accessories coordinated with the chiller manufacturer.

2.5.7 Water Cooler (Evaporator)

Cooler must be of the shell-and-coil or shell-and-tube type design. Cooler shell must be constructed of seamless or welded steel. Coil bundles must be totally removable and arranged to drain completely. Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually

replaceable. Tubes must be installed into carbon mild steel tube sheets by rolling. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Performance must be based on a water velocity not less than 3 fps nor more than 12 fps and a fouling factor per AHRI 550/590 I-P.

Brazed plate heat exchanger must be constructed of 304 or 316 stainless steel, designed to a refrigerant-side working pressure of 430 psig and a waterside working pressure of 150 psig. Evaporator must be factory tested at 1.1 times maximum allowable refrigerant side working pressure and 1.5 times maximum allowable water side working pressure. Provide cooler with factory-installed flow switches. All water connections must use either flanged or grooved-pipe connections. Factory insulate all cold surfaces.

2.5.8 Water-Cooled Condenser Coil

Condenser must be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side must be designed and factory pressure tested to comply with ANSI/ASHRAE 15 & 34. Condenser's water side must be designed and factory pressure tested for not less than 220 psi. Condensers must be complete with refrigerant relief valve/rupture disc assembly, water drain connections, and refrigerant charging valve. Low pressure refrigerant condenser must be provided with a purging device to purge non-condensibles trapped in the condenser while keeping refrigerant emissions below requirements of ASHRAE Std 147. Purge units must be certified per AHRI 580. Condenser shell must be constructed of seamless or welded steel. Coil bundles must be totally removable and arranged to drain completely. Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable, except for the coaxial tubes. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Performance must be based on water velocities not less than 3 fps nor more than 12 fps and a fouling factor per AHRI 550/590 I-P. 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 ACCESSORIES

2.6.1 Refrigerant Leak Detector

Detector must be the continuously-operating, halogen-specific type. Detector must be appropriate for the refrigerant in use. Detector must be specifically designed for area monitoring and must include a single sampling point installed where indicated. Detector design and construction must be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector must have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector must be supplied factory-calibrated for the appropriate refrigerant(s). Detector must 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 must be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector must be provided with a failure relay output that energizes when the monitor detects a fault in its operation.

2.6.2 Refrigerant Relief Valve/Rupture Disc Assembly

The assembly must be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly must be in accordance with [ASME BPVC SEC VIII D1](#) and [ANSI/ASHRAE 15 & 34](#). The assembly must be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc must be the non-fragmenting type.

2.6.3 Refrigerant Signs

Refrigerant signs must be a medium-weight aluminum type with a baked enamel finish. Signs must be suitable for indoor or outdoor service. Signs must have a white background with red letters not less than [0.5 inches](#) in height.

2.6.3.1 Installation Identification

Each new refrigerating system must 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.

2.6.3.2 Controls and Piping Identification

Refrigerant systems containing more than [110 lb](#) of refrigerant must 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).

2.6.4 Gaskets

Gaskets must conform to [ASTM F104](#) - classification for compressed sheet with nitrile binder and acrylic fibers for maximum [700 degrees F](#) service.

2.6.5 Bolts and Nuts

Bolts and nuts, except as required for piping applications, must be in accordance with [ASTM A307](#). The bolt head must be marked to identify the manufacturer and the standard with which the bolt complies in accordance with [ASTM A307](#).

2.7 FABRICATION

2.7.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating

conforming to [ASTM D520](#), Type I.

2.7.2 Factory Applied Insulation

Chiller must be provided with factory installed insulation on surfaces subject to sweating including the water cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it must 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 must 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 must 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 must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes must be determined by [ASTM E84](#). Insulation must 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 must be tested as a composite material. Jackets, facings, and adhesives must have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with [ASTM E84](#).

2.8 SUPPLEMENTAL COMPONENTS/SERVICES

2.8.1 Chilled and Condenser Water Piping and Accessories

Chilled and condenser water piping and accessories must be provided and installed in accordance with Section [23 64 26](#) CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.8.2 Refrigerant Piping

Refrigerant piping for split-system water chillers must be provided and installed in accordance with Section [23 23 00](#) REFRIGERANT PIPING.

2.8.3 Temperature Controls

Chiller control packages must be fully coordinated with and integrated into the temperature control system indicated in Section [23 30 00](#) HVAC AIR DISTRIBUTION and Section [23 09 00](#) INSTRUMENTATION AND CONTROL FOR HVAC and Section [23 09 23.02](#) BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS .

PART 3 EXECUTION

3.1 INSTALLATION

Installation of water chiller systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing must be in accordance with the manufacturer's written installation instructions, including the following:

- (1) [Water chiller - installation instructions](#)

3.1.1 Installation Instructions

Provide manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show features such as materials, dimensions, options, performance and efficiency. Data must include manufacturer's recommended installation instructions and procedures. Data must be adequate to demonstrate compliance with contract requirements.

3.1.2 Vibration Isolation

If vibration isolation is specified for a unit, vibration isolator literature must be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

3.1.3 Verification of Dimensions

Provide a letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

3.1.4 System Performance Test Schedules

Provide a schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules must identify the proposed date, time, and location for each test.

3.1.5 Certificates

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, proof of such compliance must be provided. The label or listing of the specified agency must 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 must 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.

3.1.6 Operation and Maintenance Manuals

Provide Six complete copies of an operation manual in bound 8 1/2 by 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 must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. Six complete copies of maintenance manual in bound 8 1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.1.7 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.8 Refrigeration System

3.1.8.1 Equipment

Refrigeration equipment and the installation thereof must conform to ANSI/ASHRAE 15 & 34. Necessary supports must be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, water coolers, and similar items. Compressors must be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations must be provided. Each foundation must include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment must be set on not less than a 6 inch concrete pad doweled in place. Concrete foundations for floor mounted pumps must 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 must be of mass not less than three times the combined pump, motor, and base weights. Isolators must 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 must be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts must be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Equipment must be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.1.8.2 Field Refrigerant Charging

- a. Initial Charge: Upon completion of all the refrigerant pipe tests, the vacuum on the system must be broken by adding the required charge of dry refrigerant for which the system is designed, in accordance with the manufacturer's recommendations. Contractor must 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 must be replaced. After the system is fully operational, service valve seal caps and blanks over gauge points must 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 must immediately be isolated from the remainder of the system and the refrigerant must be pumped into the system receiver or other suitable container. The refrigerant must not be discharged into the atmosphere.

- c. Contractor's Responsibility: The Contractor must, 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 must 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 must more than **3 ounces** of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year must 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.

3.1.8.3 Oil Charging

Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase must be furnished. One charge must be used during the performance testing period, and upon the satisfactory completion of the tests, the oil must be drained and replaced with the second charge.

3.1.9 Mechanical Room Ventilation

Mechanical ventilation systems must be in accordance with Section **23 30 00** HVAC AIR DISTRIBUTION.

3.1.10 Field Applied Insulation

Field installed insulation must be as specified in Section **23 07 00** THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.11 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section **09 90 00** PAINTS AND COATINGS.

3.2 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative must be provided for **2** 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 micrometers.
- (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.

3.3 CLEANING AND ADJUSTING

Equipment must be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Provide temporary filters for all fans that are operated during construction. Perform and document that proper [Indoor Air Quality During Construction](#) procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. System must be maintained in this clean condition until final acceptance. Bearings must be properly lubricated with oil or grease as recommended by the manufacturer. Belts must be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment must be adjusted to setting indicated or directed. Fans must be adjusted to the speed indicated by the manufacturer to meet specified conditions. At least one week before the official equipment warranty start date, all condenser coils on air-cooled water chillers and split-system water chillers must be cleaned in accordance with the chiller manufacturer's instructions. This work covers two coil cleanings. The condenser coils must be cleaned with an approved coil cleaner by a service technician, factory trained by the chiller manufacturer. The condenser coil cleaner must not have any detrimental affect on the materials or protective coatings on the condenser coils. Testing, adjusting, and balancing must be as specified in Section [23 05 93](#) TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.4 FIELD ACCEPTANCE TESTING

3.4.1 Test Plans

- a. Manufacturer's Test Plans: Within 120 calendar days after contract award, submit the following plans:

- (1) [Water chiller - Field Acceptance Test Plan](#)

Field acceptance test plans must be developed by the chiller manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance tests of the chiller and subsequent test reporting.

- b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls for the equipment provided under Section [23 09 23.02](#) BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.
 - c. Prerequisite testing: Chillers for which performance testing is dependent upon the completion of the work covered by Section [23 05 93](#) TESTING, ADJUSTING, AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section.

Indicate in each field acceptance test plan when such prerequisite work is required.

- d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Each test plan must include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures must be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controller must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

- e. Performance variables: Each test plan must list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Chiller manufacturer must furnish with each test procedure a description of acceptable results that have been verified.

Chiller manufacturer must identify the acceptable limits or tolerance within which each tested performance variable must acceptably operate.

- f. Job specific: Each test plan must be job specific and must address the particular cooling towers and particular conditions which exist in this contract. Generic or general preprinted test procedures are not acceptable.
- g. Specialized components: Each test plan must include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.4.2 Testing

- a. Each water chiller system must be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:

(1) [Water chiller - Field Acceptance Test Report](#)

- b. Manufacturer's recommended testing: Conduct the manufacturer's recommended field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.
- c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period,

compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.

- d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.
- e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment must be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative must review, approve, and sign the report of the manufacturer's recommended test. Signatures must be accompanied by the person's name typed.
- f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

3.5 SYSTEM PERFORMANCE TESTS

Six copies of the report must be provided in bound 8 1/2 by 11 inch booklets.

3.5.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment must be conducted by the manufacturer's approved start-up representative experienced in system start-up and testing, at such times as directed. Tests must cover a period of not less than 48 hours for each system and must demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments must be made as necessary and tests must 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 must be installed and tightened. Any refrigerant lost during the system startup must be replaced. If tests do not demonstrate satisfactory system performance, deficiencies must be corrected and the system must be retested. Tests must 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 must be provided by the Contractor. Field tests must be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.5.2 Test Report

The report must document compliance with the specified performance criteria upon completion and testing of the system. The report must indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report must also include the following information and must be taken at least three different times at outside dry-bulb temperatures that are at least 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) Running current, voltage and proper phase sequence for each phase of all motors.
- (5) The actual on-site setting of all operating and safety controls.
- (6) Chilled water pressure, flow and temperature in and out of the chiller.
- (7) The position of the capacity-reduction gear at machine off, one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

3.6 DEMONSTRATIONS

Contractor must conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total 6 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The training course must cover all of the items contained in the approved [operation and maintenance manuals](#) as well as demonstrations of routine maintenance operations.

Provide 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.

-- End of Section --

SECTION 23 64 26

CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS

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 NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.22/CSA 4.4 (2015; R 2020) Relief Valves for Hot Water Supply Systems

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1 (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASME B16.1 (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

ASME B16.3 (2021) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.5 (2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B16.9 (2018) Factory-Made Wrought Butt welding Fittings

ASME B16.11 (2016) Forged Fittings, Socket-Welding and Threaded

ASME B16.18 (2021) Cast Copper Alloy Solder Joint Pressure Fittings

ASME B16.21 (2021) Nonmetallic Flat Gaskets for Pipe Flanges

ASME B16.22 (2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASME B16.26 (2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes

ASME B16.39 (2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300

ASME B18.2.2 (2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

ASME B31.9	(2020) Building Services Piping
ASME B36.10M	(2015; Errata 2016) Welded and Seamless Wrought Steel Pipe
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003	(2020) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)
ASSE 1017	(2009) Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems - (ANSI approved 2010)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2015) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS BRH	(2007; 5th Ed) Brazing Handbook
AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A181/A181M	(2014; R 2020) Standard Specification for

	Carbon Steel Forgings, for General-Purpose Piping
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2020a) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A197/A197M	(2000; R 2019) Standard Specification for Cupola Malleable Iron
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A733	(2016) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B42	(2020) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B813	(2016) Standard Specification for Liquid

and Paste Fluxes for Soldering of Copper
and Copper Alloy Tube

ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D596	(2001; R 2018) Standard Guide for Reporting Results of Analysis of Water
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F104	(2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials
ASTM F1007	(2018) Standard Specification for Pipeline Expansion Joints of the Packed Slip Type for Marine Application
ASTM F1120	(1987; R 2019) Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications
ASTM F1199	(2021) Standard Specification for Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)
ASTM F2389	(2021) Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2015) (10th Ed) EJMA Standards

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.2	(2014) Rotodynamic (Centrifugal) Pump for Nomenclature and Definitions

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS
INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-67	(2017; Errata 1 2017) Butterfly Valves

MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-78	(2011) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends
MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF/ANSI 14	(2020) Plastics Piping System Components and Related Materials

1.2 SYSTEM DESCRIPTION

Provide the water systems having the minimum service (design) temperature-pressure rating indicated. Provision of the piping systems, including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with the required and advisory provisions of ASME B31.9 except as modified or supplemented by this specification section or design drawings. This specification section covers the water systems piping which is located within, on, and adjacent to building(s) within the building(s) 5 foot line.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Grooved Mechanical Connections For Steel; G

Grooved Mechanical Connections For Copper; G

Calibrated Balancing Valves; G

Automatic Flow Control Valves; G

Pump Discharge Valve

Water Temperature Mixing Valve; G

Water Temperature Regulating Valves; G

Water Pressure Reducing Valve

Pressure Relief Valve

Combination Pressure and Temperature Relief Valves

Expansion Joints; G

Pumps; G

Combination Strainer and Pump Suction Diffuser

Expansion Tanks

Air Separator Tanks

Water Treatment Systems; G

Proposed water treatment plan including a layout, control scheme, a list of existing make-up water conditions including the items listed in paragraph WATER ANALYSIS", a list of chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals.

SD-06 Test Reports

Piping Welds NDE Report

Pressure Tests Reports; G

Report shall be provided in bound 8-1/2 by 11 inch booklets. In the reports, document all phases of the tests performed. Include initial test summaries, all repairs/adjustments made, and the final test results.

Condenser Water Quality Test Reports; G

Test reports, each month for a period of one year after project completion, in bound 8-1/2 by 11 inch booklets. In the reports, identify the chemical composition of the condenser water. Also include the comparison of the manufacturer's recommended operating conditions for the cooling tower and condenser in relation to the condition of the condenser water. Document in the report any required corrective action taken.

One-Year Inspection Report For Cooling Water; G

At the completion of one year of service, in bound 8-1/2 by 11 inch booklets. In the report, identify the condition of each cooling tower and condenser. Include a comparison of the condition of the cooling tower and condenser with the manufacturer's recommended operating conditions. Identify all actions taken by the Contractor and manufacturer to correct deficiencies during the first year of service.

SD-07 Certificates

Employer's Record Documents (For Welding)

Welding Procedures and Qualifications

Certificates shall be submitted for the following items showing conformance with the referenced standards contained in this section.

Piping for Steam and Condensate

Piping for High-Pressure Compressed-Air Systems

Fittings

Unions

Flanges

Gaskets

Bolting

SD-08 Manufacturer's Instructions

Lesson plan for the Instruction Course; G

SD-10 Operation and Maintenance Data

Requirements for data packages are specified Section 01 78 23 OPERATION AND MAINTENANCE DATA, except as supplemented and modified by this specification section.

Submit spare parts data for each different item of equipment specified, with operation and maintenance data packages. 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.

Submit a list of qualified permanent service organizations with operation and maintenance data packages. Include service organization addresses and service area or expertise. 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.

Water Treatment Systems; G

An operation manual in bound 8-1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown. Include testing procedures used in determining water quality.

A maintenance manual in bound 8-1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide.

Calibrated Balancing Valves, Data Package 3; G

Automatic Flow Control Valves, Data Package 3; G

Pump Discharge Valve, Data Package 2; G

Water Temperature Mixing Valve, Data Package 3; G

Water Temperature Regulating Valves, Data Package 3; G

Water Pressure Reducing Valve, Data Package 3; G

Pressure Relief Valve, Data Package 2; G

Combination Pressure and Temperature Relief Valves, Data Package 2; G

Expansion Joints, Data Package 2; G

Pumps, Data Package 3; G

Combination Strainer and Pump Suction Diffuser, Data Package 2; G

Expansion Tanks, Data Package 2; G

Air Separator Tanks, Data Package 2; G

1.4 MODIFICATIONS TO 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.

1.4.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract

documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.5 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.

1.6 DELIVERY, STORAGE, AND HANDLING

Protect stored items 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, cap piping and similar openings to keep out dirt and other foreign matter. Any porous materials found to be contaminated with mold or mildew will be replaced at the Contractor's expense. Non-porous materials found to be contaminated with mold or mildew will be disinfected and cleaned prior to installation.

1.7 PROJECT/SITE CONDITIONS

1.7.1 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.

1.7.2 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.

1.7.3 Accessibility

Install all work so that parts requiring periodic inspection, operation,

maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

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 two 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. System components shall be environmentally suitable for the indicated locations.

The equipment items shall be supported by service organizations. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

2.2 STEEL PIPING

Water piping shall be steel pipe or copper tubing. Provide steel piping with a ANSI/ASME Class 125 service rating, which for 150 degrees F, the pressure rating is 175 psig.

2.2.1 Pipe

Steel pipe, conform to ASTM A53/A53M, Schedule 40, Type E or S, Grades A or B. Do not use Type F pipe.

2.2.2 Fittings and End Connections (Joints)

Piping and fittings 1 inch and smaller shall have threaded connections. Piping and fittings larger than 1 inch and smaller than 3 inches shall have either threaded, grooved, or welded connections. Piping and fittings 3 inches and larger shall have grooved, welded, or flanged connections. The manufacturer of each fitting shall be permanently identified on the body of the fitting in accordance with MSS SP-25.

2.2.2.1 Threaded Connections

Use threaded valves and pipe connections conforming to ASME B1.20.1. Used threaded fitting conforming to ASME B16.3. Use threaded unions conforming to ASME B16.39. Use threaded pipe nipples conforming to ASTM A733.

2.2.2.2 Flanged Connections

Flanges shall conform to ASME B16.1, Class 125. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 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 ASME B16.1.

2.2.2.3 Welded Connections

Welded valves and pipe connections (both butt-welds and socket-welds types) shall conform to ASME B31.9. Butt-welded fittings shall conform to ASME B16.9. Socket-welded fittings shall conform to ASME B16.11. Welded fittings shall be identified with the appropriate grade and marking symbol.

2.2.2.4 Grooved Mechanical Connections For Steel

Rigid grooved mechanical connections may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 230 degrees F. Flexible grooved connections shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein.

Each grooved mechanical joint shall be a system, including coupling housing, gasket, fasteners, all furnished by the same manufacturer. Joint installation shall be in compliance with joint manufacturer's written instructions.

Use fitting and coupling houses of malleable iron conforming to ASTM A47/A47M, Grade 32510; ductile iron conforming to ASTM A536, Grade 65-45-12; or steel conforming to ASTM A106/A106M, Grade B or ASTM A53/A53M. Use gaskets of molded synthetic rubber with central cavity, pressure responsive configuration and conforming to ASTM D2000 Grade No. 2CA615A15B44F17Z for circulating medium up to 230 degrees F or Grade No. M3BA610A15B44Z for circulating medium up to 200 degrees F. Grooved mechanical connections shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A183. Pipe connections and fittings shall be the product of the same manufacturer. Provide joint installation be in compliance with joint manufacturer's written instructions.

2.2.2.5 Dielectric Waterways and Flanges

Provide dielectric waterways with 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. Provide dielectric waterways 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. Provide dielectric flanges with the same pressure ratings as standard flanges and provide complete electrical isolation between connecting pipe and/or equipment as described herein for dielectric waterways.

2.3 POLYPROPYLENE PIPING (CHILLED WATER APPLICATIONS ONLY)

2.3.1 Pipe

Polypropylene pipe shall be Schedule 40, copolymer, and shall meet [ASTM F2389](#) and [NSF/ANSI 14](#).

2.3.2 Fittings

Fittings shall meet [ASTM F2389](#) and [NSF/ANSI 14](#) and shall be NSF listed for the service intended. Plastic pipe, fittings, and solvent cement shall bear the NSF seal "NSF-PW."

Polypropylene fittings shall conform to dimensional requirements of Schedule 40. Polypropylene piping that will be exposed to UV light shall be provided with a Factory applied UV resistant coating.

2.4 PIPING FOR STEAM AND CONDENSATE

Steam and condensate piping for 150-, 350-, 2,000-, and 6,000-pound per square inch (psi) service shall be black carbon steel (BCS). Steam and condensate piping includes fittings, unions, flanges, gaskets, and bolting.

2.4.1 Type BCS-150 (150-psi Service)

Pipe or tube (1/8 inch through 10 inches): Schedule 40 for steam, Schedule 80 for condensate, seamless black carbon steel, conforming to [ASTM A106/A106M](#), Grade B and [ASME B36.10M](#)

Fittings (1/8 inch through 2 inches): 300-psi working steam pressure (wsp) banded malleable iron, screwed end, conforming to [ASTM A197/A197M](#) and [ASME B16.3](#)

Fittings (1/8 inch through 2 inches): 2,000-or 3,000-psi water, oil, or gas (wog) forged carbon steel, socket weld or screwed end, conforming to [ASTM A105/A105M](#) and [ASME B16.11](#)

Fittings (2-1/2 through 10 inches): Wall thickness to match pipe, long radius, butt weld, black carbon steel, conforming to [ASTM A234/A234M](#), Grade WPB, and [ASME B16.9](#)

Unions (1/8 inch through 2 inches): 250-psi wsp, malleable iron, screwed end, ground joint, with brass or bronze seat insert, conforming to [ASME B16.39](#)

Unions (1/8 inch through 2 inches): 2,000 or 3,000-psi wog, forged carbon steel; socket weld through 2-inch, screwed end through 1-inch, conforming to [ASTM A105/A105M](#) and [ASME B16.11](#), with ground joint and stainless-steel seat insert

Flanges (2-1/2 through 10 inches): 150-pound, forged carbon steel, welding neck, with raised face or flat face and concentric finish, conforming to [ASTM A105/A105M](#) and [ASME B16.5](#)

Flange Gaskets: Compressed non-asbestos sheet conforming to [ASTM F104](#), Type 1, P1161A, coated on both sides with graphite or similar lubricant, containing not less than 75-percent non-asbestos fiber materials

Bolting: Bolting and flange bolting shall be hexhead and shall conform to

ASTM A325. Heavy hex-nuts shall conform to ASME B18.2.2. Square-head bolts and nuts are not acceptable.

2.4.2 Type BCS-350 (350-psiService)

Pipe or tube (1/8 inch through 10 inches): Schedule 40 for steam, Schedule 80 for condensate; seamless black carbon steel, conforming to ASTM A106/A106M, Grade B and ASME B36.10M

Fittings (1/8 inch through 2 inches): 2,000-or 3,000-psi wog to match pipe wall, forged carbon steel, socket weld or screwed end, conforming to ASTM A105/A105M and ASME B16.11

Fittings (1/8 inch through 10 inches): Schedule 40, long-radius, butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9

Unions (1/8 inch through 2 inches): 2,000-or 3,000-psi wog to match pipe wall, forged carbon steel, socket weld through 2-inch, screwed end through 1-inch, conforming to ASTM A105/A105M and ASME B16.11, with ground joint and stainless-steel seat insert

Flanges (2-1/2 through 10 inches): 300-pound, forged carbon steel, weld neck, with raised face and concentric serrated finish, conforming to ASTM A181/A181M, Class 70, and ASME B16.5

Gaskets: Spiral-wound, non-asbestos-fiber-filled, carbon steel, with centering provisions, conforming to ASME B16.5, Group 1

Bolting: Heavy hex-head, carbon-steel bolts or bolt studs and semifinished heavy hexnuts, conforming to ASTM A325.

Square-head bolts are not acceptable.

2.5 PIPING FOR HIGH-PRESSURE COMPRESSED-AIR SYSTEMS

High-pressure compressed-air condensate piping includes fittings, unions, flanges, gaskets, and bolting.

2.5.1 Type BCS-2,000 (2,000-psi Service)

Pipe or tube (1/8 inch through 3 inches): Schedule 40, seamless black carbon steel, conforming to ASTM A106/A106M, Grade B, or ASTM A53/A53M, Grade B, Type S, and ASME B36.10M

Fittings (1/8 inch through 1-1/2 inches): 2,000-psi wog, forged carbon steel, socket weld, conforming to ASTM A105/A105M and ASME B16.11

Fittings (2 through 3 inches): Schedule 40, long radius, butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, and ASME B16.9

Flanges (1 inch through 3 inches): 900-pound, forged carbon steel, welding neck, with raised face and concentric serrated finish, conforming to ASTM A105/A105M or ASTM A181/A181M, Class 60, and ASME B16.5

Gaskets: Spiral wound, non-asbestos-fiber-filled, carbon steel, with centering provisions, conforming to ASME B16.5, Group 1

Bolting: Alloy-steel bolt studs conforming to ASTM A193/A193M, Grade B7, and semifinished heavy hex-nuts, conforming to ASTM A194/A194M, Grade 2H

2.5.2 Type BCS-6,000 (6,000-psi Service)

Pipe or tube (1/2 inch through 3 inches): XXS, seamless, black carbon steel, conforming to ASTM A106/A106M, Grade B, or ASTM A53/A53M, Grade B, Type S and ASME B36.10M

Fittings (1/2 inch through 1-1/2 inches): 6,000-psi wog, forged carbon steel, socket weld, conforming to ASTM A105/A105M and ASME B16.11

Fittings (2 through 3 inches): XXS, long-radius, butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB, ASME B16.9, and ASME B36.10M

Flanges (2 through 3 inches): 2,500-pound, forged carbon steel, welding neck with raised face and concentric serrated finish, conforming to ASTM A105/A105M and ASME B16.5

Gaskets: Spiral-wound, non-asbestos-filled, carbon steel, with centering provisions, conforming to ASME B16.5, Group 1

Bolting: Alloy steel bolt studs conforming to ASTM A193/A193M, Grade B7, and semifinished heavy hex-nuts, conforming to ASTM A194/A194M, Grade 2H

2.6 COPPER TUBING

Provide copper tubing and fittings with a ANSI/ASME Class 125 service rating, which for 150 degrees F., the pressure rating is 175 psig.

2.6.1 Tube

Use copper tube conforming to ASTM B88, Type L or M for aboveground tubing, and Type K for buried tubing.

2.6.2 Fittings and End Connections (Solder and Flared Joints)

Wrought copper and bronze solder joint pressure fittings, including unions and flanges, shall conform to ASME B16.22 and ASTM B75/B75M. Provide adapters as required. Cast copper alloy solder-joint pressure fittings, including unions and flanges, shall conform to ASME B16.18. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B62. ASTM B42 copper pipe nipples with threaded end connections shall conform to ASTM B42.

Copper tubing of sizes larger than 4 inches shall have 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.

Extracted brazed tee joints may be used if produced with an acceptable tool and installed in accordance with tool manufacturer's written procedures.

2.6.3 Grooved Mechanical Connections For Copper

Rigid grooved mechanical connections may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 230 degrees F. Flexible grooved connections shall be used only

as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein.

Each grooved mechanical joint shall be a system, including coupling housing, gasket, fasteners, all furnished by the same manufacturer. Joint installation shall be in compliance with joint manufacturer's written instructions.

Grooved fitting and mechanical coupling housing shall be ductile iron conforming to [ASTM A536](#). Provide gaskets for use in grooved joints shall constructed of molded synthetic polymer of pressure responsive design and shall conform to [ASTM D2000](#) for circulating medium up to [230 degrees F](#). Provide grooved joints in conformance with [AWWA C606](#).

2.6.4 Solder

Provide solder in conformance with [ASTM B32](#), grade Sb5, tin-antimony alloy. Solder flux shall be liquid or paste form, non-corrosive and conform to [ASTM B813](#).

2.6.5 Brazing Filler Metal

Filler metal shall conform to [AWS A5.8/A5.8M](#), 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

Provide valves with a ANSI/ASME Class 125 service rating, which for [150 degrees F](#), the pressure rating is [175 psig](#).

Valves in sizes larger than [1 inch](#) and used on steel pipe systems, may be provided with rigid grooved mechanical joint ends. Such grooved end valves shall be subject to the same requirements as rigid grooved mechanical joints and fittings and, shall be furnished by the same manufacturer as the grooved pipe joint and fitting system.

2.7.1 Gate Valve

Gate valves [2-1/2 inches](#) and smaller shall conform to [MSS SP-80](#) Class 125 and shall be bronze with wedge disc, rising stem and threaded, soldered, or flanged ends. Gate valves [3 inches](#) and larger shall conform to [MSS SP-70](#), Class 125, cast iron with bronze trim, outside screw and yoke, and flanged or threaded ends.

2.7.2 Globe and Angle Valve

Globe and angle valves [2-1/2 inches](#) and smaller shall conform to [MSS SP-80](#), Class 125. Globe and angle valves [3 inches](#) and larger shall conform to [MSS SP-85](#), Class 125.

2.7.3 Check Valve

Check valves [2-1/2 inches](#) and smaller shall conform to [MSS SP-80](#). Check valves [3 inches](#) and larger shall conform to [MSS SP-71](#), Class 125.

2.7.4 Butterfly Valve

Butterfly valves shall conform to [MSS SP-67](#), Type 1 and shall be either the wafer or lug type. Valves smaller than [8 inches](#) shall have throttling handles with a minimum of two locking positions. Valves [8 inches](#) and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators.

2.7.5 Plug Valve

Plug valves [2 inches](#) and larger shall conform to [MSS SP-78](#), have flanged or threaded ends, and have cast iron bodies with bronze trim. Valves [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 have weatherproof operators with mechanical position indicators. Valves [8 inches](#) or larger shall be provided with manual gear operators with position indicators.

2.7.6 Ball Valve

Full port design. Ball valves [1/2 inch](#) and larger shall conform to [MSS SP-72](#) or [MSS SP-110](#) and shall be cast iron or bronze with threaded, soldered, or flanged ends. Valves [8 inches](#) or larger shall be provided with manual gear operators with position indicators. Ball valves may be provided in lieu of gate valves.

2.7.7 Square Head Cocks

Provide copper alloy or cast-iron body with copper alloy plugs, suitable for 125 psig water working pressure.

2.7.8 Calibrated Balancing Valves

Copper alloy or cast iron body, copper alloy or stainless internal working parts. Provide valve 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 function as a service valve when in fully closed position. Valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation.

Provide valve bodies 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 differential pressure meter connections to verify the pressure differential. Provide metal tag on each valve showing the [gallons per minute](#) flow for each differential pressure reading.

2.7.9 Automatic Flow Control Valves

Valve shall automatically maintain the constant flow indicated on the design drawings. 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. Provide valve that controls the flow within 5 percent of the tag rating. Valve materials shall be the same as specified for the ball or plug valves.

Provide valve that are electric 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. Provide the meter complete with hoses, vent, integral metering connections, and carrying case as recommended by the valve manufacturer.

2.7.10 Pump Discharge Valve

Valve 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. Provide an integral pointer on the valve 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 2 inches shall have NPT connections. Valves 2 inches and larger shall have flanged or grooved end connections. Valve design shall allow the back seat for the stem to be replaced in the field under full line pressure.

2.7.11 Water Temperature Mixing Valve

Valve, ASSE 1017 for water service.

2.7.12 Water Temperature Regulating Valves

Provide copper alloy body, direct acting, pilot operated, for the intended service.

2.7.13 Water Pressure Reducing Valve

Valve, ASSE 1003 for water service, copper alloy body.

2.7.14 Pressure Relief Valve

Valve shall prevent excessive pressure in the piping system when the piping system reaches its maximum heat buildup. Valve, ANSI Z21.22/CSA 4.4 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.

2.7.15 Combination Pressure and Temperature Relief Valves

ANSI Z21.22/CSA 4.4, copper alloy body, automatic re-seating, test lever, and discharge capacity based on AGA temperature steam rating.

2.7.16 Float Valve

Angle pattern and/or Globe pattern. Valve bodies 3 inches nominal pipe size and smaller shall be bronze. Valve bodies larger than 3 inches shall be cast iron or bronze. Steel parts shall be corrosion resistant. 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.

2.7.17 Drain Valves

Valves, **MSS SP-80** gate valves. Valve shall be manually-operated, **3/4 inch** pipe size and above with a threaded end connection. Provide valve with a water hose nipple adapter. Freeze-proof type valves shall be provided in installations exposed to freezing temperatures.

2.7.18 Air Venting Valves

Automatic type air venting shall be the ball-float type with brass/bronze or brass bodies, 300 series corrosion-resistant steel float, linkage and removable seat. Air venting valves on water coils shall have not less than **1/8 inch** threaded end connections. Air venting valves on water mains shall have not less than **3/4 inch** threaded end connections. Air venting valves on all other applications shall have not less than **1/2 inch** threaded end connections.

2.7.19 Vacuum Relief Valves

ANSI Z21.22/CSA 4.4

2.8 PIPING ACCESSORIES

2.8.1 Strainer

Strainer, **ASTM F1199**, except as modified and supplemented in this specification. Strainer shall be the cleanable, basket or "Y" type, the same size as the pipeline. Strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. Provide blowoff outlet with pipe nipple, gate valve, and discharge pipe nipple. The bodies shall have arrows clearly cast on the sides indicating the direction of flow.

Provide strainer with removable cover and sediment screen. The screen shall be made of minimum **22 gauge** brass sheet, with small perforations numbering not less than **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 Cyclonic Separator

Metal- bodied, with removal capability of removing solids 45 microns/325 mesh in size and heavier than 1.20 specific gravity, maximum pressure drop of **5 psid**, with cleanout connection.

2.8.3 Combination Strainer and Pump Suction Diffuser

Angle type body with removable strainer basket and internal straightening vanes, a suction pipe support, and a blowdown outlet and plug. Strainer shall be in accordance with **ASTM F1199**, except as modified and supplemented by this specification. Unit body shall have arrows clearly cast on the sides indicating the direction of flow.

Strainer screen shall be made of minimum **22 gauge** brass sheet, with small perforations numbering not less than **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. Provide an auxiliary disposable fine mesh strainer which shall be removed 30 days after start-up. Provide warning tag for operator indicating

scheduled date for removal.

Casing shall have connection sizes to match pump suction and pipe sizes, and be provided with adjustable support foot or support foot boss to relieve piping strains at pump suction. Provide unit casing with blowdown port and plug. Provide a magnetic insert to remove debris from system.

2.8.4 Flexible Pipe Connectors

Provide flexible bronze or stainless steel piping connectors with single braid. Equip flanged assemblies 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. Provide covers to protect the bellows where indicated.

2.8.5 Pressure and Vacuum Gauges

Gauges, **ASME B40.100** with throttling type needle valve or a pulsation dampener and shut-off valve. Provide gauges with **4.5 inch** dial, brass or aluminum case, bronze tube, and siphon. Gauge shall have a range from **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.

2.8.6 Temperature Gauges

Temperature gauges, shall be the industrial duty type and be provided for the required temperature range. Provide gauges with fixed thread connection, dial face gasketed within the case; and an accuracy within 2 percent of scale 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 **5 feet** of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located **5 to 7 feet** above the finished floor or in locations indicated. Remote element type temperature gauges shall be provided in thermal wells located **7 feet** above the finished floor or in locations indicated.

2.8.6.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, **9 inches** long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.8.6.2 Bimetallic Dial

Bimetallic dial type case shall be not less than **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.

2.8.6.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than **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.

2.8.6.4 Thermal Well

Thermal well shall be identical size, $1/2$ or $3/4$ inch NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type $1/2$ 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 1 inch.

2.8.7 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, guides, and supports: to MSS SP-58 and MSS SP-69. If ferrous materials are utilized provide hot-dipped galvanized hangers, inserts and supports.

2.8.8 Escutcheons

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Secure plates in place by internal spring tension or set screws. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.8.9 Expansion Joints

2.8.9.1 Slip-Tube Type

Slip-tube expansion joints, ASTM F1007, Class I or II. Joints shall be provided with internally-externally alignment guides, injected semi-plastic packing, and service outlets. End connections shall be flanged or beveled for welding as indicated. Initial settings shall be made in accordance with the manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer.

2.8.9.2 Flexible Ball Type

Flexible ball expansion joints shall be capable of 360 degrees rotation plus 15 degrees angular flex movement. Joints shall be constructed of carbon steel with the exterior spherical surface of carbon steel balls plated with a minimum 5 mils of hard chrome in accordance with EJMA Stds. Joint end connections shall be threaded for piping 2 inches or smaller. Joint end connections larger than 2 inches shall be grooved, flanged, or beveled for welding. Provide joint with pressure-molded composition gaskets suitable for continuous operation at twice design temperature.

2.8.9.3 Bellows Type

Bellows expansion type joints, ASTM F1120 with Type 304 stainless steel corrugated bellows, reinforced with equalizing rings, internal sleeves, and external protective covers. Joint end connections shall be grooved, 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 1.1-1.2**. 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, and have sufficient **horsepower** for the service required. 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 **60 feet of water**, the pump speed shall not exceed 1,750 rpm. 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

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 **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. Provide threaded suction and discharge pressure gage tapping with square-head plugs.

Impeller shall be statically and dynamically balanced. 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 steel shaft coupling guard. Base-mounted pump, coupling guard, and motor shall each be bolted to a fabricated steel base which shall have bolt holes for securing base to supporting surface. Pump shall be accessible for servicing without disturbing piping connections. Shaft seals shall be mechanical-seals or stuffing-box type.

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 particle 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 for, and tested to

pressure-temperature rating of 125 psi at 150 degrees F. Provide tanks precharged to the minimum operating pressure. Tank shall have a replaceable polypropylene or butyl lined diaphragm which keeps the air charge separated from the water; shall 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 constructed of stainless steel and suitable for creating the required vortex and subsequent air separation. Tank shall be steel, constructed for, and tested to pressure-temperature rating of 125 psi at 150 degrees F. Tank shall have tangential inlets and outlets connections, threaded for 2 inches and smaller and flanged for sizes 2-1/2 inches and larger. Air released from a tank shall be to the atmosphere. Tank shall be provided with a blow-down connection.

2.12 WATER TREATMENT SYSTEMS

When water treatment is specified, the use of chemical-treatment products containing equivalent chromium (CPR) is prohibited.

2.12.1 Water Analysis

Conditions of make-up water to be supplied to the condenser and chilled water systems were reported in accordance with ASTM D596 and are as follows:

Date of Sample	
Temperature	degrees F
Silica (Sino 2)	pp (mg/1)
Insoluble	pp (mg/1)
Iron and Aluminum Oxides	pp (mg/1)
Calcium (Ca)	pp (mg/1)
Magnesium (Mg)	pp (mg/1)
Sodium and Potassium (Nan and AK)	pp (mg/1)
Carbonate (HO 3)	pp (mg/1)
Sulfate (SO 4)	pp (mg/1)

Chloride (JCL)	pp (mg/1)
Nitrate (NO 3	pp (mg/1)
Turbidity	unit
pH	
Residual Chlorine	pp (mg/1)
Total Alkalinity	PM (me/1
Non-Carbonate Hardness	PM (me/1
Total Hardness	PM (me/1
Dissolved Solids	pp (mg/1)
Fluorine	pp (mg/1)
Conductivity	McMahon/cm

2.12.2 Chilled and Condenser Water

Water to be used in the chilled and condenser water systems shall be treated to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Chemicals shall meet all required federal, state, and local environmental regulations for the treatment of evaporator coils and direct discharge to the sanitary sewer.

2.12.3 Water Treatment Services

The services of a company regularly engaged in the treatment of condenser and chilled water systems shall be used to determine the correct chemicals required, the concentrations required, and the water treatment equipment sizes and flow rates required. The company shall maintain the chemical treatment and provide all chemicals required for the condenser and chilled water systems for a period of 1 year from the date of occupancy. The chemical treatment and services provided over the 1 year period shall meet the requirements of this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Acid treatment and proprietary chemicals shall not be used.

2.12.4 Chilled Water System

A shot feeder shall be provided on the chilled water piping 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.

2.12.5 Condenser Water

The water treatment system shall be capable of automatically feeding chemicals and bleeding the system to prevent corrosion, scale, and biological formations. Automatic chemical feed systems shall automatically feed chemicals into the condenser water based on varying

system conditions.

2.12.5.1 Chemical Feed Pump

One pump shall be provided for each chemical feed tank. The chemical feed pumps shall be positive displacement diaphragm type. The flow rate of the pumps shall be adjustable from 0 to 100 percent while in operation. The discharge pressure of pumps shall not be less than 1.5 times the line pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge.

2.12.5.2 Tanks

Two chemical tanks shall be provided. The tanks shall be constructed of high density polyethylene with a hinged cover. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation. A level indicating device shall be included with each tank. An electric agitator shall be provided for each tank.

2.12.5.3 Injection Assembly

An injection assembly shall be provided at each chemical injection point along the condenser water piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the condenser water piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the condenser water line.

2.12.5.4 Water Meter

Water meters shall be provided with an electric contacting register and remote accumulative counter. The meter shall be installed within the make-up water line, as indicated.

2.12.5.5 Timers

Timers shall be of the automatic reset, adjustable type, and electrically operated. The timers shall be suitable for a 120 volt current. The timers shall be located within the water treatment control panel.

2.12.5.6 Water Treatment Control Panel

The control panel shall be a NEMA 12 enclosure suitable for surface mounting. The panel shall be constructed of stainless steel with a hinged door and lock. The panel shall contain a laminated plastic nameplate identifying each of the following functions:

- (1) Main power switch and indicating light
- (2) MAN-OFF-AUTO selector switch
- (3) Indicating lamp for bleed-off valve
- (4) Indicating lamp for each chemical feed pump
- (5) Set point reading for each timer

2.12.5.7 Chemical Piping

The piping and fittings shall be constructed of schedule 80 PVC suitable for the water treatment chemicals.

2.12.5.8 Sequence of Operation

The chemicals shall be added based upon sensing the make-up water flow rate and activating appropriate timers. A separate timer shall be provided for each chemical. The blow down shall be controlled based upon the make-up water flow rate and a separate timer. The injection of the chemical required for biological control shall be controlled by a timer which can be manually set for proper chemical feed. Timer set points, blow down rates, and chemical pump flow rates shall be determined and set by the water treatment company.

2.12.5.9 Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided.

2.12.5.10 Bleed Line

A bleed line with a flow valve of the needle-valve type sized for the flow requirement or fixed orifice shall be provided in the pump return to the tower. The bleed line shall be extended to the nearest drain for continuous discharge.

2.13 ELECTRICAL WORK

Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

Provide polyphase, squirrel-cage medium induction motors, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. 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. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated 10 hp or less and adjustable frequency drives for larger motors.

2.14 PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

2.14.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided. The factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test.

Salt-spray fog test shall be in accordance with [ASTM B117](#), and for that test, the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of [0.125 inch](#) on either side of the scratch mark. The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen.

If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above [120 degrees F](#), the factory painting system shall be designed for the temperature service.

2.14.2 Shop Painting Systems for Metal Surfaces

Clean, retreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of [120 degrees F](#) shall be cleaned to bare metal.

Where hot-dip galvanized steel has been cut, resulting surfaces with no galvanizing shall be coated with a zinc-rich coating conforming to [ASTM D520](#), Type I.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

- a. Temperatures Less Than [120 Degrees F](#): Immediately after cleaning, the metal surfaces subject to temperatures less than [120 degrees F](#) shall receive one coat of pretreatment primer applied to a minimum dry film thickness of [0.3 mil](#), one coat of primer applied to a minimum dry film thickness of [one mil](#); and two coats of enamel applied to a minimum dry film thickness of [one mil](#) per coat.
- b. Temperatures Between [120 and 400 degrees F](#): Metal surfaces subject to temperatures between [120 and 400 degrees F](#) shall receive two coats of [400 degrees F](#) heat-resisting enamel applied to a total minimum thickness of [2 mils](#).
- c. Temperatures Greater Than [400 degrees F](#): Metal surfaces subject to temperatures greater than [400 degrees F](#) shall receive two coats of [600 degrees F](#) heat-resisting paint applied to a total minimum dry film thickness of [2 mils](#).

2.15 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 25 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 E84](#).

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 E84](#).

2.16 NAMEPLATES

Major equipment including pumps, pump motors, expansion tanks, and air separator tanks shall have the manufacturer's name, type or style, model or serial number on a plate secured to the item of equipment. The nameplate of the distributing agent will not be acceptable. Plates shall be durable and legible throughout equipment life and made of stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.17 RELATED COMPONENTS/SERVICES

2.17.1 Field Painting

Requirements for painting of surfaces not otherwise specified, and finish painting of items only primed at the factory, are specified in Section [09 90 00](#) PAINTS AND COATINGS.

2.17.1.1 Color Coding

Requirements for color coding for piping identification are specified in Section [09 90 00](#) PAINTS AND COATINGS.

PART 3 EXECUTION

3.1 INSTALLATION

Cut pipe accurately to measurements established at the jobsite, and work 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 is not permitted without written approval. Cut pipe or tubing square, remove burrs by reaming, and fashion to permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making

actual connections to existing systems.

3.1.1 Welding

Provide welding work specified this section for piping systems in conformance with [ASME B31.9](#), as modified and supplemented by this specification section and the accompanying drawings. The welding work includes: qualification of welding procedures, welders, welding operators, brazers, brazing operators, and nondestructive examination personnel; maintenance of welding records, and examination methods for welds.

3.1.1.1 Employer's Record Documents (For Welding)

Submit for review and approval the following documentation. This documentation and the subject qualifications shall be in compliance with [ASME B31.9](#).

- a. List of qualified welding procedures that is proposed to be used to provide the work specified in this specification section.
- b. List of qualified welders, brazers, welding operators, and brazing operators that are proposed to be used to provide the work specified in this specification section.
- c. List of qualified weld examination personnel that are proposed to be used to provide the work specified in this specification section.

3.1.1.2 Welding Procedures and Qualifications

- a. Specifications and Test Results: Submit copies of the welding procedures specifications and procedure qualification test results for each type of welding required. Approval of any procedure does not relieve the Contractor of the responsibility for producing acceptable welds. Submit this information on the forms printed in [ASME BPVC SEC IX](#) or their equivalent.
- b. Certification: Before assigning welders or welding operators to the work, submit a list of qualified welders, together with data and certification that each individual is performance qualified as specified. Do not start welding work prior to submitting welder, and welding operator qualifications. The certification shall state the type of welding and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

3.1.1.3 Examination of Piping Welds

Conduct non-destructive examinations (NDE) on piping welds and brazing and verify the work meets the acceptance criteria specified in [ASME B31.9](#). NDE on piping welds covered by [ASME B31.9](#) is visual inspection only. Submit a [piping welds NDE report](#) meeting the requirements specified in [ASME B31.9](#).

3.1.1.4 Welding Safety

Welding and cutting safety requirements shall be in accordance with [AWS Z49.1](#).

3.1.2 Directional Changes

Make changes in direction with fittings, except that bending of pipe 4 inches and smaller is 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 is not 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 is not acceptable.

3.1.3 Functional Requirements

Pitch horizontal supply mains down in the direction of flow as indicated. The grade shall not be less than 1 inch in 40 feet. Reducing fittings shall be used for changes in pipe sizes. Cap or plug open ends of pipelines and equipment 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 2-1/2 inches or less in diameter, and with flanges for pipe 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.

3.1.4 Fittings and End Connections

3.1.4.1 Threaded Connections

Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.4.2 Brazed Connections

Brazing, AWS BRH, 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. Do not use brazing flux. 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.

3.1.4.3 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 B31.9**. 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/D1.1M** or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.4.4 Grooved Mechanical Connections

Prepare grooves in accordance with the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, or narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.1.4.5 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.

3.1.4.6 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.

3.1.5 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.

3.1.6 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.

3.1.7 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.

3.1.8 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.

3.1.9 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 1 inch.

3.1.10 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as supplemented and modified in this specification section. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 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.

3.1.10.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.1.10.2 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.

3.1.10.3 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.

3.1.10.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.1.10.5 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 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Type 40 shields shall be used on all piping less than 4 inches and all piping 4 inches and larger carrying medium less than 60 degrees F. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 2 inches and larger.

3.1.10.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in [MSS SP-69](#) and a support shall be installed not over [1 foot](#) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over [5 feet](#) apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of [50 pounds](#) shall have the excess hanger loads suspended from panel points.

3.1.10.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than [15 feet](#), not more than [8 feet](#) from end of risers, and at vent terminations.

3.1.10.8 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.

3.1.10.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping [4 inches](#) and larger, a Type 39 saddle shall be used. On piping under [4 inches](#), a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.1.10.10 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.

3.1.10.11 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. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer. 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.

3.1.11 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 [5 feet](#) on each side of each expansion joint, and in lines [4 inches](#) or smaller not more than [2 feet](#) on each side of the joint.

3.1.12 Pipe Anchors

Anchors shall be provided where indicated. Unless indicated otherwise, anchors shall comply with the requirements specified. 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.

3.1.13 Building Surface Penetrations

Sleeves shall not be installed in structural members except where indicated or approved. Except as indicated otherwise piping sleeves shall comply with requirements specified. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to [ASTM A653/A653M](#), Coating Class G-90, [20 gauge](#). Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to [ASTM A53/A53M](#), Schedule 30. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than [1/2 inch](#) depth. Sleeves shall not be installed in structural members.

3.1.13.1 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 [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 [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.

3.1.13.2 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 **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 **07 92 00 JOINT SEALANTS**.

3.1.13.3 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a **.17 ounce** copper sleeve, or a **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 **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 **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 **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 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.

3.1.13.4 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section **07 84 00 FIRESTOPPING**.

3.1.13.5 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.

3.1.14 Access Panels

Access panels shall be provided where indicated for all concealed valves, vents, controls, and additionally for 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 08 31 00 ACCESS DOORS AND PANELS.

3.2 INSTALLATION FOR POLYPROPYLENE PIPING (CHILLED WATER APPLICATIONS ONLY)

3.2.1 Locations

Plastic pipe to include polypropylene shall not be installed in air plenums. Plastic pipe to include polypropylene shall not be installed in a pressure piping system in buildings greater than three stories including any basement levels.

3.2.2 Pipe Joints

Joints for polypropylene pipe and fittings shall be made by heat fusion welding socket-type or butt-fusion type fittings and shall comply with ASTM F2389. Joint surfaces shall be clean and free from moisture, and shall be undisturbed until cool.

3.2.3 Overheating Precautions

Adequate provisions shall be taken to ensure that the pipe does not exceed operating temperatures recommended by the manufacturer. This includes a safeguard provision from preventing a pump from running with zero flow, if such operation could overheat the pipe beyond pipe manufacturer's recommendations. If heat tracing is permitted elsewhere in the specifications, ensure that the heat tracing is installed per piping manufacturer's recommendations to prevent overheating of the pipe.

3.2.4 Testing and Flushing

Pressure test shall be conducted for 15 minutes at 1.5 times the operating pressure or 150 psi, whichever is greater, with no observable loss in pressure. Water, rather than air, must be used for pressure testing plastic pipe. After satisfactory pressure test is obtained, flush piping system using a minimum velocity of 4 fps through all portions of the piping system. Flushing shall be continued until discharge water shows no discoloration and strainers are no longer collecting dirt and other foreign materials. Upon completion of flushing, drain all water from system at low points, and remove/clean/replace strainers.

3.3 ELECTRICAL INSTALLATION

Install electrical equipment in accordance with NFPA 70 and manufacturers

instructions.

3.4 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.

3.5 FIELD TESTS

Field tests shall be conducted in the presence of the QC Manager or his designated representative to verify systems compliance with specifications. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor.

3.5.1 Equipment and Component Isolation

Prior to testing, equipment and components that cannot withstand the tests shall be properly isolated.

3.5.2 Pressure Tests

Each piping system , except for polypropylene piping, shall be hydrostatically tested at a pressure not less than 188 psig 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 currently calibrated test pressure gauge. Leaks shall be repaired and piping retested until test requirements are met. No leakage or reduction in gage 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.

Submit for approval [pressure tests reports](#) covering the above specified piping pressure tests; describe the systems tested, test results, defects found and repaired, and signature of the pressure tests' director. Obtain approval from the QC Manager before concealing piping or applying insulation to tested and accepted piping.

3.5.3 [Condenser Water Quality Test Reports](#)

The condenser water system shall be analyzed by the water treatment company a minimum of once a month for a period of one year after system acceptance. Submit for approval the specified [condenser water quality test reports](#). The analysis and resulting reports shall include the following information recorded in accordance with [ASTM D596](#).

Date of Sample	

Temperature	degrees F
Silica (Sino 2)	pp (mg/1)
Insoluble	pp (mg/1)
Iron and Aluminum Oxides	pp (mg/1)
Calcium (Ca)	pp (mg/1)
Magnesium (Mg)	pp (mg/1)
Sodium and Potassium (Nan and AK)	pp (mg/1)
Carbonate (HO 3)	pp (mg/1)
Sulfate (SO 4)	pp (mg/1)
Chloride (JCL)	pp (mg/1)
Nitrate (NO 3)	pp (mg/1)
Turbidity	unit
pH	
Residual Chlorine	ppm (mg/1)
Total Alkalinity	epm (meq/1)
Non-Carbonate Hardness	epm (meq/1)
Total Hardness	epm (meq/1)
Dissolved Solids	ppm (mg/1)
Fluorine	ppm (mg/1)
Conductivity	microhm/cm

3.5.4 Related Field Inspections and Testing

3.5.4.1 Piping Welds

Examination of Piping Welds is specified in the paragraph EXAMINATION OF PIPING WELDS (above).

3.5.4.2 HVAC TAB

Requirements for testing, adjusting, and balancing (TAB) of HVAC water piping, and associated equipment is specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Coordinate with the TAB team, and provide support personnel and equipment as specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC to assist TAB team to meet the TAB work requirements.

3.6 INSTRUCTION TO GOVERNMENT PERSONNEL

Furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the chilled-hot water, and condenser water piping systems. Instructors shall be thoroughly familiar with all parts of the installation and shall be instructed in operating theory as well as practical operation and maintenance work. Submit a [lesson plan for the instruction course](#) for approval. The lesson plan and instruction course shall be based on the approved operation and maintenance data and maintenance manuals.

Conduct a training course for the operating staff and maintenance staff selected by the Contracting Officer. Give the instruction 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 one man-day.. Use approximately half of the time for classroom instruction and the other time for instruction at the location of equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

3.7 [ONE-YEAR INSPECTION REPORT FOR COOLING WATER](#)

At the conclusion of the one year period, each connecting cooling tower and liquid chiller condenser inspect for problems due to corrosion, scale, and biological growth. If the equipment is found not to conform to the manufacturers recommended conditions, and the water treatment company recommendations have been followed; the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations.

-- End of Section --

SECTION 23 65 00

COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS

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.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.13 (2005; R 2010) Methods for the Measurement of Sound Pressure Levels in Air (ASA 118)

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

ANSI/AHRI 495 (2005) Performance Rating of Refrigerant Liquid Receivers

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34 (2013) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants

ASHRAE 64 (2020) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1 (2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A153/A153M (2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A653/A653M (2022) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM B117 (2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2996	(2017) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

COOLING TECHNOLOGY INSTITUTE (CTI)

CTI ATC-105	(2000) Acceptance Test Code
CTI ESG-114	(2007) Design of Cooling Towers with Douglas Fir Lumber
CTI STD-134	(2022) Plywood for Use in Cooling Towers
CTI Std-103	(2022) Redwood Lumber Specifications
CTI Std-112	(2019) Pressure Preservative Treatment of Dimensional Lumber
CTI Std-137	(2017) Fiberglass Pultruded Structural Products for Use in Cooling Towers
CTI Std-201	(2011) Standard for the Certification of Water Cooling Tower Thermal Performance

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2021) Motors and Generators
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 214	(2021) Standard on Water-Cooling Towers

REDWOOD INSPECTION SERVICE (RIS) OF THE CALIFORNIA REDWOOD ASSOCIATION (CRA)

RIS Grade Use	(1998) Redwood Lumber Grades and Uses

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J534	(2021) Lubrication Fittings

UNDERWRITERS LABORATORIES (UL)

UL 723

(2018) UL Standard for Safety Test for
Surface Burning Characteristics of
Building Materials

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA G-5

(2017) Western Lumber Grading Rules

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Cooling Towers; G

Demonstrations; G

Verification of Dimensions; G

Remote Evaporatively-Cooled Condensers

SD-06 Test Reports

Packaged Cooling Tower - Installation Instructions; G

Packaged Cooling Tower - Field Acceptance Test Plan; G

Packaged Cooling Tower - Field Acceptance Test Report; G

SD-07 Certificates

Service Organization

Cooling Tower

Remote Evaporatively-Cooled Condensers

SD-08 Manufacturer's Instructions

Packaged Cooling Tower - Installation Instructions

Remote Evaporatively-Cooled Condensers

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

Remote Evaporatively-Cooled Condensers

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 must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with [AWS Z49.1](#). Catwalk, ladder, and guardrail must be provided where indicated and in accordance with Section [05 50 13](#) MISCELLANEOUS METAL FABRICATIONS.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items must 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 must 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 must carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and must 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 must be standard commercial catalogued products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products must have been in satisfactory commercial or industrial use in field service for two years prior to bid opening. The two year use must include applications of equipment and materials under similar circumstances and of similar size. Products having less than a two 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. This 6000 hour record must not include any manufacturer's prototype or factory testing. Records of satisfactory field use must be completed by a product that had been, and presently is, sold, or offered for sale on a commercial market through the following copyrighted means: advertisements, manufacturer's catalogs, or brochures. Products must be supported by a [service organization](#). System components must be environmentally suitable for the indicated locations.

2.2 MANUFACTURER'S STANDARD NAMEPLATES

Major equipment including cooling towers, cooling tower gear drive assemblies, fans, and motors must 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 must be durable and legible throughout equipment life. Plates must be fixed in prominent locations.

2.3 ELECTRICAL WORK

- a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.
- b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.
- c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.
- d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors must be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must 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. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor enclosure type may be either TEAO or TEFC.
- e. Use adjustable frequency drives for all variable-speed motor applications. Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.
- f. Provide inverter duty premium efficiency motors for use with variable frequency drives.

2.4 COOLING TOWER MATERIALS

2.4.1 Lumber

2.4.1.1 Douglas Fir

CTI ESG-114, WHPA G-5, Grade B and better, Industrial Clear. Douglas fir must have a preservative treatment in accordance with CTI Std-112.

2.4.1.2 Plywood

CTI STD-134, Exterior Grade, type and thickness as specified for the application.

2.4.1.3 Pressure Treated Lumber

Pressure treated lumber must be in accordance with [CTI Std-112](#). Wood exposed as the result of notching, cutting, or drilling must be saturated with the preservative.

2.4.1.4 Redwood

[CTI Std-103](#), [RIS Grade Use](#) California Redwood, clear of all hearts.

2.4.2 Fiberglass Reinforced Plastic (FRP)

FRP components must be inert, corrosion resistant, and fire-retardant with a thickness of [12 ounces per square foot](#). FRP components must contain an ultraviolet (UV) ray inhibitor as per [CTI Std-137](#), Grade 1 or 3. Components manufactured of polystyrene will not be permitted.

2.4.3 Zinc-Coated Steel

Components fabricated of zinc-coated steel must be not lighter than 16 gauge [0.0635 inch](#) steel, protected against corrosion by a zinc coating. The zinc coating must conform to [ASTM A653/A653M](#), as applicable and have an extra heavy coating of not less than [2.35 ounces per square foot](#) of surface. Galvanized surfaces damaged due to welding must be coated with zinc rich coating conforming to [ASTM D520](#), Type 1.

2.4.4 Polyvinyl Chloride (PVC) Formed Sheets

[ASTM D1784](#), Type I, Grade 1 with a flame spread rating in accordance with [ASTM E84](#), Class A.

2.4.5 High Density Polyethylene (HDPE)

Components manufactured from HDPE must be seamless with a minimum thickness of [0.375 inch](#). The material must have the appropriate inhibitors to protect the component from any UV degradation. Tanks and cooling tower shells must be seamlessly molded to minimize water loss/consumption.

2.4.6 Stainless Steel Sheets

Type 316.

2.4.7 Concrete

Concrete must conform to Section [03 30 00](#) CAST-IN-PLACE CONCRETE. Exposed concrete must be rub-finished for smooth and uniform surfaces free of form marks and defects. Honeycomb concrete will not be permitted.

2.4.8 Hardware

Bolts must be cadmium-plated, zinc-coated steel, or Type 304 stainless steel. Each bolt must be provided with neoprene and cadmium-plated steel washers under the heads. Nails must be silicon bronze, commercial bronze, or stainless steel. Hardware must meet the salt-spray fog test as defined by [ASTM B117](#). Angle brackets and similar parts must be zinc-coated steel. Zinc coatings must conform to [ASTM A153/A153M](#) and [ASTM A123/A123M](#), as applicable, and must have an extra heavy coating of not less than [2.35 ounces per square foot](#) of surface. Nails must be silicon bronze,

commercial bronze, or stainless steel. Subject hardware to a salt-spray fog test in accordance with [ASTM B117](#). No signs of corrosion must be evident after 1,000 hours continuous exposure to a 5 percent salt spray.

2.5 COOLING TOWERS

2.5.1 Factory Assembled Towers

2.5.1.1 Description

The cooling tower must be of the induced mechanical draft type. The cooling tower must include frames and casings, louvers, drift eliminators, partitions, windbreak baffles, drift-check walls, cold water basin equipment, fans and fan walls, blowers, drives, electric motors, access doors, working platforms, inspection plates, and panels.

2.5.1.2 Construction

Tower must be constructed to withstand a wind pressure of not less than [30 psf](#) on any external surface. Fan deck must be constructed to withstand a live load of not less than [60 psf](#) in addition to the concentrated or distributed loads of equipment mounted on the fan deck.

The hot water distribution system must be of the open basin gravity feed type or the pressurized spray header type design.

2.5.1.3 Tower Frame and Louvers

Provide frame constructed from [316 stainless steel](#). Intermediate structural members must be provided for rigidity and support of casings, louvers, fill, distribution systems, fan decks, and other equipment. Inlet air louvers must permit free air passage but no splashout, and must be designed to prevent debris and sunlight from entering the cold water basin.

2.5.1.4 Fill

The fill must support expected loads without sag or failure and arranged to effectively break up the water. The fill must be manufactured and performance tested by the cooling tower manufacturer. The fill must be of the materials as specified. Polyvinyl chloride (PVC) fill is suitable for inlet temperatures to [125 degrees F](#) on cross flow type units and temperatures to [130 degrees F](#) on counterflow type units. Chlorinated polyvinyl chloride (CPVC) fill must be used for applications where inlet temperatures are greater than [130 degrees F](#). Fill must be in accordance with [ASTM E84](#), Class A.

2.5.1.5 Drift Eliminators

Provide drift eliminator sections designed and arranged to effectively trap water droplets entrained in the discharge airstream. Sections must be assembled in easily removable sections for counterflow induced mechanical draft tower. Drift eliminators must be constructed of Polyvinyl chloride (PVC) in accordance with [ASTM E84](#), Class A.

2.5.1.6 Cold Water Basin Equipment.

Include Type 304 stainless steel sump with stainless steel removable screen and vortex breaker, float valves, and necessary pipe connections

and fittings within the tower. Provide float valves with adjustable arms. Valve sizes larger than 1/2 inch pipe size must be the balanced piston type. Valve seats and disks must be replaceable. Electronic water level control must be provided.

Provide cold water basins and casings suitably sealed and flashed at joints and connections to ensure watertight construction.

2.5.1.6.1 Electric Basin Heater

Heater must be the electric immersion type with water-tight junction boxes mounted in the basin with sufficient capacity to maintain the basin water temperature above 55 degrees F at an ambient temperature of 40 degrees F. Heater must be complete with control thermostat, transformer, contactor, and low water level heater protection.

2.5.1.7 Fans, Blowers, and Drives.

The towers must have axial propeller-type fans having not less than four aluminum alloy or glass-reinforced polypropylene blades or squirrel-cage, centrifugal-type blowers, as applicable. Fans and blowers must be designed and constructed to withstand 50 percent overspeed above normal maximum operating speeds.

If belt drives are utilized, multi-grooved solid back single belt design must be used to avoid uneven belt stretch. Adjustment must be provided for belt tension and drive centers. Belt drives must be designed and constructed for 150 percent overload. Sheaves located in the airstream must be corrosion-resistant material. Shafting for gear drives must have flexible-type couplings requiring no lubrication. The gear assemblies must be enclosed in an oil filled housing provided with fill and drain plugs.

2.5.1.8 Tower Piping

Piping must be schedule 40 PVC and conform to ASTM D2996. Fittings for other piping materials must be of the same material or equal and of the same class and grade as the pipe.

2.5.1.9 Electric Motors

Requirements are specified in paragraph ELECTRICAL WORK.

2.5.1.10 Vibration Cutout Switch.

Provide electronic vibration cutout switch with auxiliary contacts in a protected position and most effective location, interlocked with the fan wiring to electrically open the motor circuit under excessive fan vibration.

2.5.1.11 Performance

The factory assembled tower must have Cooling Tower Institute certification that, in accordance with CTI Std-201, the cooling tower will perform thermally at the rating published by the tower manufacturer in his copyrighted literature.

2.5.1.12 Sound Power Level

Sound power levels, in decibels (dB) with a reference pressure of 0.0002 microbars, of the cooling tower must be not greater than the maximum permitted dB levels for the designated octave band as set forth in Table I or Table II. The sound power level data for the cooling tower must have been verified in tests conducted in accordance with [ASA S1.13](#).

Table I. Sound Power Level For Induced Mechanical Draft Type								
Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level (dB)	112	112	110	108	102	98	93	90

Table II. Sound Power Level For Forced Mechanical Draft Type								
Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level (dB)	112	112	110	108	102	98	93	90

2.5.1.13 Drift Loss

Drift loss must be not greater than 0.005 percent of the water circulated.

2.5.2 Lubrication

The lubricating points must be extended to the outside of the unit for easy accessibility. Hydraulic lubrication fittings must be in accordance with [SAE J534](#). Where use of high pressure lubricating equipment, 1000 psi or higher, will damage grease seals or other parts, a suitable warning must be affixed to the equipment in a conspicuous location.

2.5.3 Factory Finish System

Factory painting system must have been proven to withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Equipment located in a sea coast environment must withstand 3,000 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with [ASTM B117](#). For salt-spray fog test, the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system must be designed for the temperature service and must have been proven to pass the specified salt-spray test.

2.5.4 Drift Eliminators

Eliminators must be provided in the tower outlet to limit drift loss to not over 0.005 percent of the circulating water rate. Eliminators must be constructed of polyvinyl chloride (PVC). Eliminator sections must be supported on PVC or FRP tee sections. Tee sections must be suspended with 1/4 inch brass rods connected to stainless steel clips embedded in the bottom side of the roof deck at the time of casting. Stainless steel clips must be supplied by cooling tower manufacturer for installation by Contractor at time of roof deck pour. Eliminators may be supported by brass or stainless steel suspension rods from the fan deck or supported directly on concrete beams.

2.5.5 Cold Water Basin Equipment.

Include sump with removable screen and vortex breaker, float valves, and necessary pipe connections and fittings within the tower. Provide float valves with adjustable arms. Valve sizes larger than 1/2 inch pipe size must be the balanced piston type. Valve seats and disks must be replaceable. Electric water level control must be provided.

Provide cold water basins and casings suitably sealed and flashed at joints and connections to ensure watertight construction.

2.5.6 Fill (Heat Transfer Surface)

Tower fill must be the splash or film type. Fill material must be free to expand or contract without warping or cracking. No plasticized wood cellulose must be provided for fill material. Fill must be removable or otherwise made accessible for cleaning. Space supports must be corrosion resistant and must prevent warping, sagging, misalignment, or vibration of the fill material. Fill material and supports must be designed to provide for an even mixing of air and water. Fill material must be constructed of stainless steel in a pattern, and of sufficient height to meet the performance specifications.

2.5.7 Fire Safety

Towers must conform to NFPA 214. Fire hazard rating for plastic impregnated materials must not exceed 25. Plastics must not drip or run during combustion. Fire hazard ratings must be in accordance with ASTM E84, Class A and UL 723.

2.5.8 Meters and Controls

Tower must be provided with makeup and blowdown meters, conductivity controller, and overflow alarm.

2.6 REMOTE EVAPORATIVELY-COOLED CONDENSERS

Condenser must be rated and tested in accordance with the requirements of ASHRAE 64. Condenser must 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 may carry over into the unit

discharge outlet.

2.6.1 Condenser Casing

Enclosure must be constructed of not lighter than 18 gauge 0.516 inch 304 stainless steel, reinforced and braced. Access doors or panels suitably sized and located must 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 must 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 must be provided on each air inlet.

2.6.2 Refrigerant Section

Condenser coil must be constructed of unfinned copper or steel tubes hot-dip galvanized after fabrication. The receiver must be welded steel and must be fitted and tested in accordance with ANSI/AHRI 495. A refrigerant charging valve must be installed in the liquid line between the receiver cut-off valve and the expansion device. Refrigerant section must be tested in accordance with ANSI/ASHRAE 15 & 34 for the refrigerant employed in the system. CFC-based refrigerants are prohibited.

2.6.3 Fans

Fans must be centrifugal or propeller type as best suited for the application. Fans must be direct or V-belt driven. Belt drives must 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 must be provided. Sheave set must be matched and selected to provide the capacity indicated at the approximate midpoint of the adjustment. Fans must be statically and dynamically balanced. Fan motor must be totally enclosed type or open drip-proof and located within an enclosure to be fully protected from the weather.

2.6.4 Water Section

Water eliminators must be constructed of nonferrous metal, of an approved nonmetallic material, or of not lighter than 24 gauge 0.0276 inch steel, hot-dip galvanized after fabrication. Spray nozzles must be brass non-clogging type designed to permit easy disassembly, and must be arranged for easy access. Water pump must 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 must be fully submerged and provided with screened inlet. Water pan or sump must be constructed of not lighter than 14 gauge 0.0785 inch steel, hot-dip galvanized after fabrication, or molded acid-resistant glass-fiber-reinforced polyester. Water distribution pan must be constructed of not lighter than 16 gauge 0.0635 inch steel, hot-dip galvanized after fabrication. Joints must be watertight. Water pan or sump must 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 must be provided in the pump discharge line and must be extended to the nearest drain for continuous discharge.

2.7 FABRICATION

Equipment and component items, must have been proven to withstand 125

hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Equipment located in a sea coast environment must withstand 3,000 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with [ASTM B117](#). Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to [ASTM D520](#), Type I.

2.8 SUPPLEMENTAL COMPONENTS/SERVICES

2.8.1 Condenser Water Piping and Accessories

Condenser water piping and accessories must be provided and installed in accordance with Section [23 64 26](#) CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.8.2 Cooling Tower Water Treatment Systems

Cooling tower water treatment systems must be provided and installed in accordance with Section [23 64 26](#) CHILLED, CHILLED-HOT AND CONDENSER WATER PIPING SYSTEMS.

2.8.3 Temperature Controls

Cooling towers must be fully coordinated with and integrated into the temperature control system specified in Section [23 09 00](#) INSTRUMENTATION AND CONTROL FOR HVACSection [23 09 23.01](#) LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS .

PART 3 EXECUTION

3.1 DEMONSTRATIONS

Contractor must conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total [8](#) hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The training course must cover all of the items contained in the approved [Operation and Maintenance Manuals](#) as well as demonstrations of routine maintenance operations.

Provide 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.

3.2 INSTALLATION

Installation of cooling tower systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing must be in accordance with [NFPA 70](#), and in compliance with the manufacturer's written installation instructions, including the following:

- (1) [Packaged cooling tower - installation instructions](#)

3.2.1 Installation Instructions

Provide manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show features such as materials of construction, dimensions, options, performance and efficiency. Data must include manufacturer's recommended

installation instructions and procedures. Data must be adequate to demonstrate compliance with contract requirements.

3.2.2 Vibration Isolation

If vibration isolation is specified for a unit, vibration isolator literature must be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

3.2.3 Verification of Dimensions

Provide a letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

3.2.4 Demonstrations

Provide 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.

3.2.5 Certificates

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, proof of such compliance must be provided. The label or listing of the specified agency must 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 must 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.

3.2.6 Operation and Maintenance Manuals

Provide Six complete copies of an operation manual in bound 8 1/2 by 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 must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. Six complete copies of maintenance manual in bound 8 1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.2.7 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into

existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.3 RELATED FIELD TESTING

3.3.1 Test Plans

- a. Manufacturer's Test Plans: Within 120 calendar days after contract award, submit the following plans:

(1) **Packaged cooling tower - field acceptance test plan**

Field acceptance test plans must developed by the cooling tower manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance test plans must be the plan and procedures followed for the field acceptance tests of the cooling towers and subsequent test reporting.

- b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls for the equipment provided under Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVACSection 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS .
- c. Prerequisite testing: Cooling towers for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.
- d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Each test plan must include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures must be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controllers must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

- e. Performance variables: Each test plan must list performance variables

that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Tower manufacturer must furnish with each test procedure a description of acceptable results that have been verified.

Tower manufacturer must identify the acceptable limits or tolerances within which each tested performance variable must acceptably operate.

- f. Job specific: Each test plan must be job specific and must address the particular cooling towers and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.
- g. Specialized components: Each test plan must include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.4 TESTING

- a. Each cooling tower system must be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:
 - (1) [Packaged cooling tower - field acceptance test report](#)
- b. Manufacturer's recommended testing: Conduct the manufacturer's recommend field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.
- c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed must result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.
- d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.
- e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment must be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative must review, approve, and sign the report of the manufacturer's recommended test. Signatures must be accompanied by the person's name typed.
- f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests must be corrected in

compliance with the manufacturer's recommendations and corrections
retested in order to verify compliance.

- g. Towers with thermal performance not CTI certified to CTI Std-201 must have their thermal performance verified by field testing that meets the requirements of CTI ATC-105

-- End of Section --

SECTION 23 81 00

DECENTRALIZED UNITARY HVAC EQUIPMENT

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, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 700	(2016) Specifications for Fluorocarbon Refrigerants
ANSI/AHRI 210/240	(2008; Add 1 2011; Add 2 2012) Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment
ANSI/AHRI 460	(2005) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 15 & 34	(2013) ASHRAE Standard 34-2016 Safety Standard for Refrigeration Systems/ASHRAE Standard 34-2016 Designation and Safety Classification of Refrigerants-ASHRAE Standard 34-2016
ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-6 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 7-8 2021; Interpretation 1-4 2020; Interpretation 5-8 2021; Addenda AS-CB 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1 (2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM B117 (2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM C1071 (2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

ASTM D520 (2000; R 2011) Zinc Dust Pigment

ASTM E84 (2020) Standard Test Method for Surface Burning Characteristics of Building Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NEMA MG 2 (2014) Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

UNDERWRITERS LABORATORIES (UL)

UL 586 (2009; Reprint Dec 2017) UL Standard for Safety High-Efficiency Particulate, Air Filter Units

UL 900 (2015) Standard for Air Filter Units

UL 1995 (2015) UL Standard for Safety Heating and Cooling Equipment

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Training; G

Inventory

Supplied Products

Manufacturer's Standard Catalog Data

SD-06 Test Reports

Refrigerant Tests, Charging, and Start-Up; G

SD-07 Certificates

Service Organizations

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

SD-11 Closeout Submittals

Ozone Depleting Substances; S

1.3 QUALITY ASSURANCE

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. Submit drawings consisting 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.
- h. Equipment schedules

1.4 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Properly protect and care for all material both before and during installation. Submit an [inventory](#) of all the stored items. Replace any materials found to be damaged, at no additional cost to the Government. During installation, cap piping and similar openings capped to keep out dirt and other foreign matter.

1.5 WARRANTY

Provide equipment with the Manufacturer's Standard Warranty.

PART 2 PRODUCTS

2.1 ENERGY EFFICIENCY REQUIREMENTS

42 USC 8259b requires the procurement of energy efficient products in product categories covered by the Energy Star program or the Federal Energy Management Program for designated products. A list of covered product categories is available from the Federal Energy Management Web site at <http://energy.gov/eere/femp/covered-product-categories>.

Submit Material, Equipment, and Fixtures List of all [supplied products](#) within a covered product category, including manufacturer's catalog numbers, specification and drawing reference number, warranty information, fabrication site, and energy performance data. For product categories covered by the Federal Energy Management Program, submit documentation that the product meets or exceeds FEMP-designated efficiency requirements.

2.2 MATERIALS

Provide [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 includes manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, include vibration isolator literature containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations. Submit data for each specified component. Minimum efficiency requirements must be in accordance with [ASHRAE 90.1 - IP](#).

2.2.1 Standard Products

Provide materials and equipment that are 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 must have been in satisfactory commercial or industrial use for 2 years prior to request for proposal. The 2 year use includes 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, 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 must be supported by a service organization. Ensure system components are environmentally suitable for the indicated geographic locations.

2.2.2 Product Sustainability Criteria

2.2.2.1 Energy Efficient Equipment

Provide equipment meeting the efficiency requirements as stated within

this section.

2.2.2.2 Electrical Equipment / Motors

Provide electrical equipment, motors, motor efficiencies, and wiring which are in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical motor driven equipment specified must be provided complete with motors, motor starters, and controls. Electrical characteristics must be as shown, and unless otherwise indicated, all motors of 1 horsepower and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, must be the premium efficiency type in accordance with NEMA MG 1. Field wiring must be in accordance with manufacturer's instructions. Each motor must 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 must be continuous duty with the enclosure specified. Motor starters must be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors must be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors must be sized for the applicable loads. Motor torque must 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 must 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, must be provided.

2.2.2.3 Ozone Depleting Substances

Unitary air conditioning equipment must not use CFC-based refrigerants. Refrigerant may be an approved alternative refrigerant in accordance with EPA's Significant New Alternative Policy (SNAP) listing.

2.2.3 Nameplates

Major equipment including compressors, condensers, receivers, heat exchanges, fans, and motors must 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 must be durable and legible throughout equipment life and made of anodized aluminum. Fix plates in prominent locations with nonferrous screws or bolts.

2.2.4 Safety Devices

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 must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.

2.3 EQUIPMENT

2.3.1 Mini-Split-System Air Conditioners

2.3.1.1 Small-Capacity Split-System Air-Conditioners (Not Exceeding 65,000 Btu/hr)

Provide an air-cooled, split system which employs a remote condensing unit, a separate wall mounted indoor unit, and interconnecting refrigerant piping. Provide the air conditioning type unit conforming to applicable Underwriters Laboratories (UL) standards including UL 1995. Unit must be rated in accordance with ANSI/AHRI 210/240. Provide indoor unit with necessary fans, air filters, and galvanized steel cabinet construction. The remote unit must be as specified in paragraph CONDENSING UNIT. Provide double-width, double inlet, forward curved backward inclined, or airfoil blade, centrifugal scroll type evaporator or supply fans. Provide the manufacturer's standard condenser or outdoor fans for the unit specified and may be either propeller or centrifugal scroll type. Design unit to operate at outdoor ambient temperatures up to 115 degrees F.

2.3.1.1.1 Air-to-Refrigerant Coil

Provide condensing coils with copper tubes of 3/8 inch minimum diameter with aluminum fins that are mechanically bonded or soldered to the tubes. Casing must be galvanized steel or aluminum. Avoid contact of dissimilar metals. Test coils in accordance with ASHRAE 15 & 34 at the factory and ensure suitability for the working pressure of the installed system. Dehydrate and seal each coil testing and prior to evaluation and charging.

2.3.1.1.2 Compressor

Provide direct drive scroll type compressor. Provide compressor with internal over temperature and pressure protector; sump heater; oil pump; high pressure and low pressure controls; and liquid line dryer.

2.3.1.1.3 Refrigeration Circuit

Refrigerant-containing components must comply with ASHRAE 15 & 34 and be factory tested, cleaned, dehydrated, charged, and sealed. Provide each unit with a factory operating charge of refrigerant and oil or a holding charge. Field charge unit shipped with a holding charge. Provide refrigerant charging valves. Provide filter-drier in liquid line to prevent freeze-up in event of loss of water flow during heating cycle.

2.3.1.1.4 Unit Controls

Provide unit internally prewired with a 24 volt control circuit powered by an internal transformer. Provide terminal blocks for power wiring and external control wiring. Internally protect unit by fuses or a circuit breaker in accordance with UL 1995. Equip units with three-phase power with phase monitoring protection to protect against problems caused by phase loss, phase imbalance and phase reversal. Control unit by a programmable electronic thermostat with heating setback and cooling setup with 7-day programming capability.

Controls must include a control system interface to a BACnet Control system. The control system interface, as well as any network between physically separate units, must meet the requirements of Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING

CONTROL SYSTEMS.

Communication networks between physically separate units in a split system must be in accordance with either Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS or Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. and must match the protocol used by the control system interface.

2.3.1.1.5 Condensing Coil

Provide coils with copper tubes of 3/8 inch minimum diameter with aluminum fins that are mechanically bonded or soldered to the tubes. Provide galvanized steel or aluminum casing. Avoid contact of dissimilar metals. Test coils in accordance with ANSI/ASHRAE 15 & 34 at the factory and ensure suitability for the working pressure of the installed system. Dehydrate and seal each coil after testing and prior to evaluation and charging. Provide separate expansion devices for each compressor circuit.

2.3.1.1.6 Remote Condenser or Condensing Unit

Fit each remote condenser coil fitted with a manual isolation valve and an access valve on the coil side. Saturated refrigerant condensing temperature must not exceed 120 degrees F at 104 degrees F ambient. Provide unit with low ambient condenser controls to ensure proper operation in an ambient temperature of 20degrees F. Provide fan and cabinet construction as specified in paragraph UNITARY EQUIPMENT ACCESSORIES. Fan and condenser motors must have opendrip proof enclosures.

2.3.1.1.6.1 Air-Cooled Condenser

Provide Unit in accordance with ANSI/AHRI 460 and conform to the requirements of UL 1995. Provide factory fabricated, tested, packaged, and self-contained unit; complete with casing, propeller type fans, heat rejection coils, connecting piping and wiring, and all necessary accessories.

2.3.1.1.7 Air Filters

Provide filters of the cleanable type that are capable of filtering the entire air supply. Mount filter(s) integral within the unit and make accessible by hinged access panel(s). 1 inch MERV 7, provide throwaway filter on all units below 6 Tons.

2.3.1.1.8 Fans

Provide direct driven, statically and dynamically balanced, centrifugal or propeller type fans. Design the outdoor fan so that condensate will evaporate without drip, splash, or spray on building exterior. Provide indoor fan with a minimum two-speed motor with built-in overload protection. Fan motors must be the inherently protected, permanent split-capacitor type.

2.4 COMPONENTS

2.4.1 Refrigerant and Oil

Refrigerant must be one of the fluorocarbon gases. Refrigerants must have

number designations and safety classifications in accordance with [ASHRAE 15 & 34](#). Refrigerants must meet the requirements of [AHRI 700](#) as a minimum. Provide a complete charge of refrigerant for the installed system as recommended by the manufacturer. Lubricating oil must be of a type and grade recommended by the manufacturer for each compressor. Where color leak indicator dye is incorporated, charge must be in accordance with manufacturer's recommendation.

2.4.2 Fans

Fan wheel shafts must be supported by either maintenance-accessible lubricated antifriction block-type bearings, or permanently lubricated ball bearings. Unit fans must be selected to produce the [cfm](#) required at the fan total pressure. Motor starters, if applicable, must be magnetic across-the-line type with a opendriprooof enclosure. Thermal overload protection must be of the manual or automatic-reset type. Fan wheels or propellers must be constructed of aluminum or galvanized steel. Centrifugal fan wheel housings must be of galvanized steel, and both centrifugal and propeller fan casings must be constructed of aluminum or galvanized steel. Steel elements of fans, except fan shafts, must 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 must be recoated with an approved zinc-rich compound. Fan wheels or propellers must be statically and dynamically balanced. Direct-drive fan motors must be of the multiple-speed variety. The sheave size must 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 must be provided with streamlined orifice inlet and V-belt drive. Each drive will be independent of any other drive. Propeller fans must be irect-drive drive type with fixed pitch blades. V-belt driven fans must 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 must be protected with water slingers or shields. V-belt drives must be fitted with guards where exposed to contact by personnel and fixed pitch sheaves.

2.4.3 Air Filters

Provide filters to filter outside air and return air and locate as indicated. Provide cleanable (reusable) type. Filters must conform to [UL 900](#), Class 1 or Class 2. Polyurethane filters cannot be used on units with multiframe filters.

Air filters must 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 must be as listed under the label service and must meet the requirements of [UL 586](#).

2.4.4 Cabinet Construction

Casings for the specified unitary equipment must be constructed of galvanized steel or aluminum sheet metal and galvanized or aluminum structural members. Minimum thickness of single wall exterior surfaces must be [18 gauge](#) galvanized steel or [0.071 inch](#) thick aluminum on units with a capacity above [20 tons](#) and [20 gauge](#) galvanized steel or [0.064 inch](#) thick aluminum on units with a capacity less than [20 tons](#). Casing must 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 must be 20 gauge. Provisions to permit replacement of major unit components must be incorporated. Penetrations of cabinet surfaces, including the floor, must be sealed. Unit must be fitted with a drain pan which extends under all areas where water may accumulate. Drain pan must be fabricated from Type 300 stainless steel, galvanized steel with protective coating as required, or an approved plastic material. Pan insulation must be water impervious. Extent and effectiveness of the insulation of unit air containment surfaces must 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 must conform to ASTM C1071. Paint and finishes must comply with the requirements specified in paragraph FACTORY COATING.

2.4.4.1 Indoor Cabinet

Indoor cabinets must be suitable for the specified indoor service and enclose all unit components.

2.4.4.2 Outdoor Cabinet

Outdoor cabinets must 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.

2.4.5 Refrigerant Piping

Provide refrigerant piping in accordance with Section 23 23 00 REFRIGERANT PIPING.

2.4.6 Condensate Drain Piping

provide condensate drain piping in accordance with Section 23 05 15 COMMON PIPING FOR HVAC.

2.4.7 Ductwork

Provide ductwork in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.4.8 Temperature Controls

Temperature controls shall be in accordance with Section 23 09 23.02 BACnet DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

2.5 FINISHES

2.5.1 Equipment and Components Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish, except that items located outside of buildings must have weather resistant finishes that will withstand 125 hours exposure to the

salt spray test specified in [ASTM B117](#) using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond [1/8 inch](#) on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to [ASTM D520](#), Type I.

Where stipulated in equipment specifications of this section, coat finned tube coils of the affected equipment as specified below. Apply coating at the premises of a company specializing in such work. Degrease and prepare for coating in accordance with the coating applicator's procedures for the type of metals involved. Completed coating must show no evidence of softening, blistering, cracking, crazing, flaking, loss of adhesion, or "bridging" between the fins.

2.5.2 Factory Applied Insulation

Refrigeration equipment must 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 must be provided on the cold-gas inlet connection to the motor in accordance with manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors must 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 must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes must be determined by [ASTM E84](#). Insulation must 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 must be tested as a composite material. Jackets, facings, and adhesives must have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with [ASTM E84](#).

2.6 TESTS, INSPECTIONS, AND VERIFICATIONS

All manufactured units must be inspected and tested, and documentation provided to demonstrate that each unit is in compliance with ANSI/AHRI and UL requirements and that the minimum efficiency requirements of [ASHRAE 90.1 - IP](#) have been met.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform Verification of Dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Perform work 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 D1](#) and [ASME BPVC SEC IX](#), the design, fabrication, and installation of the system must conform to [ASME BPVC SEC VIII D1](#) and [ASME BPVC SEC IX](#).

3.2.1 Equipment

Provide refrigeration equipment conforming to **ASHRAE 15 & 34**. Provide necessary supports for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, and similar items. Isolate compressors from the building structure. If mechanical vibration isolators are not provided, provide vibration absorbing foundations. Each foundation must include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment must be set on not less than a **6 inch** concrete pad doweled in place. Concrete foundations for floor mounted pumps must 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 must be of mass not less than three times the combined pump, motor, and base weights. Isolators must be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Provide foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations must be as specified in Section **03 30 00** CAST-IN-PLACE CONCRETE. Equipment must be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.2.2 Field Applied Insulation

Apply field applied insulation as specified in Section **23 07 00** THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.2.3 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section **09 90 00** PAINTS AND COATINGS.

3.3 CLEANING AND ADJUSTING

Equipment must be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters must be provided for all fans that are operated during construction, and new filters must be installed after all construction dirt has been removed from the building. System must be maintained in this clean condition until final acceptance. Bearings must be properly lubricated with oil or grease as recommended by the manufacturer. Belts must be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment must be adjusted to setting indicated or directed. Fans must be adjusted to the speed indicated by the manufacturer to meet specified conditions. Testing, adjusting, and balancing must be as specified in Section **23 05 93** TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.4 TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total **2** hours of normal working time and start after the system is functionally completed but prior to final acceptance tests.

- a. Submit a schedule, at least weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.
- c. The posted instructions must cover all of the items contained in the approved [operation and maintenance manuals](#) as well as demonstrations of routine maintenance operations.
- d. Submit routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.5 [REFRIGERANT TESTS, CHARGING, AND START-UP](#)

Split-system refrigerant piping systems must be tested and charged as specified in Section [23 23 00](#) REFRIGERANT PIPING. Packaged refrigerant systems which are factory charged must be checked for refrigerant and oil capacity to verify proper refrigerant levels in accordance with manufacturer's recommendations. Following charging, packaged systems must be tested for leaks with a halide torch or an electronic leak detector. Submit 6 copies of each test containing the information described below in bound [8-1/2 by 11 inch](#) booklets. Individual reports must be submitted for the refrigerant system tests.

- 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.

3.5.1 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system must immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. Under no circumstances must the refrigerant be discharged into the atmosphere.

3.5.2 Contractor's Responsibility

Take steps, at all times during the installation and testing of the refrigeration system, to prevent the release of refrigerants into the atmosphere. The steps must 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 must more than [3 ounces](#) of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year must 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.

3.6 MAINTENANCE

3.6.1 Maintenance Service

Submit a certified list of qualified permanent [service organizations](#), which includes their addresses and qualifications, for support of the equipment. The service organizations must 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.

-- End of Section --

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SECTION 25 05 11.01

CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS BUILDING AUTOMATION / MANAGEMENT SYSTEM

PART 1 GENERAL

Many subparts in this Section contain text in curly braces ("{" and "}") indicating which cybersecurity control and control correlation identifier (CCI) the requirements of the subpart relate to. The text inside these curly braces is for Government reference only and enables coordination of the requirements of this Section with the RMF process throughout the design and construction process. Text in curly braces are not contractor requirements.

This Section refers to Security Requirements Guide (SRGs) and Security Technical Implementation Guide (STIGs). STIGs and SRGs are available online at the Information Assurance Support Environment (IASE) website at <https://public.cyber.mil/stigs/downloads/> and an SRG/STIG Applicability Guide and Collection Tool is available at <https://public.cyber.mil/stigs/SCAP/>. Not all control system components have applicable STIGs or SRGs. The "Control Systems SRG" does not apply to work performed under this Section; all requirements within this section to apply applicable SRGs DO NOT include the "Control Systems SRG".

1.1 CONTROL SYSTEM APPLICABILITY

There are multiple versions of this Section associated with this project. Different versions have requirements applicable to different control systems. This specific Section applies only to the following control systems: **Building Automation / Management System**.

1.2 RELATED REQUIREMENTS

This section does not contain sufficient requirements to procure a control system and must be used in conjunction with other Sections which specify control systems. This Section adds cybersecurity requirements to the control systems specified in other Sections, and as these requirements are conditioned on the control system being provided, there may be requirements in this Section that will not apply to this project. All Sections containing facility-related control systems or control system components are related to the requirements of this Section. Review all specification sections to determine related requirements.

In cases where a requirement is specified in both this Section and in another Section, the more stringent requirement must be met. In cases where a requirement in this Section conflicts with the requirements of another Section such that both requirements cannot be met at the same time, request direction from the Contracting Officer Representative to determine which requirement applies to the project.

1.3 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 OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135 (2020; Interpretation 1-8 2021; Errata 1-2 2021; Addenda CD 2021; Addenda BY-CE 2022; Interpretation 9-10 2022) BACnet—A Data Communication Protocol for Building Automation and Control Networks

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.1x (2010) Local and Metropolitan Area Networks - Port Based Network Access Control

INTERNET ENGINEERING TASK FORCE (IETF)

IETF RFC 2819 (2000) Remote Network Monitoring (RMON) Management Information Base (MIB)

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST FIPS 140-2 (2001) Security Requirements for Cryptographic Modules

NIST FIPS 201-2 (2013) Personal Identity Verification (PIV) of Federal Employees and Contractors

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 8551.01 (2014) Ports, Protocols, and Services Management (PPSM)

DTM 08-060 (2008) Policy on Use of Department of Defense (DoD) Information Systems - Standard Consent Banner and User Agreement

1.4 DEFINITIONS

1.4.1 Administrator Account

An administrator account is an account with full permissions to a device, application, or operating system, including the ability to create and modify other user accounts.

Note that the operating system Administrator Account may be different than Administrator Accounts for applications hosted on that operating system. Also, most controllers will not have any support for accounts and will therefore not have an 'Administrator Account'.

1.4.2 Computer

A computer is one of the following:

- a. a device running a non-embedded desktop or server version of Microsoft Windows
- b. a device running a non-embedded version of MacOS
- c. a device running a non-embedded version of Linux
- d. a device running a version or derivative of the Android Operating System, where Android is considered separate from Linux
- e. a device running a version of Apple iOS

Unless otherwise indicated or clear from context use of the word "device" in this Section includes computers.

1.4.3 Controller

A device other than a computer or Ethernet switch.

1.4.4 Mission Space

A device or media is in mission space if physical access to the device or media is controlled by the organization served by the device. For example, a VAV box controller in a suspended ceiling is in mission space if the VAV box serves that room; an electrical switchgear in an electrical room or an AHU in a mechanical room or on a rooftop may still be considered to be in mission space if the organization (mission) served by that switchgear or AHU controls access to the electrical room, mechanical room or rooftop.

1.4.5 Network

A network is a group of two or more devices that can communicate using a network protocol. Network protocols must provide a method for addressing devices on the network; a communication method that does not provide an addressing scheme is not a networked form of communication. Devices that communicate using a method of communication that does not support device addressing are not using a network.

1.4.6 Network Connected

A component is network connected (or "connected to a network") only when the device has a network transceiver which is directly connected to the network and implements the network protocol. A device lacking a network transceiver (and accompanying protocol implementation) can never be considered network connected. Note that (unlike many IT definitions of "Network Connected") a device connected to a non-IP network is still considered network connected (an IP connection or IP address is not required for a device to be network connected).

1.4.6.1 Wireless Network Connected

Any device that supports wireless network communication is network connected to a wireless network, regardless of whether the device is communicating using wireless. Unless physically disabled, devices with wireless transceivers support wireless, it is not sufficient to disable the wireless in software.

1.4.7 Network Media

The thing that provides the communication channel between the devices on a network. Typically wire, but might include wireless, fiber optic, or even power line (some network protocols allow sending network signals over power wiring).

1.4.8 User Account Support Levels

The support for user accounts is categorized in this Section as one of three levels:

1.4.8.1 FULLY Supported

Device supports configurable individual accounts. Accounts can be created, deleted, modified, etc. Privileges can be assigned to accounts. These devices support user-based (as opposed to role-based) authentication.

1.4.8.2 MINIMALLY Supported

Device supports a small, fixed number of accounts (perhaps only one). Accounts cannot be modified. A device with only a "User" and an "Administrator" account would fit this category. Similarly, a device with two PINs for logon - one for restricted and one for unrestricted rights would fit here (in other words, the accounts do not have to be the traditional "username and password" structure). These devices typically only support role-based authentication.

Examples of devices which MINIMALLY support accounts are a) a variable frequency drive with a single account which requires a PIN for access to configuration; and b) a room lighting control touchpad interface that has a single account.

1.4.8.3 NOT Supported

Device does not support any Access Enforcement therefore the whole concept of "account" is meaningless.

1.4.9 Manual Local Input

Manual Local Inputs are system analog or binary inputs that are adjustable by a person but are, by intrinsic hardware design, very limited in potential capabilities. Manual Local Inputs do not have touch screens or full keyboards, but may have a few buttons or dials to allow input. Manual Local Inputs do not have full graphic screens or dot-matrix displays, but may have simple lights (LEDs) or 7-segment displays. Manual Local Inputs do not have any sort of menu structure, each button has a single well-defined function.

Examples of Manual Local Inputs are H-O-A switches, simple thermostats, and disconnect switches.

1.4.10 Card Reader

A card reader is an input/output device whose primary function is to assist in two-factor authentication. A card reader must have an interface to read data from a card and may be able to write data to a card. A card reader may have a means (such as buttons, keypad, touchscreen, etc.) for a

user to input a PIN or password, as well as a limited display.

1.4.11 User Interface

A User Interface (UI) is something other than a Manual Local Input or Card Reader that allows a person to interact with the system or device. Note that while a Card Reader is not by itself a User Interface, a User Interface may contain a Card Reader in order for it to authenticate its user. Within control systems, there are a wide range of User Interfaces.

Two important distinctions are 1) whether the user interface is Local or Remote, and 2) the effective capabilities of the User Interface to alter data, which is the "privilege" of the user interface (where effective privilege available to a specific user at a specific user interface is the combination of the greatest privilege offered by the user interface and the specific account the user is logged into).

1.4.11.1 Local User Interface

A Local User Interface is a user interface where the physical hardware the user interacts with (keyboard, buttons, display, etc.) is physically part of the device being affected. All of the relevant characteristics of the user interface are embodied within a single device.

Note that a Local UI may be able to access data in a different device, Local versus Remote in this context refers to the user interface itself; the capability to access data in a different device is covered under "Full User Interface".

1.4.11.2 Remote User Interface

A Remote User Interface implements a Client/Server model where the physical hardware the user interacts with (Client) is physically distinct from the device being affected (Server). Most or all of the security and functionality characteristics of the user interface are defined by the Server, not the Client. The Client and Server communicate via a network connection. A common example of a remote user interface is a web-based interface where the browser (client) is generally on different hardware than the web server (server). A Remote UI remains a Remote UI even if the user happens to be at a Client on the same hardware as the Server. What is important is that a) the Client may be on different hardware than the Server and b) the majority of the security and functional characteristics of the interface are defined at the Server.

Note that this definition of "remote" is consistent with that generally used in the control industry but is not aligned with the NIST 800-53 definition of "Remote", which refers to "outside the system". The term "Remote" here better aligns with the NIST 800-53 definition of "Network" (remote from within the system) Access.

1.4.11.3 Types of User Interface (by capability)

User interfaces are also categorized by their capabilities as being Read Only, Limited, or Full.

1.4.11.3.1 Read-Only User Interface

A Read Only User Interface (also referred to as a View-Only User Interface) is a user interface that only allows for reading data, it does

not allow (have the capability to) modify data. A Read Only User Interface may be either Local or Remote. A User Interface that is configured to be Read Only (by some other means than the interface itself, such as using configuration software on a laptop) is a Read-Only Interface. Note a Read Only User Interface may have buttons (or touch screen, etc.) allowing the user to navigate through the presentation of data.

Examples of a Read Only User Interfaces are a) a publicly viewable "energy dashboard" showing weather data and energy usage within a building and b) digital wayfinding signage.

1.4.11.3.2 Limited User Interface

A Limited User Interface is a user interface that - by design - can only alter information local to the user interface. Note that the determination of "alter" includes only direct interactions, it explicitly excludes interactions that might occur as secondary effects. For example, an interface changing the flow setpoint in a pump controller is a direct interaction, the subsequent change in flow (as well as any subsequent downstream changes in valve position) are not direct interactions.

Two examples of LIMITED UIs are: a) a variable speed drive has a Limited Local User Interface which allows the user to change properties within the drive, but does not allow affecting things outside the drive; and b) a typical home WiFi Router has a Limited Remote User Interface which allows configuration of the Router, but does not allow direct interaction with other devices.

1.4.11.3.3 Full User Interface

A Full User Interface can alter information in devices outside the device with the user interface. For example, a typical Local Display Panel is a Full Local User Interface while a browser-based front end is a Full Remote User Interface.

1.4.11.3.4 View-Only User Interface

See Read-Only User Interface

1.4.11.4 Other User Interface Terminology

In addition to defining whether a user interface is a Hardware Limited, Read-Only, Limited or Full, and whether it is Local or Remote, user interfaces are classified by whether they are writable or privileged.

1.4.11.4.1 Writable User Interface

Any User Interface that is not Read-Only is Writable. (Limited User Interfaces and Full User Interfaces are both writable user interfaces (as they are capable of changing a value)).

1.4.11.4.2 Privileged User Interface

A Privileged UI is a UI that has sufficient capabilities or functionality that it requires specific cybersecurity measures to be put in place to limit its unauthorized use. Ultimately, whether a specific user interface is considered a Privileged User Interface must be determined by usage. Unless otherwise specified, user interfaces can be determined to be

privileged or not using the following:

- a. Read-Only User Interfaces are not privileged user interfaces.
- b. Full User Interfaces are privileged user interfaces.
- c. User interfaces that allow for configuration of auditing or allows for modification or deletion of audit logs are privileged user interface.
- d. User interfaces that allow for reprogramming a network connected device is a privileged user interface.
- e. Except as specified above, a Limited User Interface must be determined to be privileged or not based on the specific capabilities and use case of the user interface. In general however, user interfaces that do not offer significant capabilities above and beyond those available at that location via other means (e.g. such as a disconnect switch, breaker, or hand-off-auto switch, or physical attack) are not privileged.

1.4.12 Wireless Network

Any network that communicates without using wires or fiber optics as the communication media. Wireless networks include: WiFi, Bluetooth, ZigBee, cellular, satellite, 900 MHz radio, 2.4 GHz, free space optical, point-to-point laser, and IR.

1.4.13 Wired Broadcast Network

Wired Broadcast Networks are any network, such as powerline carrier networks and modem (wired telephony), that use wire-based technologies where there is not a clearly defined boundary for signal propagation.

1.5 ADMINISTRATIVE REQUIREMENTS

1.5.1 Points of Contact

Coordinate with the following Points of Contact as indicated in this Section and as required. Not all projects will require coordination with all Points of Contact. When coordination is required and no Point of Contact is indicated, coordinate with The Contracting Office Representative (COR).

- a. Government Computer Access Point of Contact: The Contracting Office Representative (COR)
- b. HTTPS Certificate Point of Contact: The Contracting Office Representative (COR)
- c. Email Address Point of Contact: The Contracting Office Representative (COR)
- d. Password Point of Contact: The Contracting Office Representative (COR)
- e. Mobile Code Point of Contact: The Contracting Office Representative (COR)
- f. PKI Infrastructure Point of Contact: The Contracting Office Representative (COR)

1.5.2 Coordination

Coordinate the execution of this Section with the execution of all other Sections related to control systems as indicated in the paragraph RELATED REQUIREMENTS. Items that must be considered when coordinating project efforts include but are not limited to:

- a. If requesting permission for wireless or wired broadcast communication, the Wireless and Wired Broadcast Communication Request submittal must be approved prior to control system device selection and installation.
- b. If requesting permission for alternate account lock permissions, the Device Account Lock Exception Request must be approved prior to control system device selection and installation.
- c. If requesting permission for the use of a device with multiple physical connections to IP networks, the Multiple IP Connection Device Request must be approved prior to control system device selection and installation.
- d. Wireless testing may be required as part of the control system testing. See requirements for the Wireless Communication Test Report submittal.
- e. If the Device Audit Record Upload Software is to be installed on a computer not being provided as part of the control system, coordination is required to identify the computer on which to install the software.
- f. The Cybersecurity Interconnection Schedule must be coordinated with other work that will be interconnected to, and interconnections must be approved by the Government before relying on them for system functionality.
- g. Cybersecurity testing support must be coordinated across control systems and with the Government cybersecurity testing schedule.
- h. Passwords must be coordinated with the indicated contact for the project site.
- i. If applicable, HTTPS web server certificates must be obtained from the indicated HTTPS Certificate Point of Contact.
- j. Contractor Computer Cybersecurity Compliance Statements must be provided for each contractor using contractor owned computers.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00.00 06 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals
Wireless and Wired Broadcast Communication Request; G

Device Account Lock Exception Request; G

Multiple Ethernet Connection Device Request; G

Contractor Computer Cybersecurity Compliance Statements; G

Contractor Temporary Network Cybersecurity Compliance Statements; G

Cybersecurity Interconnection Schedule; G

Proposed STIG and SRG Applicability Report; G

SD-02 Shop Drawings

Network Communication Report; G

Cybersecurity Riser Diagram; G

SD-03 Product Data

Control System Cybersecurity Documentation; G

SD-06 Test Reports

Wireless Communication Test Report; G

Control System Cybersecurity Testing Procedures; G

Control System Cybersecurity Testing Report; G

SD-07 Certificates

Software Licenses; G

SD-11 Closeout Submittals

Password Change Summary Report; G

Enclosure Keys; G

Software and Configuration Backups; G

Auditing Front End Software; G

Device Audit Record Upload Software; G

System Maintenance Tool Software; G

Control System Scanning Tools; G

STIG, SRG and Vendor Guide Compliance Result Report; G

Control System Inventory Report; G

1.7 CYBERSECURITY DOCUMENTATION

{For Government Reference Only: This subpart (and its subparts) relates to PL-7; CCI-003071}

1.7.1 Proposed STIG and SRG Applicability Report

For each model of network connected or network infrastructure device, use the DISA SRG/STIG Applicability Guide and Collection Tool (available at <https://public.cyber.mil/stigs/SCAP/>) to identify applicable STIGs or SRGs and provide a report indicating applicable STIGs and SRGs for each model.

1.7.2 Cybersecurity Interconnection Schedule

{For Government Reference Only: This subpart relates to CA-3(b), PL-8, SC-7(9), SC-7(11); CCI-000258, CCI-003072, CCI-003073, CCI-003075, CCI-002398, CCI-002399, CCI-002401, CCI-002402, CCI-002403.}

Provide a completed Cybersecurity Interconnection Schedule documenting network connections between the installed system and other systems. Provide the following information for each device directly communicating between systems: Device Identifier, Device Description, Transport layer Protocol, Network Address, Port (if applicable), MAC (Layer 2) address (if applicable), Media, Application Protocol, Service (if applicable), Descriptive Purpose of communication. For communication with other authorized systems also provide the Foreign Destination and POC for Destination. If other control system Sections used on this project include submittals documenting this information, provide copies of those submittals to meet this requirement.

In addition to the requirements of Section 01 33 00.00 06 SUBMITTAL PROCEDURES, provide the Cybersecurity Interconnection Schedule as an editable Microsoft Excel file (a template Cybersecurity Interconnection Schedule in Excel format is available at <https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1>

1.7.3 Network Communication Report

{For Government Reference Only: This subpart (and its subparts) relates to CA-9, PL-8; CCI-002102, CCI-002103, CCI-002104, CCI-002105, CCI-003072, CCI-003073, CCI-003075 and also the submittal requirements associated with CM-6, CM-7, SC-8 and SC-41 including CM-7(3), CCI-000388.}

Provide a network communication report. For each networked device, document the communication characteristics of the device including communication protocols, services used, encryption employed, and a general description of what information is communicated over the network. For each device using IP, document all TCP and UDP ports used. For non-IP communications, document communication protocol and media used. If other control system Sections used on this project include submittals documenting this information, provide copies of those submittals to meet this requirement.

In addition to the requirements of Section 01 33 00.00 06 SUBMITTAL PROCEDURES, provide the Network Communication Report as an editable Microsoft Excel file.

1.7.4 Control System Inventory Report

{For Government Reference Only: This subpart (and its subparts) relates to CM-8(a), SI-17, IA-3; CCI-000389, CCI-000392, CCI-000398, CCI-002773, CCI-002774, CCI-002775, CCI-000777, CCI-000778, CCI-001958}

Provide a Control System Inventory report using the Inventory Spreadsheet listed under this Section at

<https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1>

documenting all devices, including networked devices, network infrastructure devices, non-networked devices, input devices (e.g. sensors) and output devices (e.g. actuators). For each device provide all applicable information for which there is a field on the spreadsheet in accordance with the instructions on the spreadsheet.

In addition to the requirements of Section 01 33 00.00 06 SUBMITTAL PROCEDURES, provide the Control System Inventory Report as an editable Microsoft Excel file.

1.7.5 Software and Configuration Backups

{For Government Reference Only: This subpart (and its subparts) relates to CP-10; CCI-000550, CCI-000551, CCI-000552}

For each computer on which software is installed under this project, provide a recovery image of the final as-built computer. This image must allow for bare-metal restore such that restoration of the image is sufficient to restore system operation to the imaged state without the need for re-installation of software. If additional user permissions are required to meet this requirement, coordinate the creation of the image with the identified Government Computer Access Point of Contact.

For all ethernet switches provide a backup of the switch configuration. For all controllers, provide a backup of the controller configuration and the source code for all loaded application programs (all software that is not common to every controller of the same manufacturer and model).

If any or all of these are provided under another Section, provide documentation indicating this and referencing those submittals.

1.7.6 Cybersecurity Riser Diagram

{For Government Reference Only: This subpart (and its subparts) relates to PL-2(a), PL-8; CCI-003051, CCI-003053, CCI-003072, CCI-003073, CCI-003075}

Provide a cybersecurity riser diagram of the complete control system including all network and device hardware. If the control system specifications require a riser diagram submittal, provide a copy of that submittal as the cybersecurity riser diagram. Otherwise, provide a riser diagram in one-line format.

1.7.7 STIG, SRG and Vendor Guide Compliance Result Report

For every component (device or software) with an applicable STIG or SRG in the Proposed STIG and SRG Applicability Report, provide a result report documenting compliance with the STIG or SRG requirements. For components which are scannable by the SCAP (security content automation protocol) tool (available online at <https://public.cyber.mil/stigs/scap>), provide the SCAP report and raw scan results.

For every component (device or software) with manufacturer provided cybersecurity documentation, procedure, or method for secure configuration or installation, provide a report documenting how the component was

configured and any deviation from the manufacturer instructions.

1.7.8 Control System Cybersecurity Documentation

{For Government Reference Only: This subpart (and its subparts) relates to SA-5 (a),(b),(c); CCIs: CCI-003124, CCI-003125, CCI-003126, CCI-003127, CCI-003128, CCI-003129, CCI-003130, CCI-003131}

Provide a Control System Cybersecurity Documentation submittal containing the indicated information for each device and software application.

1.7.8.1 Software Applications

For all software applications running on computers provide:

- a. administrator documentation that describes secure configuration of the software {For Government Reference Only: relates to CCI-003124}
- b. administrator documentation that describes secure installation of the software {For Government Reference Only: relates to CCI-003125}
- c. administrator documentation that describes secure operation of the software {For Government Reference Only: relates to CCI-003124}
- d. administrator documentation that describes effective use and maintenance of security functions or mechanisms for the software {For Government Reference Only: relates to CCI-003127}
- e. administrator documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the software {For Government Reference Only: relates to CCI-003128}
- f. user documentation that describes user-accessible security functions or mechanisms in the software and how to effectively use those security functions or mechanisms {For Government Reference Only: relates to CCI-003129}
- g. user documentation that describes methods for user interaction which enables individuals to use the software in a more secure manner {For Government Reference Only: relates to CCI-003130}
- h. user documentation that describes user responsibilities in maintaining the security of the software {For Government Reference Only: relates to CCI-003131}

1.7.8.2 For HVAC Control System Devices

1.7.8.2.1 HVAC Control System Devices FULLY Supporting User Accounts

For all HVAC Control System Devices which FULLY support user accounts, provide:

- a. Documentation that describes secure configuration of the device {For Government Reference Only: relates to CCI-003124}
- b. Documentation that describes secure operation of the device {For Government Reference Only: relates to CCI-003124}

- c. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {For Government Reference Only: relates to CCI-003127}
- d. Documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the device {For Government Reference Only: relates to CCI-003128}
- e. Documentation that describes user-accessible security functions or mechanisms in the device and how to effectively use those security functions or mechanisms; or a specific indication that there are no user-accessible security functions or mechanisms in the device {For Government Reference Only: relates to CCI-003129}
- f. Documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {For Government Reference Only: relates to CCI-003130}

1.7.8.2.2 All Other HVAC Control System Devices

For all HVAC Control System Devices which do not FULLY support user accounts, provide:

- a. Documentation that describes secure configuration of the device; or a specific indication that there are no secure configuration steps that apply {For Government Reference Only: relates to CCI-003124}
- b. Documentation that describes effective use and maintenance of security functions or mechanisms for the device; or a specific indication that there are no security functions or mechanisms in the device {For Government Reference Only: relates to CCI-003127}
- c. For devices which include a user interface, documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {For Government Reference Only: relates to CCI-003130}

1.7.8.3 Default Requirements for Control System Devices

For control system devices where Control System Cybersecurity Documentation requirements are not otherwise indicated in this Section, provide:

- a. Documentation that describes secure configuration of the device {For Government Reference Only: relates to CCI-003124}
- b. Documentation that describes secure installation of the device {For Government Reference Only: relates to CCI-003125}
- c. Documentation that describes secure operation of the device {For Government Reference Only: relates to CCI-003124}
- d. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {For Government Reference Only: relates to CCI-003127}
- e. Documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the device {For Government Reference Only: relates to CCI-003128}

- f. Documentation that describes user-accessible security functions or mechanisms in the device and how to effectively use those security functions or mechanisms {For Government Reference Only: relates to CCI-003129}
- g. Documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {For Government Reference Only: relates to CCI-003130}
- h. Documentation that describes user responsibilities in maintaining the security of the device {For Government Reference Only: relates to CCI-003131}

1.8 SOFTWARE LICENSING

{For Government Reference Only: This subpart (and its subparts) relates to SI-2(a), SI-2(c), SI-7(14); CCI-001227, CCI-002605, CCI-002737}

For all software provided that has not already been licensed to the government or project site, provide a license to the project site for a period of no less than 5 years, and the license must also include the following software updates:

- a. Security and bug-fix patches issued by the software manufacturer.
- b. Security patches to address any vulnerability identified in the National Vulnerability Database at <http://nvd.nist.gov> with a Common Vulnerability Scoring System (CVSS) severity rating of MEDIUM or higher.

Provide a single [Software Licenses](#) submittal with documentation of the software licenses for all software provided

1.9 CYBERSECURITY DURING CONSTRUCTION

{For Government Reference Only: This subpart (and its subparts) relates to AC-18, SA-3; CCI-000258}

In addition to the control system cybersecurity requirements indicated in this section, meet following requirement throughout the construction process.

1.9.1 Contractor Computer Equipment

Contractor owned computers may be used for construction. Contractor computers connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.9.1.1 Operating System

The operating system must be an operating system currently supported by the manufacturer of the operating system. The operating system must be current on security patches and operating system manufacturer required updates.

1.9.1.2 Anti-Malware Software

The computer must run anti-malware software from a reputable software manufacturer. Anti-malware software must be a version currently supported by the software manufacturer, must be current on all patches and updates, and must use the latest definitions file. Computers used on this project must be scanned using the installed software at least once per day.

1.9.1.3 Passwords and Passphrases

The passwords and passphrases for computers, applications, and web-based applications supporting passwords must be changed from their default values. Passwords must be a minimum of eight characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.9.1.4 User-Based Authentication

Each user must have a unique account; sharing of a single account between multiple users is prohibited.

1.9.1.5 Demonstration of Compliance

The Government has the right to require demonstration of computer compliance with these requirements at any time during the project.

1.9.1.6 Contractor Computer Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Computer Cybersecurity Compliance Statements for each company using contractor owned computers. Contractor Computer Cybersecurity Compliance Statements must use the template published at

<https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1>
Each Statement must be signed by a cybersecurity representative for the relevant company.

1.9.2 Temporary IP Networks

Temporary contractor-installed IP networks may be used during construction. When used, temporary contractor-installed IP networks connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.9.2.1 Network Boundaries and Connections

The network must not extend outside the project site and must not connect to any IP network other than those specifically provided or furnished for this project. Any and all access to the network from outside the project site is prohibited.

1.9.3 Government Access to Network

Government personnel must be allowed to have complete and immediate access to the network at any time in order to verify compliance with this specification.

1.9.4 Temporary Wireless IP Networks

In addition to the other requirements on temporary IP networks, temporary wireless IP (WiFi) networks, when permitted, must not interfere with existing wireless networks, must use WPA2 security and must not broadcast the network name (SSID). Network names (SSID) for wireless networks must be changed from their default values.

1.9.5 Passwords and Passphrases

The passwords and passphrases for all network devices and network access must be changed from their default values. Passwords must be a minimum 8 characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.9.6 Contractor Temporary Network Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Temporary Network Cybersecurity Compliance Statements for each company implementing a temporary IP network. Contractor Temporary Network Cybersecurity Compliance Statements must use the template published at <https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1> Each Statement must be signed by a cybersecurity representative for the relevant company. If no temporary IP networks will be used, provide a single copy of the Statement indicating this.

1.10 CYBERSECURITY DURING WARRANTY PERIOD

All work performed on the control system after acceptance must be performed using Government Furnished Equipment or equipment specifically and individually approved by the Government.

PART 2 PRODUCTS

All products used on this project must meet the indicated requirements, but not all products specified here will be required by every project.

2.1 ETHERNET SWITCH

Provide Open Systems Interconnection (OSI) Layer 2 Ethernet switches with the following capabilities, and with an interface to support switch configuration for these capabilities:

2.1.1 Required Functionality

Switches must:

- a. Copper Ethernet ports must auto negotiate for 10, 100 and 1000 megabits-per-second links.
- b. Be capable of implementing port level access control by MAC address and limit the number of MAC addresses to one MAC address per port.
- c. For LOW Impact Systems, be capable of implementing per-port access control lists (ACLs) where the list can be filtered by source and destination IP addresses, and by source and destination UDP or TCP ports.
- d. Support Remote Network Monitoring (RMON) Port Analysis in accordance

with IETF RFC 2819

- e. Configure target port and analysis port such that switch clones all target port traffic to analysis port.
- f. Support authentication via RADIUS server (for management and 802.1x)
- g. Support IEEE 802.1x network login.

2.1.2 Configuration Requirements

Switches must:

- a. Support configuration save and restore.
- b. Support both manual IP address assignment and acquisition of a dynamic IP address via Dynamic Host Configuration Protocol (DHCP).
- c. Be capable of limiting access for configuration to one or more of: a web interface using HTTPS, a command line interface using SSH, or an SNMP connection using SNMP version 3 or later.
- d. Support the ability to lock configuration capability to a dedicated management port.

2.2 DAISY CHAIN IP CONTROLLERS

Controllers used as Daisy Chain IP Controllers must be IP controllers with exactly two Ethernet network connections and basic built-in switch capabilities to allow implementation of an Ethernet network in a daisy chain architecture. Switches incorporated by Daisy Chain IP Controllers are not required to meet the requirements for Ethernet Switches as defined in this Section.

PART 3 EXECUTION

3.1 CYBERSECURITY HARDENING AND CONFIGURATION GUIDES

Install, configure, and harden all hardware and software furnished on this project in accordance with manufacturer provided documentation, procedures, or methods for secure configuration or installation. Do not implement specific hardening actions if that action would conflict with required functionality or another requirement of this Section.

3.2 NETWORK REQUIREMENTS

3.2.1 Wireless and Wired Broadcast Communication

{For Government Reference Only: This subpart (and its subparts) relates to AC-18, AC-18(3); CCI-001438, CCI-001439, CCI-002323, CCI-001441, CCI-002252}

Unless explicitly authorized by the Government, do not use any wireless or wired broadcast communication. If requesting authorization for wireless or wired broadcast communication, wired broadcast media such as powerline carrier is preferred to wireless.

3.2.1.1 Wireless and Wired Broadcast IP Communications

Unless specifically approved and installed in accordance with the project site requirements, do not install wireless or wired broadcast IP networks, including: do not install a wireless access point; do not install or configure an ad-hoc wireless network; do not install or configure a WiFi Direct communication.

When explicitly authorized by the Government, wireless IP communication may be used to communicate with an existing wireless network.

3.2.1.2 Non-IP Wireless Communication

For LOW Impact Systems: When non-IP wireless communication is explicitly authorized by the Government, use the maximum level of encryption supported by the specific protocol employed and select signal strength and radiated power to the minimum necessary for reliable communication.

3.2.1.3 Wireless and Wired Broadcast Communication Request

Provide a report documenting the proposed use of wireless or wired broadcast communication prior to device selection using the Wireless and Wired Broadcast Communication Request Schedule at <https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1>. If there is no proposed use of wireless or wired broadcast communication, provide a document indicating this instead of the Request Schedule.

For each device proposed to use wireless or wired broadcast communication show: the device identifier, a description of the device, the location of the device, the device identifiers of other devices communicating with the device, the protocol used for communication, encryption type and strength. For wireless communication, also show: RF Frequency, Radiated Power in dBm (decibel with a milliwatt reference), free-space range, and the expected as-installed range.

3.2.1.4 Wireless Communication Testing

As part of Functional Performance Testing {FPT}, conduct testing of wireless communication for all devices indicated on the approved Wireless and Wired Broadcast Communication Request as requiring testing.

To test wireless communication, test for wireless network reception at multiple points along the wireless test boundary in the vicinity of the wireless device, and record whether a network connection can be established at each point. The wireless test boundary is the building exterior walls. If wireless testing is required, provide a [Wireless Communication Test Report](#) documenting the testing points and results at each point for each wireless device.

3.2.2 Non-IP Control Networks

When control system specifications require particular communication protocols, use only those communication protocols and only as specified. Do not implement any other communication protocol.

When control system specifications do not indicate requirements for communication protocols, use only those protocols required for operation of the system as specified.

3.2.3 IP Control Networks

{For Government Reference Only: This subpart relates to CM-6(a), CM-7(a), CM-7(b), CM-7(1)(b), SC-41; CCI-001588, CCI-000381, CCI-000380, CCI-000381, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546.}

IP Networks must be Ethernet networks and must use switches which are Ethernet Switches or Daisy Chain IP Controllers as defined in this Section. Do not use nonsecure functions, ports, protocols and services as defined in [DODI 8551.01](#) unless those ports, protocols and services are specifically required by the control system specifications or otherwise specifically authorized by the Government. Do not use ports, protocols and services that are not specified in the control system specifications or required for operation of the control system.

3.2.3.1 IP Network Routers

Do not install any device that performs IP routing.

3.2.3.2 IP Devices With Multiple Ethernet Connection

Except for Ethernet Switches and Daisy Chain IP Controllers, devices must not have more than one Ethernet connection to IP networks unless doing so is required by the project specifications and the specific application is approved. If a device with Multiple Ethernet Connections to IP networks is required, provide a [Multiple Ethernet Connection Device Request](#) using the Multiple Ethernet Connection Device Request Template at <https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1> to request approval for each device. If a device with Multiple Ethernet Connections to IP networks is not required, instead provide a document stating that no approval is being requested.

3.2.4 Cryptographic Protection

{For Government Reference Only: This subpart relates to IA-2(9), IA-3(1), SC-8, SC-13, SC-23(1), SC-23(3); CCI-001942, CCI-001959, CCI-001967, CCI-002418, CCI-002449, CCI-002450, CCI-001185, CCI-001188, CCI-001664.}

All remote user interfaces must use HTTPS for all traffic between the user interface client and user interface server.

For devices that have STIG/SRGs related to cryptographic protection (CCI-002450), comply with the requirements of those STIG/SRGs. Ensure that all network traffic is encrypted using NSA-approved cryptography; provision of digital signatures and hashing, and FIPS-validated cryptography.

3.2.5 Device Identification and Authentication

{For Government Reference Only: This subpart (and its subparts) relates to IA-3; CCI-000777, CCI-000778, CCI-001958.}

All computers must support and implement [IEEE 802.1x](#) for device authentication to the network.

3.2.5.1 For HVAC Control System Devices

Devices using HTTP as a control protocol must use HTTPS instead. Devices

using Ethernet must support IEEE 802.1x. Devices using Fox Protocol must support IEEE 802.1x. Devices using BACnet must support network security as specified for BACnet Secure Connect in ASHRAE 135.

3.2.5.2 Default Requirements for Control System Devices

For control system devices where Device Identification and Authentication requirements are not otherwise indicated in this Section: Devices using Ethernet must support IEEE 802.1x. Devices using HTTP as a control protocol must use HTTPS instead.

3.2.6 Cryptographic Module Authentication

{For Government Reference Only: This subpart (and its subparts) relates to IA-7; CCI-000803}

For devices (including but not limited to NIST FIPS 140-2 compliant radios) that have STIG/SRGs related to cryptographic module authentication (CCI-000803), comply with the requirements of those STIG/SRGs.

3.3 ACCESS CONTROL REQUIREMENTS

3.3.1 User Accounts

{For Government Reference Only: This subpart (and its subparts) relate to AC-2(a), AC-3, AC-6(1), AC-6(10), AC-6(2), AC-6(9), CM-11(2), and IA-2; CCI-002110, CCI-000213, CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-002235, CCI-000039, CCI-001419, CCI-002234, CCI-001812, and CCI-000764. }

Any user interface supporting user accounts (either FULLY or MINIMALLY) must limit access according to specified limitations for each account. Install and configure any device having a STIG or SRG in accordance with that STIG or SRG.

All user interfaces FULLY supporting accounts must implement user-based authentication where each account is uniquely assigned to a specific user. User interfaces FULLY supporting accounts must implement at least three (3) levels of user account privilege including: 1) an account with read-only permissions 2) an account with full permissions including account creation and modification and 3) an account with greater permissions than read-only but without account creation and modification.

3.3.1.1 Computers

All computer operating systems must FULLY support user accounts and implement accounts for access. Each control system software application not supporting accounts and running on a computer must be installed such that use of the software is restricted by the computer operating system to specific users.

Applications running on computers must not require the user be logged in to a computer operating system administrator account for normal operation. It is permissible to require the computer operating system administrator account for initial application installation and configuration.

3.3.1.2 Controllers

For user interfaces provided by controllers, provide access control in accordance with the User Interface Requirements table for the applicable control system and user interface type.

- a. For table entries of "NA": NA means Not Applicable, there are no interfaces in this category.
- b. For table entries of "None Required": The user interface is not required to support user accounts.
- c. For table entries of "MINIMALLY": The user interface must at least MINIMALLY support user accounts.
- d. For table entries of "FULLY": The user interface must at FULLY support user accounts.
- e. For table entries of "KEY": The user interface must have physical security in the form of either a key lock on the interface itself or be furnished inside a locked enclosure. Where this is required for a read only interface, this lock must prevent viewing of data on the interface; for other interfaces, this lock must prevent using the interface to alter data.
- f. For table entries of "Physical Security": For Local FULL interfaces, the interface must be located inside mission space. For Local Limited (not FULL) interfaces, the user interface must either a) be located within mission space or b) be protected by physical security at least as good as the control devices (and equipment controlled by the control devices) affected by the interface. For purposes of this requirement, 'affected' includes controllers with data that can be directly altered by the interface, as well as mechanical and/or electrical equipment directly controlled by those controllers, but does not include other interactions.
- g. Entries of the form "X and Y" must meet both the requirement indicated for X and the requirement indicated for Y. For example, an entry of "MINIMALLY and Physical Security" indicates the user interface must both MINIMALLY support accounts and have physical security.
- h. Entries of the form "X or Y" must meet either the requirement indicated for X or the requirement indicated for Y.

3.3.1.2.1 HVAC Control Systems

User Interface Requirements for LOW Impact HVAC Control Systems	
<u>User Interface Type</u>	<u>Access Control Requirement</u>
Local Read Only (see note 1)	None Required
Local Limited, Non-privileged	MINIMALLY
Local Limited, Privileged	MINIMALLY

User Interface Requirements for LOW Impact HVAC Control Systems	
<u>User Interface Type</u>	<u>Access Control Requirement</u>
Local Full	MINIMALLY
Remote Read Only	None Required
Remote Limited, Non-Privileged	MINIMALLY
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged	

3.3.1.2.2 Default Requirements for Other Control Systems

For control system devices where User Interface Requirements are not otherwise indicated in this Section, use the Default User Interface Requirements tables.

Default User Interface Requirements for LOW Impact Control Systems	
<u>User Interface Type</u>	<u>Access Control Requirement</u>
Local Read Only (see note 1)	None Required
Local Limited, Non-privileged	MINIMALLY
Local Limited, Privileged	MINIMALLY
Local Full	FULLY
Remote Read Only	MINIMALLY
Remote Limited, Non-Privileged	MINIMALLY
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged	

3.3.2 Unsuccessful Logon Attempts

{For Government Reference Only: This subpart (and its subparts) relate to AC-7 (a), AC-7 (b); CCI-000043, CCI-000044, CCI-001423, CCI-002236, CCI-002237, CCI-002238}

Except for high availability user interfaces indicated as exempt, devices must meet the indicated requirements for handling unsuccessful logon attempts. If a device cannot meet these requirements, document device capabilities to protect from subsequent logon attempts and propose alternate protections in a [Device Account Lock Exception Request](#) submittal. Do not implement alternate protection measures in lieu of the indicated requirements without explicit permission from the Government. If no Device Account Lock Exceptions are requested, provide a document stating that no approval is being requested as the Device Account Lock Exception Request.

3.3.2.1 Devices MINIMALLY Supporting Accounts

For LOW Impact Systems: Devices which MINIMALLY (but not FULLY) support accounts must lock the user account after three consecutive failed login attempts and must unlock the user account after 15 minutes have elapsed without an unsuccessful login attempt or by a successful login to a separate administrator account.

3.3.2.2 Devices FULLY Supporting Accounts

Devices which FULLY support accounts must meet the following requirements.

- a. It must lock the user account when three unsuccessful logon attempts occur within a 15 minute interval.
- b. Once an account is locked, the account must stay locked until unlocked by an administrator. If the account being locked is the sole administrator account on the device, the account must stay locked for 1 hour and then automatically unlock.
- c. Once the indicated number of unsuccessful logon attempts occurs, delay further logon prompts by 5 seconds.

3.3.3 System Use Notification

{For Government Reference Only: This subpart (and its subparts) relates to AC-8; CCI-000048, CCI-002247, CCI-002243, CCI-002244, CCI-002245, CCI-002246, CCI-000050, CCI-002248}

3.3.3.1 System Use Notification for Remote User Interfaces

Remote user interfaces must display a warning banner meeting the requirements of [DTM 08-060](#) on screen.

3.3.3.2 System Use Notification for Local User Interfaces

Devices which are connected to a network and have a local user interface must display a warning banner meeting the requirements of [DTM 08-060](#) on the user interface screen if capable of doing so and must have a permanently affixed label with an approved banner from [DTM 08-060](#) if unable to display the warning banner on the screen. Where it is impractical (perhaps due to device size) to affix the label to the device, affix the label to the device enclosure.

Labels must be machine printed or engraved, plastic or metal, designed for permanent installation, must use a font no smaller than 14 point, and must provide a high contrast between font and background colors.

3.3.4 Permitted Actions Without Identification or Authentication

{For Government Reference Only: This subpart (and its subparts) relates to AC-14; CCI-000061, CCI-000232}

The control system must require identification and authentication before allowing any actions except read-only actions by a user acting from a user interface which MINIMALLY or FULLY supports accounts.

3.3.5 Enclosures

Prior to final acceptance of the system, lock all lockable enclosures. Submit an [Enclosure Keys](#) submittal with all copies of keys for all enclosures and a key inventory list documenting all keys. Label each key with the matching enclosure identifier.

3.4 USER IDENTIFICATION AND AUTHENTICATION

{For Government Reference Only: This subpart (and its subparts) relates to IA-2, IA-2(1), IA-2(12), IA-5 IA-5(b), IA-5(c), IA-5(e), IA-5(g), IA-5(1), IA-5(11); CCI-000764, CCI-000765, CCI-001953, CCI-001954, CCI-001544, CCI-001989, CCI-000182, CCI-001610, CCI-000192, CCI-000193, CCI-000194, CCI-000205, CCI-001619, CCI-001611, CCI-001612, CCI-001613, CCI-001614, CCI-000195, CCI-001615, CCI-000196, CCI-000197, CCI-000199, CCI-000198, CCI-001616, CCI-001617, CCI-000200, CCI-001618, CCI-002041, CCI-002002, CCI-002003. }

This subpart indicates requirements for specific methods of identification and authentication for users and user accounts. Where these requirements conflict apply the following order of precedence: 1) If present, Device Specific Requirements take precedence over any other requirements; and then 2) multifactor authentication requirements take precedence over password requirements.

3.4.1 User Identification and Authentication for All System Types

Unless otherwise indicated, all user interfaces supporting accounts (either FULLY or MINIMALLY) must implement Identification and Authorization via passwords.

[For LOW Impact Systems: User interfaces provided by computer operating systems must implement multifactor authentication via PIV.](#)

3.4.2 User Identification and Authentication for Specific System Types

System specific requirements are in addition to and supersede those indicated for all system types. When no additional requirements are indicated for a specific system type the requirements for all systems still apply to that system type.

3.4.2.1 HVAC Control Systems Devices

[User Interfaces which FULLY support accounts and which run on a computer must use multifactor authentication via PIV.](#)

3.4.3 User Identification and Authentication for Specific Devices

There are no additional device specific user interface requirements

3.4.4 Implementation of Identification and Authorization Requirements

Identification and Authorization must be met by one of the following methods:

- a. Direct implementation in the user interface.
- b. For user interfaces on a computer: inheriting the Identification and Authorization from the computer operating system, either by the operating system limiting access to specific applications by user, or by the application itself having permissions based on the user logged into the computer.
- c. For remote interfaces: an implementation shared between the remote user interface server and the remote user interface client. For example, a requirement for PIV authentication may be met on a remote user interface by a PIV reader on a web browser client which sends the authentication information via HTTPS to the remote server.

3.4.5 Password-Based Authentication Requirements

3.4.5.1 Passwords for Software and Applications Running on Computers

All software and applications running on computers supporting password-based authentication must enforce the following requirements:

- a. Minimum password length of 12 characters
- b. Password must contain at least one uppercase character.
- c. Password must contain at least one lowercase character.
- d. Password must contain at least one numeric character.
- e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.
- f. Password must have a minimum lifetime of 24 hours.
- g. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.
- h. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters (where location is significant, a character may be reused if it is in a different position).
- i. Passwords must be cryptographically protected during storage and transmission.

3.4.5.2 Passwords for Controllers FULLY Supporting Accounts

All controllers FULLY supporting accounts and supporting password-based authentication must enforce the following requirements:

- a. Minimum password length of twelve (12) characters

- b. Password must contain at least one uppercase character.
- c. Password must contain at least one lowercase character.
- d. Password must contain at least one numeric character.
- e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.
- f. Password must have a maximum lifetime of sixty (60) days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.
- g. Password must differ from previous five (5) passwords, where differ is defined as changing at least fifty percent of the characters.
- h. Passwords must be cryptographically protected during storage and transmission.

3.4.5.3 Passwords for Remote Interfaces

Passwords for connecting to a Remote User Interface supporting password-based authentication must enforce the following requirements:

- a. Minimum password length of twelve (12) characters
- b. Password must contain at least one uppercase character.
- c. Password must contain at least one lowercase character.
- d. Password must contain at least one numeric character.
- e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.
- f. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.
- g. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters (where location is significant, a character may be reused if it is in a different position).
- h. Passwords must be cryptographically protected during storage and transmission.

3.4.5.4 Passwords for Devices Minimally Supporting Accounts

Devices MINIMALLY supporting accounts must support passwords with a minimum length of four characters.

3.4.5.5 Password Configuration and Reporting

For all devices with a password, coordinate the changing of passwords with the project site following testing of the system but prior to turnover to

the Government. Coordinate with Password Point of Contact to determine appropriate project site personnel to complete password changes. Accompany identified personnel to each device with a password and instruct personnel on the process of changing password. Record the time, date and personnel present when each device's password is changed and submit a [Password Change Summary Report](#) documenting this information.

Provide the Password Summary Report electronically in both PDF and Microsoft Excel.

3.4.6 Authenticator Feedback

{For Government Reference Only: This subpart relates to IA-6; CCI-000206}

Devices must never show authentication information, including passwords, on a display. Devices that momentarily display a character as it is entered, and then obscure the character, are acceptable. For devices that have STIGs or SRGs related to obscuring of authenticator feedback (CCI-000206), comply with the requirements of those STIGs/SRGs.

3.5 CYBERSECURITY AUDITING

Where an auditing requirement exists for email notification, notify via email the application administrator and Information System Security Officer (ISSO) of the event. Coordinate with the Email Address Point of Contact for email addresses. If outgoing email is not available to the system, configure the system for these notifications for future support of outgoing email.

3.5.1 Audit Events, Content of Audit Records, and Audit Generation

{For Government Reference Only: This subpart (and its subparts) relates to AU-2(a), AU-2(c), AU-2(d), AU-3, AU-10, AU-12, AU-13(3), AU-14(b), AU-14(1), AU-14(2), AU-14(3), CM-5(1), SC-7 (9); CCI-000123, CCI-001571, CCI-000125, CCI-001485, CCI-000130, CCI-000131, CCI-000132, CCI-012300133, CCI-000134, CCI-001487, CCI-000166, CCI-001899, CCI-000169, CCI-001459, CCI-000171, CCI-000172, CCI-001910, CCI-001914, CCI-001919, CCI-001464, CCI-001462, CCI-001920, CCI-001814, CCI-002400. }

For devices that have STIG/SRGs related to audit events, content of audit records or audit generation, comply with the requirements of those STIG/SRGs.

If auditing requirements can be met using existing control system alarm or event capabilities, those existing capabilities may be used to meet these requirements.

3.5.1.1 Computers

For each computer, provide the capability to select audited events and the content of audit logs. Configure computers to audit the indicated events, and to record the indicated information for each auditable event

3.5.1.1.1 Audited Events

Configure each computer to audit the following events:

- a. Successful and unsuccessful attempts to access, modify, or delete privileges, security objects, security levels, or categories of

information (e.g. classification levels)

- b. Successful and unsuccessful logon attempts
- c. Successful logouts
- d. Privileged activities or other system level access
- e. Concurrent logons from different workstations
- f. Successful and unsuccessful accesses to objects
- g. All program initiations
- h. All direct access to the information system
- i. All account creations, modifications, disabling, and terminations.
- j. All kernel module load, unload, and restart

3.5.1.1.2 Audit Event Information To Record

Configure each computer to record, for each auditable event, the following information (where applicable to the event):

- a. What type of event occurred
- b. When the event occurred
- c. Where the event occurred
- d. The source of the event
- e. The outcome of the event
- f. The identity of any individuals or subjects associated with the event

3.5.1.2 For HVAC Control System Controllers

3.5.1.2.1 HVAC Control System Controllers FULLY Supporting User Accounts

For each controller which FULLY supports accounts, provide the capability to select audited events and the content of audit logs. Configure controllers to audit the indicated events, and to record the indicated information for each auditable event.

3.5.1.2.1.1 Audited Events

Configure each controller to audit the following events:

- a. Successful and unsuccessful logon attempts to the controller
- b. Successful logouts
- c. All account creations, modifications, disabling, and terminations.
- d. All controller shutdown and startup

3.5.1.2.1.2 Audit Event Information To Record

Configure each controller to record, for each auditable event, the following information (where applicable to the event):

- a. what type of event occurred
- b. when the event occurred
- c. the identity of any individuals or subjects associated with the event

3.5.1.2.2 Other HVAC Control System Controllers

There are no requirements to perform auditing at HVAC field controllers that do not FULLY support accounts.

3.5.1.3 Default Requirements for Control System Controllers

For control system controllers where Audit Events, Content of Audit Records, and Audit Generation are not otherwise indicated in this Section:

3.5.1.3.1 Controllers Which FULLY Support Accounts

For each controller which FULLY supports accounts, provide the capability to select audited events and the content of audit logs. Configure controllers to audit the indicated events, and to record the indicated information for each auditable event.

3.5.1.3.1.1 Audited Events

Configure each controller to audit the following events:

- a. Successful and unsuccessful attempts to access, modify, or delete privileges, security objects, security levels, or categories of information (e.g. classification levels)
- b. Successful and unsuccessful logon attempts
- c. Successful logouts
- d. Concurrent logons from different workstations
- e. All account creations, modifications, disabling, and terminations.
- f. All kernel module load, unload, and restart

3.5.1.3.1.2 Audit Event Information To Record

Configure each controller to record, for each auditable event, the following information (where applicable to the event):

- a. what type of event occurred
- b. when the event occurred
- c. where the event occurred
- d. the source of the event

e. the outcome of the event

f. the identity of any individuals or subjects associated with the event

3.5.1.3.2 Controllers Which Do Not FULLY Support Accounts

For each controller which does not FULLY support accounts configure the controller to audit all controller shutdown and startup events and to record for each event the type of event and when the event occurred.

3.5.2 Audit Time Stamps

{For Government Reference Only: This subpart (and its subparts) relates to AU-8; CCI-000159, CCI-001889, CCI-001890.}

Any device (computer or controller) generating audit records must have an internal clock capable of providing time with a resolution of one second. Clocks must not drift more than 10 seconds per day. Configure the system so that each device (computer or controller) generating audit records maintains accurate time to within 1 second. Note that if the control system specifications include requirement for clocks, the most stringent requirement applies.

3.5.3 Auditing Front End Software

The project site currently has the following software to support control system auditing: none. If there is no existing auditing front end software or the software is not compatible with the provided control systems, provide Auditing Front End Software with audit log import and upload, export, notification, and analysis functionality. The Auditing Front End Software may be provided as a component of the control system front end or as a separate software package, and a single package may serve multiple control systems provided under the same projects if they are sharing a cybersecurity authorization.

When the Auditing Front End Software is neither existing nor installed under the requirements of another Section, furnish the Auditing Front End Software media and license for subsequent Government installation and install the software on the control system front end computer. Submit copies of Auditing Front End Software if this function is not part of the software provided with the control system to meet requirements of other Sections.

3.5.3.1 Import and Upload Requirements

Auditing Front End Software must be capable of importing audit logs from the Device Audit Record Upload Software and of uploading audit logs over the network from all control system devices supporting network upload of audit logs.

3.5.3.2 Export Requirements

Auditing Front End Software must be capable of exporting to a file format supported by Microsoft Excel.

3.5.4 Audit Storage Capacity and Audit Upload

{For Government Reference Only: This subpart (and its subparts) relates to AU-4; CCI-001848, CCI-001849}

The creation of audit records must never interfere with normal device operation. Devices must cease collection of auditing information if required to maintain normal operation.

- a. For devices that have STIG/SRGs related to audit storage capacity (CCI-001848 or CCI-001849) comply with the requirements of those STIG/SRGs.
- b. For controllers capable of generating audit records, provide 60 days worth of secure local storage, assuming 10 auditable events per day.

3.5.4.1 Device Audit Record Upload Software

For each device (computer or controller) required to audit events and for which audit logs cannot be uploaded over the network by the Auditing Front End Software, provide and license to the Government software implementing a secure mechanism of uploading audit records from the device and exporting them to the Auditing Front End Software. Where different devices use different software, provide software of each type required to upload audit logs from all devices.

When Device Audit Record Upload Software is capable of uploading audit logs over the network, install Device Audit Record Upload Software on the same computer as the Auditing Front End Software. Submit copies of device audit record upload software if this function is not part of the software provided with the control system to meet requirements of other Sections. If there are no devices requiring this software, provide a document stating this in lieu of this submittal.

3.5.5 Response to Audit Processing Failures

{For Government Reference Only: This subpart (and its subparts) relates to AU-5; CCI-000139, CCI-000140, CCI-001490.}

In the case of a failure in the auditing system, computers associated with auditing must provide email notification. In case of an audit failure, if possible, continue to collect audit records by overwriting existing audit records.

3.6 REQUIREMENTS FOR LEAST FUNCTIONALITY

{For Government Reference Only: This subpart (and its subparts), along with the network communication report submittal specified elsewhere in this section, relates to CM-6(a), CM-6(c), CM-7, CM-7(1)(b), SC-41; CCI-000363, CCI-000364, CCI-000365, CCI-001588, CCI-001755, CCI-000381, CCI-000380, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546. }

For devices that have a STIG or SRG related to Requirements for Least Functionality (such as configuration settings and port and device I/O access for least functionality), install and configure the device in accordance with that STIG or SRGs.

3.6.1 Device Capabilities

For HVAC Control Systems: Do not provide devices with remote user interfaces or with full user interfaces where one was not required. Do not use a networked sensor or actuator where a non-networked sensor or

actuator would suffice.

For Other Control Systems: For LOW Impact Systems: Do not provide devices with remote user interfaces or with full user interfaces where one was not required. Do not use a networked sensor or actuator where a non-networked sensor or actuator would suffice.

3.6.2 Software

For software that has a STIG or SRG related to Requirements for Least Functionality (such as configuration settings and port access for least functionality), install and configure the software in accordance with that STIG or SRG.

3.7 SYSTEM AND COMMUNICATION PROTECTION

3.7.1 Collaborative Computing

{For Government Reference Only: This subpart relates to SC-15(a), SC-15(b); CCI-001150, CCI-001152.}

Without explicit approval from the project site, control systems must not use collaborative computing technologies.

3.7.2 Denial of Service Protection

{For Government Reference Only: This subpart relates to SC-5, SC-39, SC-7(a); CCI-001093, CCI-002385, CCI-002386, CCI-002430, CCI-001097. }

To the greatest extent practical, implement control logic without reliance on the network. Except when required to meet the requirements of the control system Section (where the requirement can only be met using computer hardware), do not implement control logic in computers.

3.8 SAFE MODE AND FAIL SAFE OPERATION

{For Government Reference Only: This subpart (and its subparts) relates to CP-12, SI-10(3), SI-17; CCI-002855, CCI-002856, CCI-002857, CCI-002754, CCI-002773, CCI-002774, CCI-002775}

For all control system components with an applicable STIG or SRG, configure the component in accordance with all applicable STIGs and SRGs.

3.9 SYSTEM MAINTENANCE TOOL SOFTWARE

{For Government Reference Only: This subpart (and its subparts) relates to MA-3; CCI-000865.}

Submit and license to the Government all software required to operate, maintain and modify the control system such the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer. Submit hard copies of user manuals for each software with the software submittal.

For software provided and licensed to the Government under the requirements of another Section, submit a statement indicating the Section and Submittal under which the software was provided. For software provided to meet the requirements of this Section and not

provided and licensed under another Section, submit software and software user manuals on DVD or CD as a Technical Data Package and submit one hard copy of the software user manual for each piece of software.

3.10 DEVICE POWER

{For Government Reference Only: This subpart (and its subparts) relates to PE-11, PE-11(1); CCI-002955, CCI-000961. }

3.11 VULNERABILITY SCANNING

{For Government Reference Only: This subpart (and its subparts) relates to RA-5 RA-5(a),RA-5(b),RA-5(c),RA-5(d); CCI-001054, CCI-001055, CCI-000156, CCI-001641, CCI-001643, CCI-001057, CCI-001058, CCI-001059. }

All IP devices must be scannable, such that the device can be scanned by industry standard IP network scanning utilities without harm to the device, application, or functionality.

3.11.1 Computers and Software Running on Computers

Computers and applications running on computers must meet relevant vulnerability scanning STIGs/SRGs and respond to approved DoD vulnerability scanning tools.

3.11.2 Controllers

Provide controllers that are scannable by standard control system discovery tools or control system browsers and return meaningful status information including the network inputs and outputs for the controller. This information must contain sufficient detail to detect vulnerabilities or exploits of the controller.

Provide all software needed to scan the control system as the [Control System Scanning Tools](#) submittal. If the software required to scan the system is already installed at the project site or is provided under a separate section instead provide a statement indicating this.

3.12 FIPS 201-2 REQUIREMENT

{For Government Reference Only: This subpart (and its subparts) relates to SA-4 (10); CCI-003116}

Devices in the following systems which implement PIV must be on the [NIST FIPS 201-2](#) approved product list (<https://www.idmanagement.gov/approved-products-list/>): NONE.

3.13 SYSTEM AND INTEGRATION INTEGRITY

3.13.1 Malicious Code Protection

{For Government Reference Only: This subpart (and its subparts) relates to SI-3(c); CCI-001241, CCI-002623}

For all computers installed under this project, provide malware protection software media, provide licenses, and install and configure malware protection software as indicated. Coordinate with the Government Computer Access Point of Contact as required.

- a. Malware protection software licenses will be Government furnished.
- b. Malware protection software media will be Government furnished.
- c. Malware protection software will be Government installed.

3.14 CONTROL SYSTEM CYBERSECURITY TESTING

3.14.1 Control System Cybersecurity Testing Procedures

Prepare Control System Cybersecurity Testing Procedures explaining step-by-step, the actions and expected results that will demonstrate that the control system meets the requirements of this Section.

Submit 4 copies of the Control System Cybersecurity Testing Procedures. The Control System Cybersecurity Testing Procedures may be submitted as a Technical Data Package.

3.14.2 Control System Cybersecurity Testing Execution

Using the Control System Cybersecurity Testing Procedures verify that the control system meets the requirements of this Section. UNLESS GOVERNMENT WITNESSING OF A TEST IS SPECIFICALLY WAIVED BY THE GOVERNMENT, PERFORM ALL TESTS WITH A GOVERNMENT WITNESS. If testing reveals deficiencies in the system, correct the deficiency and retest until successful.

3.14.3 Control System Cybersecurity Testing Report

Prepare and submit a Control System Cybersecurity Testing Report documenting all tests performed and their results. Include all tests in the Control System Cybersecurity Testing Procedures and any additional tests performed during testing. Document test failures and repairs conducted with the test results.

Submit four copies of the Control System Cybersecurity Testing Report. The Control System Cybersecurity Testing Report may be submitted as a Technical Data Package.

3.15 FIELD QUALITY CONTROL, CYBERSECURITY VALIDATION SUPPORT

In addition to testing and testing support required by other Sections, provide a minimum of 8 hours of technical support for cybersecurity testing of control systems to support the DoD Risk Management Framework process Cybersecurity assessment of the control system. This support is independent of (and in addition to) the Control System Cybersecurity Testing specified in this section.

3.16 CYBERSECURITY TRAINING

Provide eight hours of classroom and hands-on training for six Government personnel on the cybersecurity operation and maintenance of the control system provided. This training is in addition to and must be coordinated with control system training specified in other Sections.

The Government will provide the training location. Training must cover, at a minimum: (a) applying software and firmware updates, (b) user account creation, modification and deletion, (c) audit log upload procedures and (d) identification of privileged user interfaces and system impact of those interfaces. Training session must include a question and answer

period during which government staff questions about cybersecurity aspects of the control system are answered.

-- End of Section --

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SECTION 25 05 11.02

CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS FIRE ALARM MASS NOTIFICATION SYSTEM

PART 1 GENERAL

Many subparts in this Section contain text in curly braces ("{" and "}") indicating which cybersecurity control and control correlation identifier (CCI) the requirements of the subpart relate to. The text inside these curly braces is for Government reference only and enables coordination of the requirements of this Section with the RMF process throughout the design and construction process. Text in curly braces are not contractor requirements.

This Section refers to Security Requirements Guide (SRGs) and Security Technical Implementation Guide (STIGs). STIGs and SRGs are available online at the Information Assurance Support Environment (IASE) website at <https://public.cyber.mil/stigs/downloads/> and an SRG/STIG Applicability Guide and Collection Tool is available at <https://public.cyber.mil/stigs/SCAP/>. Not all control system components have applicable STIGs or SRGs. The "Control Systems SRG" does not apply to work performed under this Section; all requirements within this section to apply applicable SRGs DO NOT include the "Control Systems SRG".

1.1 CONTROL SYSTEM APPLICABILITY

There are multiple versions of this Section associated with this project. Different versions have requirements applicable to different control systems. This specific Section applies only to the following control systems: **Fire Alarm Mass Notification System**.

1.2 RELATED REQUIREMENTS

This section does not contain sufficient requirements to procure a control system and must be used in conjunction with other Sections which specify control systems. This Section adds cybersecurity requirements to the control systems specified in other Sections, and as these requirements are conditioned on the control system being provided, there may be requirements in this Section that will not apply to this project. All Sections containing facility-related control systems or control system components are related to the requirements of this Section. Review all specification sections to determine related requirements.

In cases where a requirement is specified in both this Section and in another Section, the more stringent requirement must be met. In cases where a requirement in this Section conflicts with the requirements of another Section such that both requirements cannot be met at the same time, request direction from the Contracting Officer Representative to determine which requirement applies to the project.

1.3 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.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.1x (2010) Local and Metropolitan Area
Networks - Port Based Network Access
Control

INTERNET ENGINEERING TASK FORCE (IETF)

IETF RFC 2819 (2000) Remote Network Monitoring (RMON)
Management Information Base (MIB)

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST FIPS 140-2 (2001) Security Requirements for
Cryptographic Modules

NIST FIPS 201-2 (2013) Personal Identity Verification
(PIV) of Federal Employees and Contractors

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 8551.01 (2014) Ports, Protocols, and Services
Management (PPSM)

DTM 08-060 (2008) Policy on Use of Department of
Defense (DoD) Information Systems -
Standard Consent Banner and User Agreement

1.4 DEFINITIONS

1.4.1 Administrator Account

An administrator account is an account with full permissions to a device, application, or operating system, including the ability to create and modify other user accounts.

Note that the operating system Administrator Account may be different than Administrator Accounts for applications hosted on that operating system. Also, most controllers will not have any support for accounts and will therefore not have an 'Administrator Account'.

1.4.2 Computer

A computer is one of the following:

- a. a device running a non-embedded desktop or server version of Microsoft Windows
- b. a device running a non-embedded version of MacOS
- c. a device running a non-embedded version of Linux
- d. a device running a version or derivative of the Android Operating

System, where Android is considered separate from Linux

- e. a device running a version of Apple iOS

Unless otherwise indicated or clear from context use of the word "device" in this Section includes computers.

1.4.3 Controller

A device other than a computer or Ethernet switch. For Fire Protection systems this includes fire alarm control panels, remote operating consoles, and remote annunciators.

1.4.4 Mission Space

A device or media is in mission space if physical access to the device or media is controlled by the organization served by the device. For example, a VAV box controller in a suspended ceiling is in mission space if the VAV box serves that room; an electrical switchgear in an electrical room or an AHU in a mechanical room or on a rooftop may still be considered to be in mission space if the organization (mission) served by that switchgear or AHU controls access to the electrical room, mechanical room or rooftop.

1.4.5 Network

A network is a group of two or more devices that can communicate using a network protocol. Network protocols must provide a method for addressing devices on the network; a communication method that does not provide an addressing scheme is not a networked form of communication. Devices that communicate using a method of communication that does not support device addressing are not using a network.

1.4.6 Network Connected

A component is network connected (or "connected to a network") only when the device has a network transceiver which is directly connected to the network and implements the network protocol. A device lacking a network transceiver (and accompanying protocol implementation) can never be considered network connected. Note that (unlike many IT definitions of "Network Connected") a device connected to a non-IP network is still considered network connected (an IP connection or IP address is not required for a device to be network connected).

1.4.6.1 Wireless Network Connected

Any device that supports wireless network communication is network connected to a wireless network, regardless of whether the device is communicating using wireless. Unless physically disabled, devices with wireless transceivers support wireless, it is not sufficient to disable the wireless in software.

1.4.7 Network Media

The thing that provides the communication channel between the devices on a network. Typically wire, but might include wireless, fiber optic, or even power line (some network protocols allow sending network signals over power wiring).

1.4.8 User Account Support Levels

The support for user accounts is categorized in this Section as one of three levels:

1.4.8.1 FULLY Supported

Device supports configurable individual accounts. Accounts can be created, deleted, modified, etc. Privileges can be assigned to accounts. These devices support user-based (as opposed to role-based) authentication.

1.4.8.2 MINIMALLY Supported

Device supports a small, fixed number of accounts (perhaps only one). Accounts cannot be modified. A device with only a "User" and an "Administrator" account would fit this category. Similarly, a device with two PINs for logon - one for restricted and one for unrestricted rights would fit here (in other words, the accounts do not have to be the traditional "username and password" structure). These devices typically only support role-based authentication.

Examples of devices which MINIMALLY support accounts are a) a variable frequency drive with a single account which requires a PIN for access to configuration; and b) a room lighting control touchpad interface that has a single account.

1.4.8.3 NOT Supported

Device does not support any Access Enforcement therefore the whole concept of "account" is meaningless.

1.4.9 Manual Local Input

Manual Local Inputs are system analog or binary inputs that are adjustable by a person but are, by intrinsic hardware design, very limited in potential capabilities. Manual Local Inputs do not have touch screens or full keyboards, but may have a few buttons or dials to allow input. Manual Local Inputs do not have full graphic screens or dot-matrix displays, but may have simple lights (LEDs) or 7-segment displays. Manual Local Inputs do not have any sort of menu structure, each button has a single well-defined function.

Examples of Manual Local Inputs are H-O-A switches, simple thermostats, and disconnect switches.

1.4.10 Card Reader

A card reader is an input/output device whose primary function is to assist in two-factor authentication. A card reader must have an interface to read data from a card and may be able to write data to a card. A card reader may have a means (such as buttons, keypad, touchscreen, etc.) for a user to input a PIN or password, as well as a limited display.

1.4.11 User Interface

A User Interface (UI) is something other than a Manual Local Input or Card Reader that allows a person to interact with the system or device. Note that while a Card Reader is not by itself a User Interface, a User Interface may contain a Card Reader in order for it to authenticate its

user. Within control systems, there are a wide range of User Interfaces.

Two important distinctions are 1) whether the user interface is Local or Remote, and 2) the effective capabilities of the User Interface to alter data, which is the "privilege" of the user interface (where effective privilege available to a specific user at a specific user interface is the combination of the greatest privilege offered by the user interface and the specific account the user is logged into).

1.4.11.1 Local User Interface

A Local User Interface is a user interface where the physical hardware the user interacts with (keyboard, buttons, display, etc.) is physically part of the device being affected. All of the relevant characteristics of the user interface are embodied within a single device.

Note that a Local UI may be able to access data in a different device, Local versus Remote in this context refers to the user interface itself; the capability to access data in a different device is covered under "Full User Interface".

1.4.11.2 Remote User Interface

A Remote User Interface implements a Client/Server model where the physical hardware the user interacts with (Client) is physically distinct from the device being affected (Server). Most or all of the security and functionality characteristics of the user interface are defined by the Server, not the Client. The Client and Server communicate via a network connection. A common example of a remote user interface is a web-based interface where the browser (client) is generally on different hardware than the web server (server). A Remote UI remains a Remote UI even if the user happens to be at a Client on the same hardware as the Server. What is important is that a) the Client may be on different hardware than the Server and b) the majority of the security and functional characteristics of the interface are defined at the Server.

Note that this definition of "remote" is consistent with that generally used in the control industry but is not aligned with the NIST 800-53 definition of "Remote", which refers to "outside the system". The term "Remote" here better aligns with the NIST 800-53 definition of "Network" (remote from within the system) Access.

1.4.11.3 Types of User Interface (by capability)

User interfaces are also categorized by their capabilities as being Read Only, Limited, or Full.

1.4.11.3.1 Read-Only User Interface

A Read Only User Interface (also referred to as a View-Only User Interface) is a user interface that only allows for reading data, it does not allow (have the capability to) modify data. A Read Only User Interface may be either Local or Remote. A User Interface that is configured to be Read Only (by some other means than the interface itself, such as using configuration software on a laptop) is a Read-Only Interface. Note a Read Only User Interface may have buttons (or touch screen, etc.) allowing the user to navigate through the presentation of data.

Examples of a Read Only User Interfaces are a) a publicly viewable "energy dashboard" showing weather data and energy usage within a building and b) digital wayfinding signage.

1.4.11.3.2 Limited User Interface

A Limited User Interface is a user interface that - by design - can only alter information local to the user interface. Note that the determination of "alter" includes only direct interactions, it explicitly excludes interactions that might occur as secondary effects. For example, an interface changing the flow setpoint in a pump controller is a direct interaction, the subsequent change in flow (as well as any subsequent downstream changes in valve position) are not direct interactions.

Two examples of LIMITED UIs are: a) a variable speed drive has a Limited Local User Interface which allows the user to change properties within the drive, but does not allow affecting things outside the drive; and b) a typical home WiFi Router has a Limited Remote User Interface which allows configuration of the Router, but does not allow direct interaction with other devices.

1.4.11.3.3 Full User Interface

A Full User Interface can alter information in devices outside the device with the user interface. For example, a typical Local Display Panel is a Full Local User Interface while a browser-based front end is a Full Remote User Interface.

1.4.11.3.4 View-Only User Interface

See Read-Only User Interface

1.4.11.4 Other User Interface Terminology

In addition to defining whether a user interface is a Hardware Limited, Read-Only, Limited or Full, and whether it is Local or Remote, user interfaces are classified by whether they are writable or privileged.

1.4.11.4.1 Writable User Interface

Any User Interface that is not Read-Only is Writable. (Limited User Interfaces and Full User Interfaces are both writable user interfaces (as they are capable of changing a value)).

1.4.11.4.2 Privileged User Interface

A Privileged UI is a UI that has sufficient capabilities or functionality that it requires specific cybersecurity measures to be put in place to limit its unauthorized use. Ultimately, whether a specific user interface is considered a Privileged User Interface must be determined by usage. Unless otherwise specified, user interfaces can be determined to be privileged or not using the following:

- a. Read-Only User Interfaces are not privileged user interfaces.
- b. Full User interfaces for Fire Alarm Systems are privileged user interfaces as indicated and shown, or when another requirement of this Section establishes they are privileged. For all other systems, full User Interfaces are privileged user interfaces.

- c. User interfaces that allow for configuration of auditing or allows for modification or deletion of audit logs are privileged user interface.
- d. User interfaces that allow for reprogramming a network connected device is a privileged user interface.
- e. For Fire Protection Systems, User Interfaces that can inhibit or force the activation of a fire suppression system (e.g. such as for a pre-action or deluge system) are privileged user interfaces.
- f. Except as specified above, a Limited User Interface must be determined to be privileged or not based on the specific capabilities and use case of the user interface. In general however, user interfaces that do not offer significant capabilities above and beyond those available at that location via other means (e.g. such as a disconnect switch, breaker, or hand-off-auto switch, or physical attack) are not privileged.

1.4.12 Wireless Network

Any network that communicates without using wires or fiber optics as the communication media. Wireless networks include: WiFi, Bluetooth, ZigBee, cellular, satellite, 900 MHz radio, 2.4 GHz, free space optical, point-to-point laser, and IR.

1.4.13 Wired Broadcast Network

Wired Broadcast Networks are any network, such as powerline carrier networks and modem (wired telephony), that use wire-based technologies where there is not a clearly defined boundary for signal propagation.

1.5 ADMINISTRATIVE REQUIREMENTS

1.5.1 Points of Contact

Coordinate with the following Points of Contact as indicated in this Section and as required. Not all projects will require coordination with all Points of Contact. When coordination is required and no Point of Contact is indicated, coordinate with The Contracting Office Representative (COR).

- a. Government Computer Access Point of Contact: The Contracting Office Representative (COR)
- b. HTTPS Certificate Point of Contact: The Contracting Office Representative (COR)
- c. Email Address Point of Contact: The Contracting Office Representative (COR)
- d. Password Point of Contact: The Contracting Office Representative (COR)
- e. Mobile Code Point of Contact: The Contracting Office Representative (COR)
- f. PKI Infrastructure Point of Contact: The Contracting Office Representative (COR)

1.5.2 Coordination

Coordinate the execution of this Section with the execution of all other Sections related to control systems as indicated in the paragraph RELATED REQUIREMENTS. Items that must be considered when coordinating project efforts include but are not limited to:

- a. If requesting permission for wireless or wired broadcast communication, the Wireless and Wired Broadcast Communication Request submittal must be approved prior to control system device selection and installation.
- b. If requesting permission for alternate account lock permissions, the Device Account Lock Exception Request must be approved prior to control system device selection and installation.
- c. If requesting permission for the use of a device with multiple physical connections to IP networks, the Multiple IP Connection Device Request must be approved prior to control system device selection and installation.
- d. Wireless testing may be required as part of the control system testing. See requirements for the Wireless Communication Test Report submittal.
- e. If the Device Audit Record Upload Software is to be installed on a computer not being provided as part of the control system, coordination is required to identify the computer on which to install the software.
- f. The Cybersecurity Interconnection Schedule must be coordinated with other work that will be interconnected to, and interconnections must be approved by the Government before relying on them for system functionality.
- g. Cybersecurity testing support must be coordinated across control systems and with the Government cybersecurity testing schedule.
- h. Passwords must be coordinated with the indicated contact for the project site.
- i. If applicable, HTTPS web server certificates must be obtained from the indicated HTTPS Certificate Point of Contact.
- j. Contractor Computer Cybersecurity Compliance Statements must be provided for each contractor using contractor owned computers.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00.00 06 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Device Account Lock Exception Request; G

Multiple Ethernet Connection Device Request; G

Contractor Computer Cybersecurity Compliance Statements; G

Contractor Temporary Network Cybersecurity Compliance Statements; G

Cybersecurity Interconnection Schedule; G

Proposed STIG and SRG Applicability Report; G

SD-02 Shop Drawings

Network Communication Report; G

Cybersecurity Riser Diagram; G

SD-03 Product Data

Control System Cybersecurity Documentation; G

SD-06 Test Reports

Control System Cybersecurity Testing Procedures; G

Control System Cybersecurity Testing Report; G

SD-07 Certificates

Software Licenses; G

SD-11 Closeout Submittals

Password Change Summary Report; G

Enclosure Keys; G

Software and Configuration Backups; G

Auditing Front End Software; G

Device Audit Record Upload Software; G

System Maintenance Tool Software; G

Control System Scanning Tools; G

STIG, SRG and Vendor Guide Compliance Result Report; G

Control System Inventory Report; G

Integrity Verification Software; G

1.7 CYBERSECURITY DOCUMENTATION

{For Government Reference Only: This subpart (and its subparts) relates to PL-7; CCI-003071}

1.7.1 Proposed STIG and SRG Applicability Report

For each model of network connected or network infrastructure device, use the DISA SRG/STIG Applicability Guide and Collection Tool (available at <https://public.cyber.mil/stigs/SCAP/>) to identify applicable STIGs or SRGs and provide a report indicating applicable STIGs and SRGs for each model.

1.7.2 Cybersecurity Interconnection Schedule

{For Government Reference Only: This subpart relates to CA-3(b), PL-8, SC-7(9), SC-7(11); CCI-000258, CCI-003072, CCI-003073, CCI-003075, CCI-002398, CCI-002399, CCI-002401, CCI-002402, CCI-002403. For MODERATE Impact systems, this subpart also relates to SC-7; CCI-001126, CCI-001109}

Provide a completed Cybersecurity Interconnection Schedule documenting network connections between the installed system and other systems. Provide the following information for each device directly communicating between systems: Device Identifier, Device Description, Transport layer Protocol, Network Address, Port (if applicable), MAC (Layer 2) address (if applicable), Media, Application Protocol, Service (if applicable), Descriptive Purpose of communication. For communication with other authorized systems also provide the Foreign Destination and POC for Destination. For MODERATE Impact Systems: Also describe the impact of loss of the connection on the control system. If other control system Sections used on this project include submittals documenting this information, provide copies of those submittals to meet this requirement.

In addition to the requirements of Section 01 33 00.00 06 SUBMITTAL PROCEDURES, provide the Cybersecurity Interconnection Schedule as an editable Microsoft Excel file (a template Cybersecurity Interconnection Schedule in Excel format is available at <https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1>

1.7.3 Network Communication Report

{For Government Reference Only: This subpart (and its subparts) relates to CA-9, PL-8; CCI-002102, CCI-002103, CCI-002104, CCI-002105, CCI-003072, CCI-003073, CCI-003075 and also the submittal requirements associated with CM-6, CM-7, SC-8 and SC-41 including CM-7(3), CCI-000388.}

Provide a network communication report. For each networked device, document the communication characteristics of the device including communication protocols, services used, encryption employed, and a general description of what information is communicated over the network. For each device using IP, document all TCP and UDP ports used. For non-IP communications, document communication protocol and media used. If other control system Sections used on this project include submittals documenting this information, provide copies of those submittals to meet this requirement.

In addition to the requirements of Section 01 33 00.00 06 SUBMITTAL PROCEDURES, provide the Network Communication Report as an editable Microsoft Excel file.

1.7.4 Control System Inventory Report

{For Government Reference Only: This subpart (and its subparts) relates to CM-8(a), SI-17, IA-3; CCI-000389, CCI-000392, CCI-000398, CCI-002773, CCI-002774, CCI-002775, CCI-000777, CCI-000778, CCI-001958}

Provide a Control System Inventory report using the Inventory Spreadsheet listed under this Section at

<https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1> documenting all devices, including networked devices, network infrastructure devices, non-networked devices, input devices (e.g. sensors) and output devices (e.g. actuators). For each device provide all applicable information for which there is a field on the spreadsheet in accordance with the instructions on the spreadsheet.

In addition to the requirements of Section 01 33 00.00 06 SUBMITTAL PROCEDURES, provide the Control System Inventory Report as an editable Microsoft Excel file.

1.7.5 Software and Configuration Backups

{For Government Reference Only: This subpart (and its subparts) relates to CP-10; CCI-000550, CCI-000551, CCI-000552}

For each computer on which software is installed under this project, provide a recovery image of the final as-built computer. This image must allow for bare-metal restore such that restoration of the image is sufficient to restore system operation to the imaged state without the need for re-installation of software. If additional user permissions are required to meet this requirement, coordinate the creation of the image with the identified Government Computer Access Point of Contact.

For all ethernet switches provide a backup of the switch configuration. For all controllers, provide a backup of the controller configuration and the source code for all loaded application programs (all software that is not common to every controller of the same manufacturer and model).

If any or all of these are provided under another Section, provide documentation indicating this and referencing those submittals.

1.7.6 Cybersecurity Riser Diagram

{For Government Reference Only: This subpart (and its subparts) relates to PL-2(a), PL-8; CCI-003051, CCI-003053, CCI-003072, CCI-003073, CCI-003075}

Provide a cybersecurity riser diagram of the complete control system including all network and device hardware. If the control system specifications require a riser diagram submittal, provide a copy of that submittal as the cybersecurity riser diagram. Otherwise, provide a riser diagram in one-line format.

1.7.7 STIG, SRG and Vendor Guide Compliance Result Report

For every component (device or software) with an applicable STIG or SRG in the Proposed STIG and SRG Applicability Report, provide a result report documenting compliance with the STIG or SRG requirements. For components which are scannable by the SCAP (security content automation protocol) tool (available online at <https://public.cyber.mil/stigs/scap>), provide the SCAP report and raw scan results.

For every component (device or software) with manufacturer provided cybersecurity documentation, procedure, or method for secure configuration

or installation, provide a report documenting how the component was configured and any deviation from the manufacturer instructions.

1.7.8 Control System Cybersecurity Documentation

{For Government Reference Only: This subpart (and its subparts) relates to SA-5 (a),(b),(c); CCIs: CCI-003124, CCI-003125, CCI-003126, CCI-003127, CCI-003128, CCI-003129, CCI-003130, CCI-003131}

Provide a Control System Cybersecurity Documentation submittal containing the indicated information for each device and software application.

1.7.8.1 Software Applications

For all software applications running on computers provide:

- a. administrator documentation that describes secure configuration of the software {For Government Reference Only: relates to CCI-003124}
- b. administrator documentation that describes secure installation of the software {For Government Reference Only: relates to CCI-003125}
- c. administrator documentation that describes secure operation of the software {For Government Reference Only: relates to CCI-003124}
- d. administrator documentation that describes effective use and maintenance of security functions or mechanisms for the software {For Government Reference Only: relates to CCI-003127}
- e. administrator documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the software {For Government Reference Only: relates to CCI-003128}
- f. user documentation that describes user-accessible security functions or mechanisms in the software and how to effectively use those security functions or mechanisms {For Government Reference Only: relates to CCI-003129}
- g. user documentation that describes methods for user interaction which enables individuals to use the software in a more secure manner {For Government Reference Only: relates to CCI-003130}
- h. user documentation that describes user responsibilities in maintaining the security of the software {For Government Reference Only: relates to CCI-003131}

1.7.8.2 Default Requirements for Control System Devices

For control system devices where Control System Cybersecurity Documentation requirements are not otherwise indicated in this Section, provide:

- a. Documentation that describes secure configuration of the device {For Government Reference Only: relates to CCI-003124}
- b. Documentation that describes secure installation of the device {For Government Reference Only: relates to CCI-003125}

- c. Documentation that describes secure operation of the device {For Government Reference Only: relates to CCI-003124}
- d. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {For Government Reference Only: relates to CCI-003127}
- e. Documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the device {For Government Reference Only: relates to CCI-003128}
- f. Documentation that describes user-accessible security functions or mechanisms in the device and how to effectively use those security functions or mechanisms {For Government Reference Only: relates to CCI-003129}
- g. Documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {For Government Reference Only: relates to CCI-003130}
- h. Documentation that describes user responsibilities in maintaining the security of the device {For Government Reference Only: relates to CCI-003131}

1.8 SOFTWARE LICENSING

{For Government Reference Only: This subpart (and its subparts) relates to SI-2(a), SI-2(c), SI-7(14); CCI-001227, CCI-002605, CCI-002737}

For all software provided that has not already been licensed to the government or project site, provide a license to the project site for a period of no less than 5 years, and the license must also include the following software updates:

- a. Security and bug-fix patches issued by the software manufacturer.
- b. Security patches to address any vulnerability identified in the National Vulnerability Database at <http://nvd.nist.gov> with a Common Vulnerability Scoring System (CVSS) severity rating of MEDIUM or higher.

Provide a single [Software Licenses](#) submittal with documentation of the software licenses for all software provided

1.9 CYBERSECURITY DURING CONSTRUCTION

{For Government Reference Only: This subpart (and its subparts) relates to AC-18, SA-3; CCI-000258}

In addition to the control system cybersecurity requirements indicated in this section, meet following requirement throughout the construction process.

1.9.1 Contractor Computer Equipment

Contractor owned computers may be used for construction. Contractor computers connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.9.1.1 Operating System

The operating system must be an operating system currently supported by the manufacturer of the operating system. The operating system must be current on security patches and operating system manufacturer required updates.

1.9.1.2 Anti-Malware Software

The computer must run anti-malware software from a reputable software manufacturer. Anti-malware software must be a version currently supported by the software manufacturer, must be current on all patches and updates, and must use the latest definitions file. Computers used on this project must be scanned using the installed software at least once per day.

1.9.1.3 Passwords and Passphrases

The passwords and passphrases for computers, applications, and web-based applications supporting passwords must be changed from their default values. Passwords must be a minimum of eight characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.9.1.4 User-Based Authentication

Each user must have a unique account; sharing of a single account between multiple users is prohibited.

1.9.1.5 Demonstration of Compliance

The Government has the right to require demonstration of computer compliance with these requirements at any time during the project.

1.9.1.6 Contractor Computer Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Computer Cybersecurity Compliance Statements for each company using contractor owned computers. Contractor Computer Cybersecurity Compliance Statements must use the template published at <https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1> Each Statement must be signed by a cybersecurity representative for the relevant company.

1.9.2 Temporary IP Networks

Temporary contractor-installed IP networks may be used during construction. When used, temporary contractor-installed IP networks connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.9.2.1 Network Boundaries and Connections

The network must not extend outside the project site and must not connect to any IP network other than those specifically provided or furnished for this project. Any and all access to the network from outside the project site is prohibited.

1.9.3 Government Access to Network

Government personnel must be allowed to have complete and immediate access to the network at any time in order to verify compliance with this specification.

1.9.4 Temporary Wireless IP Networks

In addition to the other requirements on temporary IP networks, temporary wireless IP (WiFi) networks, when permitted, must not interfere with existing wireless networks, must use WPA2 security and must not broadcast the network name (SSID). Network names (SSID) for wireless networks must be changed from their default values.

1.9.5 Passwords and Passphrases

The passwords and passphrases for all network devices and network access must be changed from their default values. Passwords must be a minimum 8 characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.9.6 Contractor Temporary Network Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Temporary Network Cybersecurity Compliance Statements for each company implementing a temporary IP network. Contractor Temporary Network Cybersecurity Compliance Statements must use the template published at

<https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1>

Each Statement must be signed by a cybersecurity representative for the relevant company. If no temporary IP networks will be used, provide a single copy of the Statement indicating this.

1.10 CYBERSECURITY DURING WARRANTY PERIOD

All work performed on the control system after acceptance must be performed using Government Furnished Equipment or equipment specifically and individually approved by the Government.

PART 2 PRODUCTS

All products used on this project must meet the indicated requirements, but not all products specified here will be required by every project.

2.1 ETHERNET SWITCH

Provide Open Systems Interconnection (OSI) Layer 2 Ethernet switches with the following capabilities, and with an interface to support switch configuration for these capabilities:

2.1.1 Required Functionality

Switches must:

- a. Copper Ethernet ports must auto negotiate for 10, 100 and 1000 megabits-per-second links.
- b. Be capable of implementing port level access control by MAC address and limit the number of MAC addresses to one MAC address per port.

- c. For MODERATE Impact Systems, be capable of implementing per-port access control lists (ACLs) where the list can be filtered by source and destination IP addresses, and by source and destination UDP or TCP ports.
- d. Support Remote Network Monitoring (RMON) Port Analysis in accordance with IETF RFC 2819
- e. Configure target port and analysis port such that switch clones all target port traffic to analysis port.
- f. Support authentication via RADIUS server (for management and 802.1x)
- g. Support IEEE 802.1x network login.

2.1.2 Configuration Requirements

Switches must:

- a. Support configuration save and restore.
- b. Support both manual IP address assignment and acquisition of a dynamic IP address via Dynamic Host Configuration Protocol (DHCP).
- c. Be capable of limiting access for configuration to one or more of: a web interface using HTTPS, a command line interface using SSH, or an SNMP connection using SNMP version 3 or later.
- d. Support the ability to lock configuration capability to a dedicated management port.

2.2 DAISY CHAIN IP CONTROLLERS

Controllers used as Daisy Chain IP Controllers must be IP controllers with exactly two Ethernet network connections and basic built-in switch capabilities to allow implementation of an Ethernet network in a daisy chain architecture. Switches incorporated by Daisy Chain IP Controllers are not required to meet the requirements for Ethernet Switches as defined in this Section.

2.3 DATABASE AND WEB SERVER SOFTWARE FOR MODERATE IMPACT SYSTEMS

{For Government Reference Only: This subpart (and its subparts) relate to RA-5(1), RA-5(5); CCI-001062, CCI-001067, CCI-001645, CCI-002906}

All computer-based databases must use Microsoft SQL Server or Oracle or MySQL. All computer-based web interfaces must use Internet Information Services (IIS) or Apache as the web server.

PART 3 EXECUTION

3.1 CYBERSECURITY HARDENING AND CONFIGURATION GUIDES

Install, configure, and harden all hardware and software furnished on this project in accordance with manufacturer provided documentation, procedures, or methods for secure configuration or installation. Do not implement specific hardening actions if that action would conflict with required functionality or another requirement of this Section.

3.2 NETWORK REQUIREMENTS

3.2.1 Information Flow Enforcement In MODERATE Impact Systems

{For Government Reference Only: This subpart (and its subparts) relate to AC-4; CCI-001368, CCI-001414, CCI-001548, CCI-001549, CCI-001550, CCI-001551}

Install and configure Ethernet switches to block all traffic on all ports not required by the control protocol.

3.2.2 Wireless and Wired Broadcast Communication for Fire Protection Systems

The use of wireless and wired broadcast communication for fire protection systems within a facility is prohibited. Wireless communication may be used to provide communication from the fire protection system in a facility to the central monitoring station. Communication between the fire protection system and the central monitoring station must be via FIPS 140-2 certified devices.

3.2.3 Non-IP Control Networks

When control system specifications require particular communication protocols, use only those communication protocols and only as specified. Do not implement any other communication protocol.

When control system specifications do not indicate requirements for communication protocols, use only those protocols required for operation of the system as specified.

3.2.4 IP Control Networks

{For Government Reference Only: This subpart relates to CM-6(a), CM-7(a), CM-7(b), CM-7(1)(b), SC-41; CCI-001588, CCI-000381, CCI-000380, CCI-000381, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546. For Moderate Impact Systems, this subpart (and its subparts) also relates to SC-5(1), SC-5(2); CCI-001094 CCI-001095}

IP Networks must be Ethernet networks and must use switches which are Ethernet Switches or Daisy Chain IP Controllers as defined in this Section. Do not use nonsecure functions, ports, protocols and services as defined in DODI 8551.01 unless those ports, protocols and services are specifically required by the control system specifications or otherwise specifically authorized by the Government. Do not use ports, protocols and services that are not specified in the control system specifications or required for operation of the control system.

For MODERATE Impact Systems, unless explicitly authorized, do not use IP networks if the same control functionality is available through the use of non-IP networks.

3.2.4.1 IP Network Routers

Do not install any device that performs IP routing.

3.2.4.2 IP Devices With Multiple Ethernet Connection

Except for Ethernet Switches and Daisy Chain IP Controllers, devices must

not have more than one Ethernet connection to IP networks unless doing so is required by the project specifications and the specific application is approved. If a device with Multiple Ethernet Connections to IP networks is required, provide a [Multiple Ethernet Connection Device Request](#) using the Multiple Ethernet Connection Device Request Template at <https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1> to request approval for each device. If a device with Multiple Ethernet Connections to IP networks is not required, instead provide a document stating that no approval is being requested.

3.2.5 Cryptographic Protection

{For Government Reference Only: This subpart relates to IA-2(9), IA-3(1), SC-8, SC-13, SC-23(1), SC-23(3); CCI-001942, CCI-001959, CCI-001967, CCI-002418, CCI-002449, CCI-002450, CCI-001185, CCI-001188, CCI-001664.}

All remote user interfaces must use HTTPS for all traffic between the user interface client and user interface server.

For devices that have STIG/SRGs related to cryptographic protection (CCI-002450), comply with the requirements of those STIG/SRGs. Ensure that all network traffic is encrypted using NSA-approved cryptography; provision of digital signatures and hashing, and FIPS-validated cryptography.

3.2.6 Device Identification and Authentication

{For Government Reference Only: This subpart (and its subparts) relates to IA-3; CCI-000777, CCI-000778, CCI-001958. For MODERATE Impact systems, this subpart (and its subparts) also relates to SC-23, SC-23(5); CCI-001184, CCI-002470.}

All computers must support and implement IEEE 802.1x for device authentication to the network.

3.2.6.1 Default Requirements for Control System Devices

For control system devices where Device Identification and Authentication requirements are not otherwise indicated in this Section: Devices using Ethernet must support IEEE 802.1x. Devices using HTTP as a control protocol must use HTTPS instead.

3.2.7 Cryptographic Module Authentication

{For Government Reference Only: This subpart (and its subparts) relates to IA-7; CCI-000803}

For devices (including but not limited to NIST FIPS 140-2 compliant radios) that have STIG/SRGs related to cryptographic module authentication (CCI-000803), comply with the requirements of those STIG/SRGs.

3.3 ACCESS CONTROL REQUIREMENTS

3.3.1 User Accounts

{For Government Reference Only: This subpart (and its subparts) relate to AC-2(a), AC-3, AC-6(1), AC-6(10), AC-6(2), AC-6(9), CM-11(2), and IA-2; CCI-002110, CCI-000213, CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-002235, CCI-000039, CCI-001419, CCI-002234, CCI-001812, and CCI-000764.}

For MODERATE Impact systems, this subpart (and its subparts) also relate to AC-2 (2), AC-2(3), AC-2(4), AC-6(1), and CM-5(1); CCI-001361, CCI-000017, CCI-000217, CCI-000018, CCI-001403, CCI-001404, CCI-001405, CCI-002130, CCI-001683, CCI-001684, CCI-001685, CCI-001686, CCI-002132, CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-001813.}

Any user interface supporting user accounts (either FULLY or MINIMALLY) must limit access according to specified limitations for each account. Install and configure any device having a STIG or SRG in accordance with that STIG or SRG.

All user interfaces FULLY supporting accounts must implement user-based authentication where each account is uniquely assigned to a specific user. User interfaces FULLY supporting accounts must implement at least three (3) levels of user account privilege including: 1) an account with read-only permissions 2) an account with full permissions including account creation and modification and 3) an account with greater permissions than read-only but without account creation and modification.

3.3.1.1 Computers

All computer operating systems must FULLY support user accounts and implement accounts for access. Each control system software application not supporting accounts and running on a computer must be installed such that use of the software is restricted by the computer operating system to specific users.

Applications running on computers must not require the user be logged in to a computer operating system administrator account for normal operation. It is permissible to require the computer operating system administrator account for initial application installation and configuration.

3.3.1.2 Controllers

For user interfaces provided by controllers, provide access control in accordance with the User Interface Requirements table for the applicable control system and user interface type.

- a. For table entries of "NA": NA means Not Applicable, there are no interfaces in this category.
- b. For table entries of "None Required": The user interface is not required to support user accounts.
- c. For table entries of "MINIMALLY": The user interface must at least MINIMALLY support user accounts.
- d. For table entries of "FULLY": The user interface must at FULLY support user accounts.
- e. For table entries of "KEY": The user interface must have physical security in the form of either a key lock on the interface itself or be furnished inside a locked enclosure. Where this is required for a read only interface, this lock must prevent viewing of data on the interface; for other interfaces, this lock must prevent using the interface to alter data.

- f. For table entries of "Physical Security": For Local FULL interfaces, the interface must be located inside mission space. For Local Limited (not FULL) interfaces, the user interface must either a) be located within mission space or b) be protected by physical security at least as good as the control devices (and equipment controlled by the control devices) affected by the interface. For purposes of this requirement, 'affected' includes controllers with data that can be directly altered by the interface, as well as mechanical and/or electrical equipment directly controlled by those controllers, but does not include other interactions.
- g. Entries of the form "X and Y" must meet both the requirement indicated for X and the requirement indicated for Y. For example, an entry of "MINIMALLY and Physical Security" indicates the user interface must both MINIMALLY support accounts and have physical security.
- h. Entries of the form "X or Y" must meet either the requirement indicated for X or the requirement indicated for Y.

3.3.1.2.1 Fire Protection Systems

User Interface Requirements for LOW Impact Fire Protection Systems	
<u>User Interface Type</u>	<u>Access Control Requirement</u>
Local Read Only (see note 1)	None Required
Local Limited, Non-privileged	KEY or MINIMALLY
Local Limited, Privileged	KEY and Physical Security
Local Full	KEY
Remote Read Only	None Required
Remote Limited, Non-Privileged	MINIMALLY
Remote Limited, Privileged AND Remote Full	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged	
User Interface Requirements for MODERATE Impact Fire Protection Systems	
<u>User Interface Type</u>	<u>Access Control Requirement</u> (See note 2)
Local Read Only	None Required
Local Limited, Non-privileged	KEY or MINIMALLY
Local Limited, Privileged	KEY and Physical Security

User Interface Requirements for MODERATE Impact Fire Protection Systems	
<u>User Interface Type</u>	<u>Access Control Requirement</u> (See note 2)
Local Full	KEY
Remote Read Only	None Required
Remote Limited, Non-Privileged	FULLY
Remote Limited, Privileged AND Remote Full	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Devices outside mission space require physical security protections as indicated (in "PHYSICAL SECURITY IN MODERATE IMPACT SYSTEMS")	

3.3.1.2.2 Default Requirements for Other Control Systems

For control system devices where User Interface Requirements are not otherwise indicated in this Section, use the Default User Interface Requirements tables.

Default User Interface Requirements for LOW Impact Control Systems	
<u>User Interface Type</u>	<u>Access Control Requirement</u>
Local Read Only (see note 1)	None Required
Local Limited, Non-privileged	MINIMALLY
Local Limited, Privileged	MINIMALLY
Local Full	FULLY
Remote Read Only	None Required
Remote Limited, Non-Privileged	MINIMALLY
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged	

Default User Interface Requirements for MODERATE Impact Control Systems	
<u>User Interface Type</u>	<u>Access Control Requirement</u> (See note 3)
Local Read Only (see note 1)	None Required
Local Limited, Non-privileged	MINIMALLY
Local Limited, Privileged	MINIMALLY and Physical Security
Local Full	FULLY
Remote Read Only	None Required
Remote Limited, Non-Privileged	FULLY
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged 3)Devices outside mission space require physical security protections as indicated (in "PHYSICAL SECURITY IN MODERATE IMPACT SYSTEMS")	

3.3.1.3 Additional User Account Expiration Requirements In MODERATE Impact Systems:

In addition to other user account requirements, user account expiration and auditing must be configured as indicated.

3.3.1.3.1 For Control System Applications Running on Computers

If temporary accounts are supported, expire temporary accounts 72 hours after creation. Expire all other accounts after 35 days of inactivity.

3.3.1.3.2 For Other Control System Devices FULLY Supporting Accounts

If temporary accounts are supported, expire temporary accounts 72 hours after creation. Expire all other accounts after 365 days of inactivity.

3.3.2 Unsuccessful Logon Attempts

{For Government Reference Only: This subpart (and its subparts) relate to AC-7 (a), AC-7 (b); CCI-000043, CCI-000044, CCI-001423, CCI-002236, CCI-002237, CCI-002238}

Except for high availability user interfaces indicated as exempt, devices must meet the indicated requirements for handling unsuccessful logon attempts. If a device cannot meet these requirements, document device capabilities to protect from subsequent logon attempts and propose alternate protections in a [Device Account Lock Exception Request](#) submittal. Do not implement alternate protection measures in lieu of the indicated requirements without explicit permission from the Government. If no Device Account Lock Exceptions are requested, provide a document

stating that no approval is being requested as the Device Account Lock Exception Request.

3.3.2.1 Devices MINIMALLY Supporting Accounts

For MODERATE Impact Systems: Devices which MINIMALLY (but not FULLY) support accounts must lock the user account after three consecutive failed login attempts and must unlock the user account after 60 minutes have elapsed without an unsuccessful login attempt or by a successful login to a separate administrator account.

3.3.2.2 Devices FULLY Supporting Accounts

Devices which FULLY support accounts must meet the following requirements.

- a. It must lock the user account when three unsuccessful logon attempts occur within a 15 minute interval.
- b. Once an account is locked, the account must stay locked until unlocked by an administrator. If the account being locked is the sole administrator account on the device, the account must stay locked for 1 hour and then automatically unlock.
- c. Once the indicated number of unsuccessful logon attempts occurs, delay further logon prompts by 5 seconds.

3.3.3 System Use Notification

{For Government Reference Only: This subpart (and its subparts) relates to AC-8; CCI-000048, CCI-002247, CCI-002243, CCI-002244, CCI-002245, CCI-002246, CCI-000050, CCI-002248}

3.3.3.1 System Use Notification for Remote User Interfaces

Remote user interfaces must display a warning banner meeting the requirements of DTM 08-060 on screen.

3.3.3.2 System Use Notification for Local User Interfaces

Devices which are connected to a network and have a local user interface must display a warning banner meeting the requirements of DTM 08-060 on the user interface screen if capable of doing so and must have a permanently affixed label with an approved banner from DTM 08-060 if unable to display the warning banner on the screen. Where it is impractical (perhaps due to device size) to affix the label to the device, affix the label to the device enclosure.

Labels must be machine printed or engraved, plastic or metal, designed for permanent installation, must use a font no smaller than 14 point, and must provide a high contrast between font and background colors.

3.3.4 Session Lock and Session Termination Requirements In MODERATE Impact Systems:

{For Government Reference Only: This subpart (and its subparts) relates to AC-11(a), AC-11(b), AC-11(1), AC-12, SC-10; AC-10; CCI-000058, CCI-000059, CCI-000056, CCI-000057, CCI-000060, CCI-002360, CCI-002361, CCI-001133, CCI-001134, CCI-000054, CCI-000055, CCI-002252}

3.3.4.1 Session Termination

When session termination is required for a User Interface, the User Interface must implement session termination a) based on manual initiation, or b) based on lack of activity, or c) based on either manual initiation or lack of activity, as indicated.

Session Termination must result in logging out the user. A logged out User Interface may only perform actions as indicated in the "Permitted Actions Without Identification or Authentication" subpart of this Section or display a publicly viewable image or blank screen. User Interfaces must remain logged out (session terminated) until a user enters correct authentication information, which must initiate a new session. All User Interfaces running on computers and all Remote User Interfaces must also terminate network connections as part of session termination.

3.3.4.2 Session Lock

When session lock is required for a User Interface, the User Interface must implement session lock a) based on manual initiation, or b) based on lack of activity, or c) based on either manual initiation or lack of activity, as indicated.

Session lock must result in the User Interface being suspended and the user interface must display a publicly viewable image or blank screen. No interaction with the user interface must be possible until either a) the same user enters valid authentication information, in which case that session must be continued, or b) until a different user enters valid authentication information at which point the first session must be terminated and a new session initiated for the new user.

3.3.4.3 Session Lock and Termination for Computers

User Interface sessions provided by computer operating systems must support the requirement for both Session Lock and Session Termination. Session Lock and Session Termination must be capable of being initiated by the user and must also be initiated by lack of activity. Session Lock must occur after 15 minutes of inactivity, and Session Termination must occur after 30 minutes total of inactivity (including, not in addition to, the time for Session Lock). When a user initiates a new session, terminate existing sessions if necessary to limit the total number of concurrent sessions to 1.

Other User Interface sessions running on computers (for local user interfaces) or hosted on a computer (for remote user interfaces) and supporting accounts must support user initiation of Session Termination and session lock. Session lock may be initiated by user initiation or automatically after 15 minutes of inactivity. In addition, remote User Interface sessions must also initiate Session Termination after 30 minutes of inactivity.

3.3.4.4 Session Lock and Termination for Controllers

Writable Remote User Interfaces must support requirements for Session Termination, and must both be capable of being initiated by the user and initiated by lack of activity. Session Termination must initiate after 30 minutes of inactivity.

Local User Interfaces supporting accounts must support manual initiation of Session Termination. Privileged Local User Interfaces must also support timed initiation of Session Termination, unless otherwise indicated in the Session Lock and Termination Exceptions table, with Session Termination initiated at 30 minutes of inactivity. They must also support session lock, where session lock may be initiated by user initiation or automatically after 15 minutes of inactivity.

3.3.5 Permitted Actions Without Identification or Authentication

{For Government Reference Only: This subpart (and its subparts) relates to AC-14; CCI-000061, CCI-000232}

The control system must require identification and authentication before allowing any actions except read-only actions by a user acting from a user interface which MINIMALLY or FULLY supports accounts.

3.3.6 Physical Security in MODERATE Impact Systems

{For Government Reference Only: This subpart relates to PE-3(1), PE-4, PE-5, SC-7(a), SC-7(c), SC-8, SC-8(1); CCI-000928, CCI-002926, CCI-000936, CCI-002930, CCI-002931, CCI-000937, CCI-001097, CCI-001109, CCI-002418, CCI-002419, CCI-002421.}

3.3.6.1 Physical Security for Media

3.3.6.1.1 Physical Security for Media Inside Mission Space

Install all non-IP network media located inside of the mission space in conduit. Install all IP network media located inside of the mission space in intermediate metallic conduit.

3.3.6.1.2 Physical Security for Media Outside Mission Space

Install all network media (both IP and non-IP) located outside of the mission space in rigid metallic conduit.

3.3.6.1.3 Physical Security for Non-Network Media in Fire Protection Systems

For Fire Suppression Systems which can be inhibited or forced to activate by manipulation of non-network wiring, install all non-network media outside of mission space, including analog and binary instrumentation wiring and power wiring, in rigid metallic conduit.

3.3.6.2 Physical Security for Devices

Install all devices (computers and controllers) which are located outside of mission space in lockable enclosures. (Recall that per definition of mission space, a room controlled by the mission is mission space regardless of whether it is contiguous with other mission space.)

Install all controllers connected to an IP network in lockable enclosures (both inside and outside of mission space).

3.3.6.2.1 Physical Security for Devices in Fire Protection Systems

For Fire Suppression systems with a release panel, install all components of the suppression system either inside mission space, or within locked

enclosures. Components of these systems include: release panel, any relay or interface panels, analog and binary inputs or outputs, control valves, manual valves.

3.3.6.3 Physical Security for User Interfaces

Physical security requirements for User Interfaces are specified in the preceding paragraphs of this Section.

3.3.7 Enclosures

Prior to final acceptance of the system, lock all lockable enclosures. Submit an [Enclosure Keys](#) submittal with all copies of keys for all enclosures and a key inventory list documenting all keys. Label each key with the matching enclosure identifier.

3.4 USER IDENTIFICATION AND AUTHENTICATION

{For Government Reference Only: This subpart (and its subparts) relates to IA-2, IA-2(1), IA-2(12), IA-5 IA-5(b), IA-5(c), IA-5(e), IA-5(g), IA-5(1), IA-5(11); CCI-000764, CCI-000765, CCI-001953, CCI-001954, CCI-001544, CCI-001989, CCI-000182, CCI-001610, CCI-000192, CCI-000193, CCI-000194, CCI-000205, CCI-001619, CCI-001611, CCI-001612, CCI-001613, CCI-001614, CCI-000195, CCI-001615, CCI-000196, CCI-000197, CCI-000199, CCI-000198, CCI-001616, CCI-001617, CCI-000200, CCI-001618, CCI-002041, CCI-002002, CCI-002003. For MODERATE Impact systems, this subpart also relates to AC-6 (1), AC-6(10), AC-6(2), AC-6(9)IA-2(4), IA-5(13); CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-002235, CCI-000039, CCI-001419, CCI-002234, CCI-000768, CCI-002007.}

This subpart indicates requirements for specific methods of identification and authentication for users and user accounts. Where these requirements conflict apply the following order of precedence: 1) If present, Device Specific Requirements take precedence over any other requirements; and then 2) multifactor authentication requirements take precedence over password requirements.

3.4.1 User Identification and Authentication for All System Types

Unless otherwise indicated, all user interfaces supporting accounts (either FULLY or MINIMALLY) must implement Identification and Authorization via passwords.

For MODERATE Impact Systems: User interfaces provided by computer operating systems must implement multifactor authentication via PIV. User interfaces supporting accounts (FULLY or MINIMALLY) on computers must implement multifactor authentication via PIV. Devices with writable remote user interfaces must implement multifactor authentication via PIV. Devices with Privileged Remote User Interfaces must implement multifactor authentication via PIV. Software running on computers and computer operating systems must manage cached authenticators in accordance with the relevant STIGs. All other devices and software must not use cached authenticators.

3.4.2 User Identification and Authentication for Specific System Types

System specific requirements are in addition to and supersede those indicated for all system types. When no additional requirements are indicated for a specific system type the requirements for all systems

still apply to that system type.

3.4.3 Implementation of Identification and Authorization Requirements

Identification and Authorization must be met by one of the following methods:

- a. Direct implementation in the user interface.
- b. For user interfaces on a computer: inheriting the Identification and Authorization from the computer operating system, either by the operating system limiting access to specific applications by user, or by the application itself having permissions based on the user logged into the computer.
- c. For remote interfaces: an implementation shared between the remote user interface server and the remote user interface client. For example, a requirement for PIV authentication may be met on a remote user interface by a PIV reader on a web browser client which sends the authentication information via HTTPS to the remote server.

3.4.4 Password-Based Authentication Requirements

3.4.4.1 Passwords for Software and Applications Running on Computers

All software and applications running on computers supporting password-based authentication must enforce the following requirements:

- a. Minimum password length of 12 characters
- b. Password must contain at least one uppercase character.
- c. Password must contain at least one lowercase character.
- d. Password must contain at least one numeric character.
- e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.
- f. Password must have a minimum lifetime of 24 hours.
- g. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.
- h. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters (where location is significant, a character may be reused if it is in a different position).
- i. Passwords must be cryptographically protected during storage and transmission.

3.4.4.2 Passwords for Controllers FULLY Supporting Accounts

All controllers FULLY supporting accounts and supporting password-based authentication must enforce the following requirements:

- a. Minimum password length of twelve (12) characters
- b. Password must contain at least one uppercase character.
- c. Password must contain at least one lowercase character.
- d. Password must contain at least one numeric character.
- e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.
- f. Password must have a maximum lifetime of sixty (60) days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.
- g. Password must differ from previous five (5) passwords, where differ is defined as changing at least fifty percent of the characters.
- h. Passwords must be cryptographically protected during storage and transmission.

3.4.4.3 Passwords for Remote Interfaces

Passwords for connecting to a Remote User Interface supporting password-based authentication must enforce the following requirements:

- a. Minimum password length of twelve (12) characters
- b. Password must contain at least one uppercase character.
- c. Password must contain at least one lowercase character.
- d. Password must contain at least one numeric character.
- e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.
- f. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.
- g. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters (where location is significant, a character may be reused if it is in a different position).
- h. Passwords must be cryptographically protected during storage and transmission.

3.4.4.4 Passwords for Devices Minimally Supporting Accounts

Devices MINIMALLY supporting accounts must support passwords with a minimum length of four characters.

3.4.4.5 Password Configuration and Reporting

For all devices with a password, coordinate the changing of passwords with

the project site following testing of the system but prior to turnover to the Government. Coordinate with Password Point of Contact to determine appropriate project site personnel to complete password changes. Accompany identified personnel to each device with a password and instruct personnel on the process of changing password. Record the time, date and personnel present when each device's password is changed and submit a [Password Change Summary Report](#) documenting this information.

Provide the Password Summary Report electronically in both PDF and Microsoft Excel.

3.4.5 Authenticator Feedback

{For Government Reference Only: This subpart relates to IA-6; CCI-000206}

Devices must never show authentication information, including passwords, on a display. Devices that momentarily display a character as it is entered, and then obscure the character, are acceptable. For devices that have STIGs or SRGs related to obscuring of authenticator feedback (CCI-000206), comply with the requirements of those STIGs/SRGs.

3.5 CYBERSECURITY AUDITING

Where an auditing requirement exists for email notification, notify via email the application administrator and Information System Security Officer (ISSO) of the event. Coordinate with the Email Address Point of Contact for email addresses. If outgoing email is not available to the system, configure the system for these notifications for future support of outgoing email.

3.5.1 Audit Events, Content of Audit Records, and Audit Generation

{For Government Reference Only: This subpart (and its subparts) relates to AU-2(a), AU-2(c), AU-2(d), AU-3, AU-10, AU-12, AU-13(3), AU-14(b), AU-14(1), AU-14(2), AU-14(3), CM-5(1), SC-7 (9); CCI-000123, CCI-001571, CCI-000125, CCI-001485, CCI-000130, CCI-000131, CCI-000132, CCI-012300133, CCI-000134, CCI-001487, CCI-000166, CCI-001899, CCI-000169, CCI-001459, CCI-000171, CCI-000172, CCI-001910, CCI-001914, CCI-001919, CCI-001464, CCI-001462, CCI-001920, CCI-001814, CCI-002400. For MODERATE Impact systems, this subpart (and its subparts) also relates to AU-3 (1); CCI-000135, CCI-001488}

For devices that have STIG/SRGs related to audit events, content of audit records or audit generation, comply with the requirements of those STIG/SRGs.

If auditing requirements can be met using existing control system alarm or event capabilities, those existing capabilities may be used to meet these requirements.

3.5.1.1 Computers

For each computer, provide the capability to select audited events and the content of audit logs. Configure computers to audit the indicated events, and to record the indicated information for each auditable event

3.5.1.1.1 Audited Events

Configure each computer to audit the following events:

- a. Successful and unsuccessful attempts to access, modify, or delete privileges, security objects, security levels, or categories of information (e.g. classification levels)
- b. Successful and unsuccessful logon attempts
- c. Successful logouts
- d. Privileged activities or other system level access
- e. Concurrent logons from different workstations
- f. Successful and unsuccessful accesses to objects
- g. All program initiations
- h. All direct access to the information system
- i. All account creations, modifications, disabling, and terminations. For MODERATE Impact Systems, also provide email notification when these audit events occur.
- j. All kernel module load, unload, and restart

3.5.1.1.2 Audit Event Information To Record

Configure each computer to record, for each auditable event, the following information (where applicable to the event):

- a. What type of event occurred
- b. When the event occurred
- c. Where the event occurred
- d. The source of the event
- e. The outcome of the event
- f. The identity of any individuals or subjects associated with the event
- h. For MODERATE Impact Systems: For all privileged commands, full-text recording of the executed command and the user executing the command

For MODERATE Impact Systems: Audit records must provide sufficient detail to reconstruct events to determine cause of compromise and magnitude of damage, malfunction, or security violation.

3.5.1.2 Default Requirements for Control System Controllers

For control system controllers where Audit Events, Content of Audit Records, and Audit Generation are not otherwise indicated in this Section:

3.5.1.2.1 Controllers Which FULLY Support Accounts

For each controller which FULLY supports accounts, provide the capability to select audited events and the content of audit logs. Configure controllers to audit the indicated events, and to record the indicated

information for each auditable event.

3.5.1.2.1.1 Audited Events

Configure each controller to audit the following events:

- a. Successful and unsuccessful attempts to access, modify, or delete privileges, security objects, security levels, or categories of information (e.g. classification levels)
- b. Successful and unsuccessful logon attempts
- c. Successful logouts
- d. Concurrent logons from different workstations
- e. All account creations, modifications, disabling, and terminations. For MODERATE Impact Systems, also provide email notification when these audit events occur.
- f. All kernel module load, unload, and restart
- g. For privileged user interfaces in MODERATE Impact Systems: All user commands.

3.5.1.2.1.2 Audit Event Information To Record

Configure each controller to record, for each auditable event, the following information (where applicable to the event):

- a. what type of event occurred
- b. when the event occurred
- c. where the event occurred
- d. the source of the event
- e. the outcome of the event
- f. the identity of any individuals or subjects associated with the event
- g. For privileged user interfaces in MODERATE Impact Systems: Full text recording of the executed command and the user executing the command.

For MODERATE Impact Systems: Audit records must provide sufficient detail to reconstruct events to determine cause of compromise and magnitude of damage, malfunction, or security violation

3.5.1.2.2 Controllers Which Do Not FULLY Support Accounts

For each controller which does not FULLY support accounts configure the controller to audit all controller shutdown and startup events and to record for each event the type of event and when the event occurred.

3.5.2 Audit Time Stamps

{For Government Reference Only: This subpart (and its subparts) relates to AU-8; CCI-000159, CCI-001889, CCI-001890. For MODERATE Impact systems,

this subpart (and its subparts) also relates to AU-8 (1); CCI-001891, CCI-001892, CCI-002046.}

Any device (computer or controller) generating audit records must have an internal clock capable of providing time with a resolution of one second. Clocks must not drift more than 10 seconds per day. Configure the system so that each device (computer or controller) generating audit records maintains accurate time to within 1 second. Note that if the control system specifications include requirement for clocks, the most stringent requirement applies.

3.5.3 Auditing Front End Software

The project site currently has the following software to support control system auditing: none. If there is no existing auditing front end software or the software is not compatible with the provided control systems, provide Auditing Front End Software with audit log import and upload, export, notification, and analysis functionality. The Auditing Front End Software may be provided as a component of the control system front end or as a separate software package, and a single package may serve multiple control systems provided under the same projects if they are sharing a cybersecurity authorization.

When the Auditing Front End Software is neither existing nor installed under the requirements of another Section, furnish the Auditing Front End Software media and license for subsequent Government installation and install the software on the control system front end computer. Submit copies of Auditing Front End Software if this function is not part of the software provided with the control system to meet requirements of other Sections.

3.5.3.1 Import and Upload Requirements

Auditing Front End Software must be capable of importing audit logs from the Device Audit Record Upload Software and of uploading audit logs over the network from all control system devices supporting network upload of audit logs.

3.5.3.2 Export Requirements

Auditing Front End Software must be capable of exporting to a file format supported by Microsoft Excel.

3.5.3.3 Notification Of Audit Failure in Devices in MODERATE Impact Systems

The auditing front end software must be capable of receiving notifications of audit failure from control system devices and computers and be able to provide email notification based on receipt of the notification.

3.5.3.4 Audit Reduction and Report Generation In MODERATE Impact Systems

{For Government Reference Only: This subpart (and its subparts) relates to AU-6(4), AU-7(a), AU-7(b), AU-7(1), AU-12(1); CCI-000154, CCI-001875, CCI-001876, CCI-001877, CCI-001878, CCI-001879, CCI-001880, CCI-001881, CCI-001882, CCI-000158, CCI-000173, CCI-000174, CCI-001577.}

Auditing Front End Software must provide audit reduction and reporting capabilities that supports on-demand review and analysis, on demand reporting, and after the fact investigations of security incidents. The

software must be able to combine audit records from all components within the system and analyze them as a single audit record. The software must correct for discrepancies in timestamps of audit logs from different sources and be able to account for discrepancies up to 2 seconds between sources. The software must not alter original audit record content or time ordering of audit records. The software must have the capability to filter audit records using user-defined fields within the audit records.

The audit reduction and reporting capabilities may incorporate third party application, such as Excel or Access.

3.5.4 Audit Storage Capacity and Audit Upload

{For Government Reference Only: This subpart (and its subparts) relates to AU-4; CCI-001848, CCI-001849}

The creation of audit records must never interfere with normal device operation. Devices must cease collection of auditing information if required to maintain normal operation.

- a. For devices that have STIG/SRGs related to audit storage capacity (CCI-001848 or CCI-001849) comply with the requirements of those STIG/SRGs.
- b. For controllers capable of generating audit records, provide 60 days worth of secure local storage, assuming 10 auditable events per day.

3.5.4.1 Audit Log Storage Notification In MODERATE Impact Systems

{For Government Reference Only: This subpart (and its subparts) relates to AU-5(1); CCI-001855.}

Controllers storing audit logs must provide notification when audit logs reach 75 percent of capacity either directly through email or indirectly by sending a notification to a computer, and the computer sending an email. Computers storing audit logs must provide notification when audit logs reach 75 percent of capacity directly through email.

3.5.4.2 Device Audit Record Upload Software

For each device (computer or controller) required to audit events and for which audit logs cannot be uploaded over the network by the Auditing Front End Software, provide and license to the Government software implementing a secure mechanism of uploading audit records from the device and exporting them to the Auditing Front End Software. Where different devices use different software, provide software of each type required to upload audit logs from all devices.

When Device Audit Record Upload Software is capable of uploading audit logs over the network, install Device Audit Record Upload Software on the same computer as the Auditing Front End Software. Submit copies of device audit record upload software if this function is not part of the software provided with the control system to meet requirements of other Sections. If there are no devices requiring this software, provide a document stating this in lieu of this submittal.

3.5.5 Response to Audit Processing Failures

{For Government Reference Only: This subpart (and its subparts) relates

to AU-5; CCI-000139, CCI-000140, CCI-001490.}

In the case of a failure in the auditing system, computers associated with auditing must provide email notification. For MODERATE Impact systems, the computer must also notify the associated auditing front end software. In case of an audit failure, if possible, continue to collect audit records by overwriting existing audit records.

For MODERATE Impact Systems: In the case of an audit failure at a controller performing auditing, the device must notify the associated auditing front end software of the audit failure if able, and must continue to collect audit records by overwriting existing audit records if able. The auditing front end software must provide notification as indicated, treating the notification of failure from the device as a failure in the auditing system.

3.6 REQUIREMENTS FOR LEAST FUNCTIONALITY

{For Government Reference Only: This subpart (and its subparts), along with the network communication report submittal specified elsewhere in this section, relates to CM-6(a), CM-6(c), CM-7, CM-7(1)(b), SC-41; CCI-000363, CCI-000364, CCI-000365, CCI-001588, CCI-001755, CCI-000381, CCI-000380, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546. For MODERATE Impact systems, this subpart (and its subparts) also relates to CM-7(2), CM-7(5)(a), CM-7(5)(b); CCI-000381, CCI-000380, CCI-000382, CCI-001761, CCI-001762}

For devices that have a STIG or SRG related to Requirements for Least Functionality (such as configuration settings and port and device I/O access for least functionality), install and configure the device in accordance with that STIG or SRGs.

3.6.1 Device Capabilities

Do not provide devices with remote user interfaces or full user interfaces where one was not required. Do not use a networked sensor or actuator where a non-networked sensor or actuator would suffice.

Unless specifically required by the government, do not provide a capability to update device firmware over the network.

3.6.2 Software

For software that has a STIG or SRG related to Requirements for Least Functionality (such as configuration settings and port access for least functionality), install and configure the software in accordance with that STIG or SRG.

For MODERATE Impact Systems: Do not provide (install) software that is not specifically required to meet a contract requirement. Do not implement functionality within software that is not specifically required to meet contract requirements.

3.7 SYSTEM AND COMMUNICATION PROTECTION

3.7.1 Collaborative Computing

{For Government Reference Only: This subpart relates to SC-15(a), SC-15(b); CCI-001150, CCI-001152.}

Without explicit approval from the project site, control systems must not use collaborative computing technologies.

3.7.2 Denial of Service Protection and Application Partitioning In MODERATE Impact Systems:

{For Government Reference Only: This subpart relates to SC-5, SC-39, SC-7(a); CCI-001093, CCI-002385, CCI-002386, CCI-002430, CCI-001097. For MODERATE Impact systems, this subpart also relates to SC-2; CCI-001082.}

To the greatest extent practical, implement control logic without reliance on the network. Except when required to meet the requirements of the control system Section (where the requirement can only be met using computer hardware), do not implement control logic in computers. For MODERATE Impact systems, do not implement control logic in a device providing (i.e. acting as a server for) a Full Remote User Interface.

3.7.2.1 Default Requirements for MODERATE Impact Control Systems

Except for networked input and outputs on input-output buses specifically designed to provide high reliability or redundancy, sensors and actuators must not rely on the network to exchange data with the controller executing the sequence of operation which uses the sensor value or determines the actuator command.

Sensor values required by multiple devices may be shared over the network provided they are connected to a controller requiring the value for execution of the sequence and that controller shares the value on the network.

3.7.3 Mobile Code In MODERATE Impact Systems:

{For Government Reference Only: This subpart relates to SC-18(a), SC-18(b), SC-18(c), SC-18(1), SC-18(3), SC-18(4); CCI-001160, CCI-001161, CCI-001162, CCI-001163, CCI-001164, CCI-001165, CCI-001166, CCI-001662, CCI-002457, CCI-002458, CCI-001169, CCI-001695, CCI-001170, CCI-002469}

Devices with STIGs/SRGs related to Mobile Code and to Security Control SC-18 must be installed in accordance with the relevant STIGs/SRGs. All remote user interfaces must meet the requirements of the "Web Browsers and Application SRG".

Mobile code may only be downloaded from a specifically authorized mobile code repository. Coordinate with the Mobile Code Point of Contact for the location of a repository.

3.7.4 Process Isolation and Boundary Protection in Moderate Impact Fire Protection Systems

{For Government Reference Only: This subpart relates to SC-7(a), SC-7(c), SC-7(4)(a), SC-7(4)(c), SC-7(5), SC-7(7), SC-7(9)(a), SC-7(11), SC-7(13), SC-7(13), SC-7(18); CCI-001097, CCI-001098, CCI-001102, CCI-002396, CCI-001109, CCI-002397, CCI-002398, CCI-002399, CCI-002403, CCI-001120, CCI-001119, CCI-001126}

3.7.4.1 Radio Interfaces for Fire Protection Systems

When radios interfacing a local fire protection system to a supervisory

system are not NIST FIPS 140-2 validated, use a relay panel interface between the local fire protection system and the radio. Install and configure the relay panel to prohibit initiating any action within the local fire protection system other than causing the system to play a pre-recorded message or causing the system to play a live audio message. Install relays using the normally closed contact such that they pass a signal when they open, and so that a relay that loses power or has a failed coil passes the signal.

3.7.4.2 Fire Suppression System Network Isolation

For fire suppression systems including a release panel, any network used in these systems must be dedicated to these systems and must be isolated from any other network, including other components of the Fire Alarm and Fire Suppression systems. Use only dry contacts and relays to transfer signals from these systems to any other systems. Install relays using the normally closed contact such that they pass a signal when they open, and so that a relay that loses power or has a failed coil passes the signal.

3.8 SAFE MODE AND FAIL SAFE OPERATION

{For Government Reference Only: This subpart (and its subparts) relates to CP-12, SI-10(3), SI-17; CCI-002855, CCI-002856, CCI-002857, CCI-002754, CCI-002773, CCI-002774, CCI-002775}

For all control system components with an applicable STIG or SRG, configure the component in accordance with all applicable STIGs and SRGs.

3.9 SYSTEM MAINTENANCE TOOL SOFTWARE

{For Government Reference Only: This subpart (and its subparts) relates to MA-3; CCI-000865.}

Submit and license to the Government all software required to operate, maintain and modify the control system such the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer. Submit hard copies of user manuals for each software with the software submittal.

For software provided and licensed to the Government under the requirements of another Section, submit a statement indicating the Section and Submittal under which the software was provided. For software provided to meet the requirements of this Section and not provided and licensed under another Section, submit software and software user manuals on DVD or CD as a Technical Data Package and submit one hard copy of the software user manual for each piece of software.

3.10 DEVICE POWER

{For Government Reference Only: This subpart (and its subparts) relates to PE-11, PE-11(1); CCI-002955, CCI-000961. For MODERATE Impact systems, this subpart (and its subparts) also relates to PE-9, PE-9(1); CCI-000952, CCI-002953, CCI-002954.}

For MODERATE Impact Systems: Provide control system with power supply meeting or exceeding the reliability of the controlled equipment. Powering control system devices using the same power source as the equipment controlled by the device is a permissible method of meeting this

requirement. Without explicit approval from the government, do not install local uninterruptible power supplies (UPSs) as a source of device power.

3.10.1 Device Behavior on Loss of Power In MODERATE Impact Systems:

Application programs and configuration settings must be stored in devices in manner such that a loss of power does not result in a loss of the application program or configuration settings: Loss of power must never result in the loss of application programs, regardless of the length of time power is lost; and loss of power for less than 2,500 hours must not result in the loss of configured settings.

In the event of a loss of power, when power is restored, controllers and computers executing control logic (and the underlying equipment) must recover and resume their normal sequences of operation. Note that the sequence of operation may require specific actions (e.g. startup sequences) upon recovery from loss of power.

3.11 VULNERABILITY SCANNING

{For Government Reference Only: This subpart (and its subparts) relates to RA-5 RA-5(a), RA-5(b), RA-5(c), RA-5(d); CCI-001054, CCI-001055, CCI-000156, CCI-001641, CCI-001643, CCI-001057, CCI-001058, CCI-001059. For MODERATE Impact systems, this subpart (and its subparts) also relates to RA-5(1), RA-5(5); CCI-001062, CCI-001067, CCI-001645, CCI-002906.}

All IP devices must be scannable, such that the device can be scanned by industry standard IP network scanning utilities without harm to the device, application, or functionality.

3.11.1 Controllers

Provide controllers that are scannable by standard control system discovery tools or control system browsers and return meaningful status information including the network inputs and outputs for the controller. This information must contain sufficient detail to detect vulnerabilities or exploits of the controller.

Provide all software needed to scan the control system as the [Control System Scanning Tools](#) submittal. If the software required to scan the system is already installed at the project site or is provided under a separate section instead provide a statement indicating this.

3.12 FIPS 201-2 REQUIREMENT

{For Government Reference Only: This subpart (and its subparts) relates to SA-4 (10); CCI-003116}

Devices in the following systems which implement PIV must be on the [NIST FIPS 201-2](#) approved product list (<https://www.idmanagement.gov/approved-products-list/>): NONE.

3.13 SYSTEM AND INTEGRATION INTEGRITY

3.13.1 Software, Firmware, and Information Integrity In MODERATE Impact Systems:

If there exists [Integrity Verification Software](#) that can check software, firmware, or information in the control system and verify its integrity,

provide it. If no such software exists provide a statement to this affect in lieu of the software.

3.13.2 Information System Monitoring

{For Government Reference Only: This subpart relates to SI-4 (a),(b); CCI-001253, CCI-002645}

3.14 CONTROL SYSTEM CYBERSECURITY TESTING

{For Government Reference Only: For MODERATE Impact systems, this subpart (and its subparts) relates to SA-11(a), SA-11(b), SA-11(c), SA-11(d), SA-11(e); CCI-003171, CCI-003172, CCI-003173, CCI-003174, CCI-003175, CCI-003176, CCI-003177, CCI-003178.}

3.14.1 Control System Cybersecurity Testing Procedures

Prepare Control System Cybersecurity Testing Procedures explaining step-by-step, the actions and expected results that will demonstrate that the control system meets the requirements of this Section.

Submit 4 copies of the Control System Cybersecurity Testing Procedures. The Control System Cybersecurity Testing Procedures may be submitted as a Technical Data Package.

3.14.2 Control System Cybersecurity Testing Execution

Using the Control System Cybersecurity Testing Procedures verify that the control system meets the requirements of this Section. UNLESS GOVERNMENT WITNESSING OF A TEST IS SPECIFICALLY WAIVED BY THE GOVERNMENT, PERFORM ALL TESTS WITH A GOVERNMENT WITNESS. If testing reveals deficiencies in the system, correct the deficiency and retest until successful.

3.14.3 Control System Cybersecurity Testing Report

Prepare and submit a Control System Cybersecurity Testing Report documenting all tests performed and their results. Include all tests in the Control System Cybersecurity Testing Procedures and any additional tests performed during testing. Document test failures and repairs conducted with the test results.

Submit four copies of the Control System Cybersecurity Testing Report. The Control System Cybersecurity Testing Report may be submitted as a Technical Data Package.

3.15 FIELD QUALITY CONTROL, CYBERSECURITY VALIDATION SUPPORT

In addition to testing and testing support required by other Sections, provide a minimum of 8 hours of technical support for cybersecurity testing of control systems to support the DoD Risk Management Framework process Cybersecurity assessment of the control system. This support is independent of (and in addition to) the Control System Cybersecurity Testing specified in this section.

3.16 CYBERSECURITY TRAINING

Provide eight hours of classroom and hands-on training for six Government personnel on the cybersecurity operation and maintenance of the control system provided. This training is in addition to and must be coordinated

with control system training specified in other Sections.

The Government will provide the training location. Training must cover, at a minimum: (a) applying software and firmware updates, (b) user account creation, modification and deletion, (c) audit log upload procedures and (d) identification of privileged user interfaces and system impact of those interfaces. Training session must include a question and answer period during which government staff questions about cybersecurity aspects of the control system are answered.

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SECTION 25 10 10

UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION

PART 1 GENERAL

1.1 SUMMARY

Provide a Utility Monitoring and Control System (UMCS) which performs supervisory monitoring and supervisory control of base-wide building control systems and utility control systems using one or more of: **CEA-709.1-D** (LonWorks) with LonWorks Network Services (LNS), **ASHRAE 135** (BACnet), **MODBUS Protocol**, **MODBUS TCP/IP**, **OPC DA**, or the **Niagara Framework** with Fox protocol as indicated and shown. **Integrate ASHRAE 135 (BACnet) field control systems installed per Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS** as specified.

1.1.1 System Requirements

Provide a UMCS as specified and indicated, and in accordance with the following characteristics:

1.1.1.1 General System Requirements

- a. The system performs supervisory monitoring and control functions including but not limited to Scheduling, Alarm Handling, Trending, Overrides, Report Generation, and Electrical Demand Limiting as specified.
- b. The system includes a Graphical User Interface which allows for graphical navigation between systems, graphical representations of systems, access to real-time data for systems, ability to override points in a system, and access to all supervisory monitoring and control functions.
- c. All software used by the UMCS and all software used to install and configure the UMCS is licensed to and delivered to the installation.
- d. All necessary documentation, configuration information, configuration tools, programs, drivers, and other software is licensed to and otherwise remains with the Government such that the Government or their agents are able to repair, replace, upgrade, and expand the system without subsequent or future dependence on the Contractor. Software licenses must not require periodic fees and must be valid in perpetuity.
- e. Provide sufficient documentation and data, including rights to documentation and data, such that the Government or their agents can execute work to repair, replace, upgrade, and expand the system without subsequent or future dependence on the Contractor.
- f. The UMCS interfaces directly to **ASHRAE 135**, **CEA-709.1-D**, **MODBUS Protocol**, **MODBUS TCP/IP**, **OPC DA**, and **Niagara Framework** field control systems as specified and may interface to field control systems using other protocols via an M&C Software protocol driver or a Gateway.

- g. For UMCS systems with Monitoring and Control Software functionality implemented in Monitoring and Control (M&C) Controller Hardware, provide sufficient additional controller hardware to support the full capacity requirements as specified.

1.1.1.2 BACnet Requirements

- a. The UMCS must communicate using **ASHRAE 135** Annex J over the Government furnished IP network as specified.
- b. All communication between the UMCS and **ASHRAE 135** field control networks must be via the **ASHRAE 135** protocol over the IP network.
- c. All communication between the M&C Software and the field control system devices must be via standard **ASHRAE 135** services other than PrivateTransfer and ConfirmedPrivateTransfer except as follows:
 - (1) PrivateTransfer and ConfirmedPrivateTransfer may be used for device configuration and device programming.
 - (2) PrivateTransfer and ConfirmedPrivateTransfer may be used for communication between the M&C Software and the field control system if and only if both the M&C Software and the field control system devices automatically (without requiring reconfiguration) revert to the use of other standard **ASHRAE 135** services when one of the components is modified or replaced.

1.1.1.3 Modbus Requirements

Modbus communications must support all of the following Modbus data types:

- a. The four standard data types defined by **MODBUS Protocol**, **MODBUS TCP/IP**: Discrete Inputs, Coils, Input Registers, and Holding Registers. (Note that these four data types are included in the **MODBUS Protocol**, **MODBUS TCP/IP** standard. The remaining data types indicated in this Section are not included in the **MODBUS Protocol**, **MODBUS TCP/IP** standard but are defined by this Section to provide a standard for communication between systems.)
- b. Character: Character data using a single Input Register or single Holding Register where that Modbus register is interpreted as two 8 bit **ISO 8859-1** characters, with the low order bits representing the right-hand character.
- c. Floating Point: Floating point data using two consecutive Input Registers or two consecutive Holding Registers where the resulting 32 bits are interpreted as a Binary32 (Single Precision Floating point) number as specified in **IEEE 754**. Use the first Register for the higher 16 bits, and the second Register for the lower 16 bits.
- d. Integer Date: Date data using three consecutive Input Registers or three consecutive Holding Registers where the resulting 48 bits are interpreted as a 48-bit unsigned big-endian integer. The value is the number of milliseconds, not including leap seconds, from 1970-01-01T00:00:00.000 (12AM, January 1, 1970). Use the first Register for the highest 16 bits and the third Register for the lowest 16 bits.

- e. Character Date: Date data using the format specified in ISO 8601 of "YYYY-MM-DDTHH:MM:SS.SSS", where the individual characters are formatted as specified for character data.

1.1.2 Symbols, Definition and Abbreviations

Use symbols, definitions, and engineering unit abbreviations indicated in the contract drawings for displays, submittals and reports. For symbols, definitions and abbreviations not in the contract drawings use terms conforming at a minimum to IEEE Std Dictionary and the ASHRAE FUN IP, as applicable.

1.1.3 System Units and Accuracy

Use English (inch-pound) units for displays, print-outs and calculations. Perform calculations with an accuracy of at least three significant figures. For displays and printouts present values to at least three significant figures.

1.1.4 Data Packages/Submittals Requirements

Technical data packages consisting of computer software and technical data (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications must be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered must be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered shop drawings under the Federal Acquisition Regulation Supplement (FARS) and must contain no proprietary information and must be delivered with unrestricted rights.

1.2 RELATED SECTIONS

Cybersecurity requirements related to this Section are specified in a separate cybersecurity specification derived from UFGS 25 05 11. Sections 25 05 11.01 and 25 05 11.02 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS specify cybersecurity requirements related to this Section.

1.3 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 OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135

(2020; Interpretation 1-8 2021; Errata 1-2 2021; Addenda CD 2021; Addenda BY-CE 2022; Interpretation 9-10 2022) BACnet—A Data Communication Protocol for Building Automation and Control Networks

ASHRAE FUN IP

(2021) Fundamentals Handbook, I-P Edition

CONSUMER ELECTRONICS ASSOCIATION (CEA)

- CEA-709.1-D (2014) Control Network Protocol Specification
- CEA-852-C (2014) Tunneling Device Area Network Protocols Over Internet Protocol Channels

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

- IEEE 754 (2008) Floating-Point Arithmetic - IEEE Computer Society
- IEEE 1815 (2015; CORR 2016) Exchanging Information Between Networks Implementing IEC 61850 and IEEE Std 1815 Distributed Network Protocol (DNP3)
- IEEE C62.41 (1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
- IEEE Stds Dictionary (2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

- ISO 8601 (2004) Data Elements and Interchange Formats - Information Interchange - Representation of Dates and Times
- ISO 8859-1 (1998) Information Technology - 8-Bit Single-Byte Coded Graphic Character Sets - Part 1: Latin Alphabet No. 1

INTERNET ENGINEERING TASK FORCE (IETF)

- IETF RFC 4361 (2006) Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)

LONMARK INTERNATIONAL (LonMark)

- LonMark Interoperability Guide (2005) LonMark Application-Layer Interoperability Guide and LonMark Layer 1-6 Interoperability Guide; Version 3.4
- LonMark SNVT List (2014) LonMark SNVT Master List; Version 15
- LonMark XIF Guide (2001) LonMark External Interface File Reference Guide; Revision 4.402

MODBUS ORGANIZATION, INC (MODBUS)

- MODBUS Protocol (2012) Modbus Application Protocol Specification; Version 1.1b3
- MODBUS TCP/IP (2006) Modbus Messaging on TCP/IP Implementation Guide; Version V1.0b

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 262	(2019) Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces

OPC FOUNDATION (OPC)

OPC DA	(Ver 3.0; Errata) OPC Data Access (DA)

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

TRIDIUM, INC (TRIDIUM)

Niagara Framework	(2012) NiagaraAX User's Guide

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC EMC	(2002) FCC Electromagnetic Compliance Requirements
FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 60950	(2000; Reprint Oct 2007) Safety of Information Technology Equipment

1.4 DEFINITIONS

The following list of definitions may contain terms not found elsewhere in this Section but are included here for completeness. Some terms are followed with a protocol reference in parenthesis indicating to which protocol the term and definition applies. Inclusion of protocol-specific definitions does not create a requirement to support that protocol, nor does it relax any requirements to support specific protocols as indicated elsewhere in this section.

1.4.1 Alarm Generation

The process of comparing a point value (the point being alarmed) with a pre-defined alarm condition (e.g. a High Limit) and performing some action based on the result of the comparison.

1.4.2 Alarm Handling

see Alarm Routing

1.4.3 Alarm Routing

Alarm routing is M&C software functionality that starts with a notification that an alarm exists (typically as the output of an Alarm Generation process) and sends a specific message to a specific alarm recipient or device.

1.4.4 BACnet (BACnet)

The term BACnet is used in two ways. First meaning the BACnet Protocol Standard - the communication requirements as defined by [ASHRAE 135](#) including all annexes and addenda. The second to refer to the overall technology related to the [ASHRAE 135](#) protocol.

1.4.5 BACnet Advanced Application Controller (B-AAC)(BACnet)

A hardware device BTL Listed as a B-AAC. A control device which contains BIBBs in support of scheduling and alarming but otherwise has limited resources relative to a B-BC. It may be intended for specific applications and supports some degree of programmability.

1.4.6 BACnet Advanced Operator Workstation (B-AWS)(BACnet)

Monitoring and Control (M&C) Software BTL Listed as an Advanced Operator Workstation and includes the ability to manage scheduling, alarming and trending in an open manner. The B-AWS is the advanced operator's window into a BACnet system. It is primarily used to monitor the performance of a system and to modify parameters that affect the operation of a system.

1.4.7 BACnet Application Specific Controller (B-ASC)(BACnet)

A hardware device BTL Listed as a B-ASC. A controller with limited resources relative to a B-AAC. It is intended for use in a specific application and supports limited programmability.

1.4.8 BACnet Building Controller (B-BC)(BACnet)

A hardware device BTL Listed as a B-BC. A general-purpose, field-programmable device capable of carrying out a variety of building automation and control tasks including control and monitoring via direct digital control (DDC) of specific systems and data storage for trend information, time schedules, and alarm data. Like the other BTL Listed controller types (B-AAC, B-ASC etc.) a B-BC device is required to support the server ("B") side of the ReadProperty and WriteProperty services, but unlike the other controller types it is also required to support the client ("A") side of these services. Communication between controllers requires that one of them support the client side and the other support the server side, so a B-BC is often used when communication between controllers is needed.

1.4.9 BACnet Internetwork (BACnet)

Two or more BACnet networks connected with BACnet routers. In a BACnet Internetwork, there exists only one message path between devices.

1.4.10 BACnet Interoperability Building Blocks (BIBBs) (BACnet)

A BIBB is a collection of one or more BACnet services intended to define a higher level of interoperability. BIBBs are combined to build the BACnet functional requirements for a device in a specification. Some BIBBs define additional requirements (beyond requiring support for specific services) in order to achieve a level of interoperability. For example, the BIBB DS-V-A (Data Sharing-View-A), which would typically be used by an M&C client, not only requires the client to support the ReadProperty Service, but also provides a list of data types (Object / Properties) which the client must be able to interpret and display for the user.

1.4.11 BACnet Operator Display (B-OD)(BACnet)

A hardware device BTL Listed as a B-OD. A basic operator interface with limited capabilities relative to a B-OWS. It is not intended to perform direct digital control. The B-OD profile could be used for wall-mounted LCD devices, displays affixed to BACnet devices; hand-held terminals or other very simple user interfaces.

1.4.12 BACnet Operator Workstation (B-OWS)(BACnet)

Monitoring and Control (M&C) Software BTL Listed as a B-OWS. An operator interface with limited capabilities relative to a B-AWS. The B-OWS is used for monitoring and basic control of a system, but differs from a B-AWS in that it does not support configuration activities, nor does it provide advanced troubleshooting capabilities.

1.4.13 BACnet Smart Actuator (B-SA)(BACnet)

A hardware device BTL Listed as a B-SA. A simple control output device with limited resources; it is intended for specific applications.

1.4.14 BACnet Smart Sensor (B-SS)(BACnet)

A hardware device BTL Listed as a B-SS. A simple sensing device with very limited resources.

1.4.15 BACnet Testing Laboratories (BTL)(BACnet)

Established by BACnet International to support compliance testing and interoperability testing activities and consists of BTL Manager and the BTL Working Group (BTL-WG). BTL also publishes Implementation Guidelines.

1.4.16 BACnet Testing Laboratories (BTL) Listed (BACnet)

A device that has been certified by BACnet® Testing Laboratory. Devices may be certified to a specific device profile, in which case the certification indicates that the device supports the required capabilities for that profile, or may be certified as "other".

1.4.17 Binary

A two-state system or signal; for example one where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. 'Digital' is sometimes used interchangeably with 'binary'.

1.4.18 Broadcast

Unlike most messages, which are intended for a specific recipient device, a broadcast message is intended for all devices on the network.

1.4.19 Building Control Network (BCN)

The network used by the Building Control System. Typically the BCN is a BACnet [ASHRAE 135](#) or LonWorks [CEA-709.1-D](#) network installed by the building control system contractor.

1.4.20 Building Control System (BCS)

One type of Field Control System. A control system for building electrical and mechanical systems, typically HVAC (including central plants) and lighting. A BCS generally uses Direct Digital Control (DDC) Hardware and generally does NOT include its own local front end.

1.4.21 Building Point of Connection (BPOC)

A FPOC for a Building Control System. (This term is being phased out of use in preference for FPOC but is still used in some specifications and criteria. When it was used, it typically referred to a piece of control hardware. The current FPOC definition typically refers instead to IT hardware)

1.4.22 Commandable (BACnet)

A point (Object) is commandable if its Present_Value Property is writable and it supports the optional Priority_Array Property. This functionality is useful for Overrides.

1.4.23 Control Logic Diagram

A graphical representation of control logic for multiple processes that make up a system.

1.4.24 Device Object (BACnet)

Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object_Identifier number on the BACnet Internetwork. This number is often referred to as the device instance or device ID.

1.4.25 Field Point Of Connection (FPOC)

The FPOC is part of the UMCS IP network and acts as the point of connection between the UMCS IP Network and the field control IP network. The FPOC is an IT device such as a switch, IP router, or firewall, typically managed by the site IT staff. (Note that the field control IP network may consist of a single IP device, or that integration may require installation of a field control network IP device.)

1.4.26 Field Control Network

The network used by a field control system.

1.4.27 Field Control System (FCS)

A building control system or utility control system.

1.4.28 Gateway

A device that translates from one protocol to another. Devices that change only the transport mechanism of the protocol - "translating" from LonWorks over TP/FT-10 to LonWorks over IP for example - are not gateways as the underlying protocol (data format) does not change. Gateways are also called Communications Bridges or Protocol Translators.

1.4.29 Internetwork (BACnet)

See BACnet Internetwork.

1.4.30 LNS Plug-in (LonWorks)

Software which runs in an LNS compatible software tool, typically a network configuration tool. Device configuration plug-ins provide a 'user friendly' method to edit a device's configuration properties.

1.4.31 Modbus

A basic protocol for control network communications generally used in utility control systems. The Modbus protocol standard is maintained by The Modbus Organization.

1.4.32 Master-Slave/Token Passing (MS/TP)(BACnet)

Data link protocol as defined by the BACnet standard. Multiple speeds (data rates) are permitted by the BACnet MS/TP standard.

1.4.33 Monitoring and Control (M&C) Software

The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

1.4.34 Network (BACnet)

In BACnet, a portion of the control internetwork consisting of one or more segments of the same media connected by repeaters. Networks are separated by routers.

1.4.35 Object (BACnet)

A BACnet Object. The concept of organizing BACnet information into standard components with various associated Properties. Examples include Analog Input objects and Binary Output objects.

1.4.36 Override

To change the value of a point outside of the normal sequence of operation where this change has priority over the sequence. An override can be accomplished in one of two ways: the point itself may be Commandable and written to with a priority or there may be a separate point on the controller for the express purpose of implementing the override.

Typically this override is from the Utility Monitoring and Control System (UMCS) Monitoring and Control (M&C) Software. Note that this definition is not standard throughout industry.

1.4.37 Point, Calculated

A value within the M&C Software that is not a network point but has been calculated by logic within the software based on the value of network points or other calculated points. Calculated points are sometimes called virtual points or internal points.

1.4.38 Point, Network

A value that the M&C Software reads from or writes to a field control network.

1.4.39 Polling

A requested transmission of data between devices, rather than an unrequested transmission such as Change-Of-Value (COV) or Binding where data is automatically transmitted under certain conditions.

1.4.40 Property (BACnet)

A BACnet Property - a data element associated with an Object. Different Objects have different Properties, for example an Analog Input Object has a Present_Value Property (which provides the value of the underlying hardware analog input), a High_Limit Property (which contains a high limit for alarming), as well as other properties.

1.4.41 Protocol Implementation Conformance Statement (PICS)(BACnet)

A document, created by the manufacturer of a device, which describes which portions of the BACnet standard are implemented by a given device.

1.4.42 Repeater

A device that connects two control network segments and retransmits all information received on one side onto the other.

1.4.43 Router (BACnet)

A device that connects two or more BACnet networks and controls traffic between the networks by retransmitting signals received from one network onto another based on the signal destination. Routers are used to subdivide an internetwork and to control bandwidth usage.

1.4.44 Segment

A 'single' section of a control network that contains no repeaters or routers. There is generally a limit on the number of devices on a segment, and this limit is dependent on the topology/media and device type. For example, a TP/FT-10 segment with locally powered devices is limited to 64 devices, and a BACnet MS/TP segment is limited to 32 devices.

1.4.45 Service (BACnet)

A BACnet Service. A defined method for sending a specific type of data between devices. Services are always defined in a Client-Server manner,

with a Client initiating a Service request and a Server Executing the Service. Some examples are ReadProperty (a client requests a data value from a server), WriteProperty (a client writes a data value to a server), and CreateObject (a client requests that a server create a new object within the server device).

1.4.46 Standard BACnet Object/Property/Service (BACnet)

BACnet Objects, Properties, or Services that are standard Objects, Properties, or Services enumerated and defined in [ASHRAE 135](#). Clause 23 of [ASHRAE 135](#) defines methods to extend [ASHRAE 135](#) to non-standard or proprietary information. Standard BACnet Objects/Properties/Services specifically exclude any vendor specific extensions.

1.4.47 Supervisory Controller

A controller implementing a combination of supervisory logic (global control strategies or optimization strategies), scheduling, alarming, event management, trending, web services or network management. Note this is defined by use; many supervisory controllers have the capability to also directly control equipment.

1.4.48 Supervisory Gateway

A device that is both a supervisory controller and a gateway.

1.4.49 UMCS Network

An IP network connecting multiple field control systems to the Monitoring and Control Software using one or more of: LonWorks ([CEA-709.1-D](#) and [CEA-852-C](#)), BACnet ([ASHRAE 135](#) Annex J), [MODBUS Protocol](#), [MODBUS TCP/IP](#) or [OPC DA](#).

1.4.50 Utility Control System (UCS)

One type of field control system. Used for control of utility systems such as an electrical substation, sanitary sewer lift station, water pump station, etc. Building controls are excluded from a UCS, however it is possible to have a Utility Control System and a Building Control System in the same facility, and for those systems to share components such as the FPOC. A UCS may include its own local front-end.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section [01 33 00](#) SUBMITTAL PROCEDURES and TABLE 1: PROJECT SEQUENCING:

[SD-02 Shop Drawings](#)

[UMCS Contractor Design Drawings; G](#)

UMCS Contractor Design Drawings as a single complete package: [four \(4\)](#) hard copies and [four \(4\)](#) copies on CDRom. Submit hardcopy drawings on [17 by 11 inches](#) sheets, and electronic drawings in both PDF and AutoCAD format.

Draft As-Built Drawings; G

Draft As-Built Drawings as a single complete package: four (4) hard copies and four (4) copies on CDRom. Submit hardcopy drawings must on 17 by 11 inches sheets, and electronic drawings in both PDF and AutoCAD format.

Final As-Built Drawings; G

Final As-Built Drawings as a single complete package: four (4) hard copies and four (4) copies on CDRom. Submit hardcopy drawings on 17 by 11 inches sheets, and electronic drawings in both PDF and AutoCAD format.

SD-03 Product Data

Product Data Sheets; G

Computer Software; G

The most recent versions of all computer software provided under this specification delivered as a Technical Data Package. Submit the user manuals for all software delivered for this project with the software.

SD-05 Design Data

UMCS IP Network Bandwidth Usage Estimate; G

Four copies of the UMCS IP Network Bandwidth Usage Estimate.

SD-06 Test Reports

Pre-Construction QC Checklist; G

Four copies of the Pre-Construction QC Checklist.

Post-Construction QC Checklist; G

Four copies of the Post-Construction QC Checklist.

Factory Test Procedures; G

Four copies of the Factory Test Procedures. The Factory Test Procedures may be submitted as a Technical Data Package.

Factory Test Report; G

Four copies of the Factory Test Report. The Factory Test Report may be submitted as a Technical Data Package.

Existing Conditions Report; G

Four copies of the Existing Conditions Report.

Start-Up and Start-Up Testing Report; G

Four copies of the Start-Up and Start-Up Testing Report. The

Start-Up and Testing report may be submitted as a Technical Data Package.

PVT Phase I Procedures; G

Four copies of the PVT Phase I Procedures. The PVT Procedures may be submitted as a Technical Data Package.

PVT Phase I Report; G

Four copies of the PVT Phase I Report. The PVT Phase I Report may be submitted as a Technical Data Package.

PVT Phase II Report; G

Four copies of the PVT Phase II Report. The PVT Phase II Report may be submitted as a Technical Data Package.

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G

Four bound O&M Instructions and **four (4)** copies of the Instructions in PDF format on optical disc. Index and tab bound instructions. Submit instructions in PDF form as a single PDF file, or as multiple PDF files with a PDF file table of contents containing links to the other files. O&M Instructions may be submitted as a Technical Data Package.

Preventive Maintenance Work Plan; G

Four copies of the Preventive Maintenance Work Plan. The Preventive Maintenance Work Plan may be submitted as a Technical Data Package.

Basic Training Documentation; G

Training manuals for Basic Training delivered for each trainee on the Course Attendance List with **four (4)** additional copies delivered for archival at the project site. Submit **four (4)** copies of the Course Attendance List with the archival copies. The Basic Training Documentation may be submitted as a Technical Data Package.

Advanced Training Documentation; G

One set of training manuals delivered for each trainee on the Course Attendance List with **four (4)** additional copies delivered for archival at the project site. Submit **four (4)** copies of the Course Attendance List with the archival copies. The Advanced Training Documentation may be submitted as a Technical Data Package.

Refresher Training Documentation; G

One set of training manuals delivered for each trainee on the Course Attendance List with **four (4)** additional copies delivered for archival at the project site. Submit **four (4)** copies of the Course Attendance List with the archival copies. The Refresher

Training Documentation may be submitted as a Technical Data Package.

SD-11 Closeout Submittals

Closeout QC Checklist; G

Four copies of the Closeout QC Checklist.

1.6 PROJECT SEQUENCING

TABLE I: PROJECT SEQUENCING specifies the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3 EXECUTION (denoted by an 'E' in the 'TYPE' column).

1.6.1 Sequencing for Submittals

The sequencing specified for submittals is the deadline by which the submittal must be initially submitted to the Government. Following submission there will be a Government review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, revise the submittal and resubmit it to the Government within 14 days of notification that the submittal has been rejected. Upon re-submittal there will be an additional Government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.

1.6.2 Sequencing for Activities

The sequencing specified for activities indicates the earliest the activity may begin.

1.6.3 Abbreviations

In TABLE I the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

TABLE I. PROJECT SEQUENCING

ITEM	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
1		Notice to proceed	
2	S	Existing Conditions Report	30 days after #1
3	S	Design Drawings	60 days after #1
4	S	Product Data Sheets	60 days after #1

TABLE I. PROJECT SEQUENCING

ITEM	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
5	S	UMCS IP Network Bandwidth Usage Estimate	60 days after #1
6	S	Pre-construction QC Checklist	60 days after #1
7	E	Install UMCS	AA0 #2 thru #6
8	E	Start-Up and Start-Up Testing	AC0 #7
9	S	Post-Construction QC Checklist	30 days AC0 #8
10	S	Computer Software	30 days AC0 #8
11	S	Start-Up and Start-Up Testing Report	30 days AC0 #8
12	S	Draft As-Built Drawings	60 days AC0 #8
13	S	PVT Phase I Procedures	30 days before scheduled start of #14 and AA0 #11
14	E	PVT Phase I	AA0 #13 and #12
15	S	PVT Phase I Report	14 days AC0 #14
16	S	Preventive Maintenance Work Plan	AA0 #11
17	S	O&M Instructions	AA0 #11
18	S	Basic Training Documentation	AA0 #11 and 30 days before scheduled start of #19
19	E	Basic Training (PVT Phase II)	AA0 #16, #17 and #18
20	S	PVT Phase II Report	14 days AC0 #19
21	S	Final As-Built Drawings	30 days AA0 #20
22	S	Advanced Training Documentation	30 days before schedule start of #23 and AA0 #18

TABLE I. PROJECT SEQUENCING

ITEM	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
23	E	Advanced Training	ACO #19, 14 days AA0 #22, and no later than 60 days ACO #19
24	S	Refresher Training Documentation	30 days before #25 and AA0 #18 and #22
25	E	Refresher Training	between 180 and 360 days ACO #19 and AA0 #24
26	S	Closeout QC Checklist	ACO #23

1.7 QUALITY CONTROL (QC) CHECKLISTS

The Contractor's Chief Quality Control (QC) Representative must complete the QC Checklist in APPENDIX A, and must submit the [Pre-Construction QC Checklist](#), [Post-Construction QC Checklist](#) and [Closeout QC Checklist](#) as specified. The QC Representative must verify each item in the Checklist and initial in the provided area to indicate that the requirement has been met. The QC Representative must sign and date the Checklist prior to submission to the Government.

The APPENDIX A QC Checklist is available as an editable file at <http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-10-10>

1.8 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Provide UMCS Operation and Maintenance Instructions which include:

- a. Procedures for the UMCS system start-up, operation and shut-down.
- b. Final As-Built drawings.
- c. Routine maintenance checklist, arranged in a columnar format: The first column listing all installed devices, the second column stating the maintenance activity or stating that no maintenance required, the third column stating the frequency of the maintenance activity, and the fourth column providing any additional comments or reference.
- d. Qualified service organization list including points of contact with phone numbers.
- e. Start-Up and Start-Up Testing Report.
- f. Performance Verification Test (PVT) Procedures and Reports.

PART 2 PRODUCTS

2.1 EQUIPMENT REQUIREMENTS

2.1.1 Product Certifications

For computing devices, as defined in [FCC Part 15](#), supplied as part of the UMCS provide devices which are certified to comply with the requirements of Class B computing devices.

2.1.2 Product Sourcing

For units of the same type of equipment, provide products of a single manufacturer. For each major component of equipment provide equipment with the manufacturer's name and the model and serial number in a conspicuous place. For materials and equipment, provide new standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products.

2.1.3 General Requirements

Provide components that meet the following requirements:

- a. Portions of the data communications equipment system installed in unconditioned spaces must operate properly in an environment with ambient temperatures between [32 and 120 degrees F](#) and ambient relative humidity between 10 percent and 90 percent noncondensing.
- b. Components must accept 100 to 125 volts AC (Vac), 60 Hz, single phase, three wire with a three-pronged, dedicated circuit outlet or be provided with a transformer to meet the component's power requirements.
- c. The equipment must meet the requirements of [NFPA 70](#), [UL 60950](#), [NFPA 262](#), [FCC EMC](#), and [FCC Part 15](#).

2.1.4 Nameplates

Provide nameplates of laminated plastic identifying the function, network address, if applicable, and identifier of the device. Laminated plastic must be at least [0.125 inch](#) thick, white with black center core. Nameplates must be a minimum of [1 by 3 inch](#) with minimum [0.25 inch](#) high engraved block lettering.

2.1.5 Product Data Sheets

For all products (equipment) specified in PART 2 and supplied under this contract, submit copies of all manufacturer catalog cuts and specification sheets to indicate conformance to product requirements. [For Monitoring and Control \(M&C\) Software also include the PICS verifying BTL Listing as a B-AWS.](#)

2.2 CONTROL HARDWARE

2.2.1 Control Protocol Routers

2.2.1.1 BACnet/IP Router

Provide BACnet/IP Routers which perform layer 3 routing of [ASHRAE 135](#) packets over an IP network in accordance with [ASHRAE 135](#) Annex J and Clause 6. The router must provide the appropriate connection to the IP

network and connections to a **ASHRAE 135** MS/TP, or other **ASHRAE 135** network. Devices used as BACnet/IP Routers must be BTL Listed and must support the Network Management-Router Configuration-B (NM-RC-B) BIBB.

2.2.1.2 Modbus/IP Router

Provide Modbus/IP Routers which perform layer 3 routing of **MODBUS Protocol/MODBUS TCP/IP** packets over an IP network in accordance with **MODBUS Protocol/MODBUS TCP/IP**. The router must provide the appropriate connection to the IP network and connections to a non-IP **MODBUS Protocol/MODBUS TCP/IP** network. Modbus/IP Routers must support the Dynamic Host Configuration Protocol (DHCP; **IETF RFC 4361**) for IP configuration but must not rely on this service for configuration. Modbus/IP Routers must be capable of disabling the capability for remote configuration of Modbus routing information from the IP network.

2.2.2 Monitoring and Control (M&C) Controller Hardware

Provide Monitoring and Control (M&C) Controller Hardware which is a microprocessor-based direct digital control hardware and which communicates over the UMCS IP network using one of:

- a. **CEA-709.1-D** in accordance with **CEA-852-C** and using only Standard Network Variable Types (SNVTs) as defined by the LonMark SNVT List.
- b. **ASHRAE 135** in accordance with **ASHRAE 135** Annex J and using only Standard **ASHRAE 135** services.

Monitoring and Control (M&C) Controller Hardware must either meet the requirements of the **LonMark Interoperability Guide** or be BTL Listed.

2.2.3 BACnet Supervisory Controller Hardware

Provide BACnet Supervisory Controller Hardware which is direct digital control hardware and which:

- a. is BTL Listed
- b. communicates using **ASHRAE 135** over an IP network in accordance with **ASHRAE 135** Annex J
- c. has a configurable Object_Name Property
- d. supports the following BIBBS
 - (1) DS-RP-B (Data Sharing-Read Property-B) BIBB for Objects requiring read access from the M&C Software
 - (2) DS-WP-B (Data Sharing-Write Property-B) BIBB for Objects requiring write access from the M&C Software.
 - (3) SCHED-E-B (Scheduling-External-B)
 - (4) AE-N-I-B (Alarm and Event-Notification Internal-B)
 - (5) AE-ACK-B (Alarm and Event-ACK-B)
 - (6) T-VMT-I-B (Trending-Viewing and Modifying Trends-Internal-B)

(7) T-ATR-B (Trending-Automated Trend Retrieval-B)

- e. has a Writable Recipient_List Property of the Notification Class Object

2.2.4 Control Protocol Gateways

Provide Control Protocol Gateways which perform bi-directional protocol translation between two of the following protocols, or between one of the following protocols and another protocol: CEA-709.1-D, ASHRAE 135, MODBUS Protocol, MODBUS TCP/IP, and OPC DA. Provide Control Protocol Gateways which also meet the following requirements.

- a. Gateways must have two or more separate network connections, each appropriate for the protocol and media used. A single network connection must not be used for both protocols.
- b. Gateways must be capable of being installed, configured and programmed through the use of instructions in the manual supplied by the Contractor.
- c. Provide and license to the Government all software required for gateway configuration.
- d. Gateways must retain their configuration after a power loss of an indefinite time, and must automatically return to their pre-power loss state once power is restored.
- e. Gateways must provide capacity for mapping all required points as indicated plus an additional 20 percent between the two protocols it uses.
- f. Gateways must, in addition, meet all requirements specified (in the following subparagraphs) for each of the two protocols it translates.

2.2.4.1 Gateway for CEA-709.1

For a gateways using CEA-709.1-D provide gateways which meet the following requirements in addition to the requirements for all gateways:

- a. It must allow bi-directional mapping of data in the Gateway to Standard Network Variable Types (SNVTs) according to the LonMark SNVT List.
- b. Gateways communicating CEA-709.1-D over an IP network must communicate in accordance with CEA-852-C.
- c. It must allow of its standard network variables (SNVTs) and support transmitting data using the "min, max, and delta" (throttling and heartbeat) methodology.
- d. It must provide the ability to label SNVTs.
- e. It must supply a LonMark external interface file (XIF) as defined in the LonMark XIF Guide for use with LNS tools and utilities.
- f. It must have a "service pin" which, when pressed, will cause the Gateway to broadcast its 48-bit NodeID and ProgramID over the network.
- g. It must provide a configurable self-documenting string.

2.2.4.2 Gateway for ASHRAE 135

For gateways using **ASHRAE 135** provide gateways which meets the following requirements in addition to the requirements for all gateways:

- a. It must allow bi-directional mapping of data in the Gateway to Standard Objects as defined in **ASHRAE 135**.
- b. All **ASHRAE 135** Objects must have a configurable Object_Name Property.
- c. It must be BTL Listed.
- d. Gateways communicating **ASHRAE 135** over an IP network must communicate in accordance with **ASHRAE 135** Annex J.
- e. Gateways communicating **ASHRAE 135** to a field control systems must support the DS-RP-A (Data Sharing-Read Property-A) BIBB and the DS-WP-A (Data Sharing-Write Property-A) BIBB.
- f. Gateways communicating **ASHRAE 135** to the M&C Software or to a BACnet Supervisory Controller must support the DS-RP-B (Data Sharing-Read Property-B) BIBB for Objects requiring read access from the M&C Software and the DS-WP-B (Data Sharing-Write Property-B) BIBB for Objects requiring write access from the M&C Software

2.2.4.3 Gateway for Modbus

For gateways that use **MODBUS Protocol/MODBUS TCP/IP** provide gateways that meet the requirements specified for all gateways and which allow bi-directional mapping of data in the Gateway to **MODBUS Protocol/MODBUS TCP/IP** registers using the four standard Modbus register types (Discrete Input, Coil, Input Register, and Holding Register). Gateways communicating **MODBUS Protocol/MODBUS TCP/IP** to the M&C Software must communicate via **MODBUS Protocol/MODBUS TCP/IP** over TCP/IP and must present floating point values, character values, and date values using the appropriate data type as specified in paragraph **MODBUS REQUIREMENTS**.

2.2.4.4 Gateway for OPC

For gateways that use **OPC DA**, provide gateways that meet the requirements specified for all gateways and which allow bi-directional mapping of data in the Gateway using **OPC DA** tags and which communicate over an IP network in accordance with **OPC DA**.

2.2.4.5 Gateway for DNP3

For gateways that use DNP3, provide gateways that meet the requirements specified for all gateways and which allow bi-directional mapping of data in the Gateway to DNP3 object groups and variations as defined by **IEEE 1815**. Gateways communicating DNP3 over an IP network must communicate in accordance with the LAN/WAN Networking volume of **IEEE 1815**.

2.3 COMPUTER SOFTWARE

2.3.1 M&C Controller Hardware Configuration Software

Provide M&C Controller Hardware Configuration Software consisting of the software required to configure, program, or configure and program each

Monitoring and Control (M&C) Controller Hardware provided for the functions it performs.

2.3.2 Monitoring and Control (M&C) Software

Provide monitoring and control (M&C) software which is a client-server software package with a graphical user interface (GUI) using web-browser based clients. Provide M&C Software which communicates via ASHRAE 135, and MODBUS Protocol/MODBUS TCP/IP, and The M&C Software may support other field control protocols. Provide M&C Software which is BACnet Testing Laboratories Certified ("Listed") as a B-AWS.

Provide a single software package which implements the Scheduling, Alarming, Trending, Graphical System Display, and System Display Editor functionality. Other specified M&C functionality may be implemented in the same software package or in additional software packages. As specified in PART 3 EXECUTION, the M&C Software must operate on Server hardware, except that software for Point Calculations and Demand Limiting may operate on M&C Controller Hardware.

2.3.2.1 Supported Field Control Protocols

Provide M&C Software which supports field control protocols as follows:

- a. The M&C Software must include a driver to ASHRAE 135 over IP in accordance with ASHRAE 135 Annex J.
- b. The M&C Software must include a driver to MODBUS Protocol/MODBUS TCP/IP over TCP/IP. The M&C Software must be capable of reading and writing the Modbus data types as defined in paragraph MODBUS REQUIREMENTS and must, in addition, be capable of manipulating and presenting arbitrary data formats derived from the four standard Modbus data types.
- c. The M&C Software may, in addition, include drivers to other protocols.

Provide M&C Software capable of reading values from and writing values to points via any supported field protocol, and capable of reading values from one field protocol and writing them to another. All points obtained from any field protocol must be available to all M&C Software functionality.

2.3.2.2 Supported Enterprise Protocols

Provide M&C Software which supports oBIX, BACnet Web Services or OPC as an enterprise protocol and which meets the following requirements:

- a. It is able to read values from any point or collection of points (network point, internal point, trend log or schedule) and transmit these values via the enterprise protocol.
- b. It is able to receive data via the enterprise protocol and use this data to change the value of any point.
- c. License the enterprise protocol interface to the project site and document the interface such that any system capable of communicating with that protocol can be used to read and write data from the M&C Software.

2.3.2.3 Point Information

Every point, both network and internal, in the M&C Software must contain the following fields:

2.3.2.3.1 Name

A configurable name used for identification of the point within the M&C Software.

2.3.2.3.2 Description

A configurable description of no less than 80 alpha-numeric characters.

2.3.2.3.3 Value

A field containing the current point value.

2.3.2.3.4 Units

A field containing the engineering units.

2.3.2.3.5 Source

A field identifying the source of the point. For network points, this is generally the address or identification of the field device (for example, the Domain-Subnet-Node address for LonWorks field control devices or the DeviceID for BACnet devices).

2.3.2.4 Point Calculations

Provide M&C software capable of performing calculations and computing the value of a calculated point based on the values of two or more network points and calculated points. Mathematical operators must include: addition, subtraction, multiplication, division, exponentiation (y^x , power), square root, reciprocal, natural logarithm, sin, cos, tan, arcsin, arccos, arctan, and parenthesis. Pi and e must be available as constants for use in calculations.

2.3.2.5 Graphical System Displays

Provide graphical displays consisting of building system (air handler units, VAV boxes, chillers, cooling towers, boilers, etc.) graphic displays. Data associated with an active display must be updated at least once every 5 seconds.

2.3.2.5.1 Navigation Scheme

System graphic displays of building systems and points must be hierarchical displays using a building-to-equipment point-and-click navigation scheme which allows navigation from a garrison-wide display, through a building-wide display to the individual units. Each display must show the building name and number. Each display must show system wide data such as outside air temperature and humidity in the case of an HVAC system application.

- a. For each Building or Building Sub-Area display, show the building footprint and basic floor plan, and clearly show and distinguish between the individual zones and the equipment serving each zone and space.

Show all space sensor and status readings, as applicable, for the individual zones such as space temperature, humidity, occupancy status, etc. Show the locations of individual pieces of monitored and controlled equipment.

- b. For each equipment display show a one-line diagram control schematic representation of the individual pieces of equipment using the symbols and M&C point data types as specified. Use different colors and textures to indicate various components and real time data. Use consistent color and texture meanings across all displays.
- c. Provide displays which clearly distinguish between the following point data types and information:
 - (1) Real-time data.
 - (2) Other user-entered data.
 - (3) Devices in alarm (unacknowledged).
 - (4) Out-of-range, bad, or missing data.
 - (5) Points which are overridden.

2.3.2.5.2 Navigation Commands

Provide system displays which support English language operator commands via point-and-click mouse or keyboard entry for defining and selecting points, parameters, graphics, report generation, and all other functions associated with operation. The operator commands must be usable from any operator workstation with individual operator passwords as specified.

2.3.2.6 Alarms

- a. Alarm Data. Alarm data to be displayed and stored must include:
 - (1) Identification of alarm including building, system (or sub-system), and device name.
 - (2) Date and time to the nearest second of occurrence.
 - (3) Alarm type:
 - (a) Unreliable: Indicates that the source device has failed due to the sensing device or alarm parameter being out-of-range or bad data.
 - (b) High Alarm.
 - (c) Low Alarm.
 - (4) Current value or status of the alarm point, including engineering units
 - (5) Alarm limits, including engineering units.
 - (6) Alarm priority.
 - (7) Alarm Message: A unique message with a field of at least 60

characters. Assignment of messages to an alarm must be an operator editable function.

- (8) Acknowledgement status of the alarm including the time, date and user of acknowledgement.

2.3.2.7 Custom Report Generation

Provide M&C software capable of generating custom reports, including but not limited to the following standard reports:

2.3.2.7.1 Electrical Power Usage Report

An electrical power Usage summary, operator selectable for substations, meters, or transducers, individual meters and transducers, any group of meters and transducers, and all meters for an operator selected time period. The report must include the voltage, current, power factor, electrical demand, electrical power consumption, reactive power (Kvar) for each substation, facility, system or equipment as selected by the operator. The report must be automatically printed at the end of each summary period and include:

- a. Total period consumption.
- b. Demand interval peak for the period, with time of occurrence.
- c. Energy consumption (kWh) over each demand interval.
- d. Time-of-use peak, semi-peak, off-peak, or baseline total kWh consumption.
- e. Reactive power during each demand interval.
- f. Power factor during each demand interval.
- g. Outside air (OA) temperature and relative humidity (RH) taken at the maximum and minimum of OA temperature of the report period with the time and dates of occurrence. At the installation's peak demand interval, the OA temperature and RH must also be recorded.
- h. Calculated heating and cooling degree days based on a 65 degrees F balance point.

2.3.2.7.2 Electrical Peak Demand Prediction Report

A report based on the demand limiting program, which includes:

- a. Electrical Demand Target (EDT).
- b. Actual peak and predicted peak for each demand interval for that day.
- c. Predicted demand for the next demand interval.

2.3.2.7.3 Energy usage Report

An energy usage summary, operator selectable, for a unit, building, area, installation, and the entire UMCS. The report must be divided by utility, and must be capable of reporting on at least four separate utilities. The report must include the following information:

- a. Beginning and ending dates and times.
- b. Total energy usage for each utility for the current and previous day.
- c. Total energy usage for each utility for the current and previous month.
- d. Maximum 15-minute interval average rate of consumption for each utility for the current and previous day and current and previous month.
- e. Outside air (OA) temperature and OA humidity for current and previous month and current and previous day:
 - (1) Average temperature and humidity.
 - (2) Temperature and humidity at maximum and minimum OA temperature with time and date of occurrence.
 - (3) Temperature and humidity at maximum and minimum humidity with time and date of occurrence.
 - (4) Temperature and humidity at the installation's peak demand interval with the time and date of occurrence
- f. Calculated degree days. Reports which include humidity must be configurable to report either dewpoint or relative humidity.

2.3.2.7.4 Water Usage Report

A water usage summary, operator selectable, for a unit, building, area, installation, and the entire UMCS. The report must include the following information:

- a. Beginning and ending dates and times.
- b. Total energy water usage for the current and previous day.
- c. Total water usage for the current and previous month.

2.3.2.7.5 Alarm Report

Outstanding alarms by building or unit, including time of occurrence.

2.3.2.7.6 M&C Software Override Report

Points overridden by the M&C Software, including time overridden, and identification of operator overriding the point.

2.3.2.7.7 Run Time Reports

A report totalizing the accumulated run time of individual pieces of equipment. The operator must be able to define equipment groupings and to generate reports based on these groupings.

2.3.2.7.8 Cooling Tower Profiles

A cooling tower profile for each cooling tower as indicated, including:

- a. Total daily and monthly on-time (each fan).
- b. Number of on and off transitions (each fan).
- c. Maximum and minimum daily condenser water temperature and the time of occurrence for the current and previous months.
- d. Total daily and monthly makeup water consumption.

2.3.2.7.9 Chiller usage Report

A report of the operation of each chiller as shown on a daily and monthly basis, for each of at least 10 discrete loading levels. The report must include:

- a. Average power for the month at each level in kW
- b. Total monthly energy use in kWh at each level
- c. Total monthly energy use in kWh for the chiller (all levels)
- d. Total daily run hours at each level
- e. Total Monthly run hours at each level

2.3.2.7.10 Device Offline Report

A report listing all offline devices in all ASHRAE 135 building control systems integrated to the M&C Software.

PART 3 EXECUTION

3.1 FACTORY TEST

Perform factory testing of the UMCS as specified. The Contractor is responsible for providing personnel, equipment, instrumentation, and supplies necessary to perform required testing. Provide written notification of planned testing to the Government at least 21 days prior to testing, and do not give this notice until after receiving written Government approval of the specific Factory Test Procedures. Provide [Factory Test Procedures](#) which define the tests required to ensure that the system meets technical, operational, and performance specifications. Within the Procedures define location of tests, milestones for the tests, and identify simulation programs, equipment, personnel, facilities, and supplies required. Provide procedures which test all capabilities and functions specified and indicated. Perform the Factory Test using equipment and software of the same manufacturer, model and revision as will be used for the specified project. Include detailed instructions for test setup, execution, and evaluation of test results in the Procedures. Upon completion of the test, prepare a [Factory Test Report](#), documenting the results of the Test, and submit it as specified.

Perform the Factory Test and provide Factory Test Submittals as shown in TABLE II. FACTORY TEST SEQUENCING.

TABLE II. FACTORY TEST SEQUENCING

ITEM #	DESCRIPTION	SEQUENCING
		(START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
1	Submit Factory Test Procedures	90 days after notice to proceed
2	Perform Factory Test	After Approval Of #1
3	Submit Factory Test Report	14 days After Completion Of #2

3.2 EXISTING CONDITIONS SURVEY

Perform a field survey, including but not limited to testing and inspection of equipment to be part of the UMCS, and submit an [Existing Conditions Report](#) documenting the current status and its impact on the Contractor's ability to meet this specification. For field control systems to be integrated to the UMCS which are not already connected to the UMCS IP network, verify the availability of the building network backbone at the FPOC location, and verify that FPOCs shown as existing are installed at the FPOC location.

3.3 DRAWINGS AND CALCULATIONS

3.3.1 [UMCS IP Network Bandwidth Usage Estimate](#)

Provide a UMCS IP Network Bandwidth Usage Estimate for a small, medium or large systems. In this estimate account for field control systems using all M&C required protocols and the integration of field control system via gateways. Define all assumptions used to create the estimate, including but not limited to: trending, fast trends for commissioning, schedules, alarms, display of system graphics and load shedding.

3.3.2 [UMCS Contractor Design Drawings](#)

Revise and update the Contract Drawings to include details of the system design and all hardware components, including contractor provided and Government furnished components. Details to be shown on the Design Drawing include:

- The logical structure of the network, including but not limited to the location of all Control Hardware (including but not limited to each [BACnet Supervisory Controller](#), Control Protocol Gateway, Control Protocol Router, and Monitoring and Control (M&C) Controller).
- Manufacturer and model number for each piece of Computer Hardware and Control Hardware.
- Physical location for each piece of Computer Hardware and Control Hardware.
- Version and service pack number for all software and for all Control Hardware firmware.

3.3.3 As-Built Drawings

Prepare draft as-built drawings consisting of Points Schedule drawings for the entire UMCS, including Points Schedules for each Gateway, and an updated Design Drawing including details of the actual installed system as it is at the conclusion of Start-Up and Start-Up Testing. Provide As-Built Drawings which include details of all hardware components, including contractor provided and Government furnished components. In addition to the details shown in the design drawings, the as-built drawing must include:

- a. IP address(es) and Ethernet MAC address(es) as applicable for each piece of Control Hardware (including but not limited to each BACnet Supervisory Controller, Control Protocol Gateway, Control Protocol Router, and Monitoring and Control (M&C) Controller).
- b. IP address and Ethernet MAC address for each computer server, workstation, and networked printer.
- c. Network identifier (name) for each printer, computer server and computer workstation.
- d. List of ports, protocols and network services for each device connected to an IP network.
- e. Network Addresses: ASHRAE 135 address and Object_ID of the Device Object for all Control Hardware using ASHRAE 135. MODBUS Protocol/ MODBUS TCP/IP address for all Control Hardware using MODBUS Protocol/ MODBUS TCP/IP.

Prepare Draft As-Built Drawings upon the completion of Start-Up and Start-Up Testing and Final As-Built Drawings upon completion of PVT Phase II.

3.4 INSTALLATION REQUIREMENTS

3.4.1 General

Install system components as shown and specified and in accordance with the manufacturer's instructions and provide necessary interconnections, services, and adjustments required for a complete and operable system. Install communication equipment and cable grounding as necessary to preclude ground loops, noise, and surges from adversely affecting system operation. Install Fiber Optic cables and wiring in exposed areas, including low voltage wiring but not including network cable in telecommunication closets, in metallic raceways or EMT conduit as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Do not install equipment in any space which experiences temperatures or humidity outside of the rated operating range of the equipment.

3.4.2 Isolation, Building Penetrations and Equipment Clearance

Provide dielectric isolation where dissimilar metals are used for connection and support. Make all penetrations through and mounting holes in the building exteriors watertight. Drill or core drill holes in concrete, brick, steel and wood walls with proper equipment. Seal conduits installed through openings with materials which are compatible with existing materials. Seal openings with materials which meet the requirements of NFPA 70 and SECTION 07 84 00 FIRESTOPPING.

3.4.3 Nameplates

Provide Nameplates for all Control Hardware and all Computer Hardware. Attach Nameplates to the device in a conspicuous location.

3.5 INSTALLATION OF EQUIPMENT

3.5.1 Wire and Cable Installation

Install system components and appurtenances in accordance with NFPA 70, manufacturer's instructions and as indicated. Provide necessary interconnections, services, and adjustments required for a complete and operable signal distribution system. Label components in accordance with TIA-606. Firestop Penetrations in fire-rated construction in accordance with Section 07 84 00 FIRESTOPPING. Install conduits, outlets and raceways in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Install wiring in accordance with TIA-568.1 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Mark wiring terminal blocks and outlets in accordance with TIA-606. Do not install non-fiber-optic cables in the same cable tray, utility pole compartment, or floor trench compartment with power cables. Properly secure and install neat in appearance cables not installed in conduit or raceways.

3.5.2 Grounding

Install signal distribution system ground in accordance with TIA-607 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Connect equipment racks to the electrical safety ground.

3.5.3 Power-Line Surge Protection

Protect equipment connected to ac circuits must be protected against or withstand power-line surges. Provide equipment protection which meets the requirements of IEEE C62.41. Do not use fuses for surge protection.

3.5.4 IP Addresses

For all Control Hardware requiring an IP address on the UMCS IP Network, coordinate with the Contracting Officer's Representative to obtain IP addresses.

3.5.5 Computer Hardware and Software

3.5.5.1 Monitoring and Control (M&C) Software Configuration

Configure the Monitoring and Control (M&C) Software as specified, as indicated and as follows:

- a. Set up M&C Software user accounts. Coordinate user accounts and permissions with the HVAC shop supervisor.
- b. Change the default password on all accounts. Remove or disable any accounts which do not require authentication (such as guest accounts).
- c. Configure e-mail capability to use a Government furnished SMTP server. Coordinate with Contracting Officer's Representative for SMTP server information.

- d. Disable all ports, protocols, and network services other than those required or specifically permitted by this Section. Services to be disabled include but are not limited to: FTP, Telnet and SSH.
- e. Install web server certificate.

3.5.5.2 Control Hardware Installation

Install Control Hardware in a lockable enclosure and as specified. Configure Control Hardware as specified, as required to meet the functions for which the hardware is used and as follows:

- a. Disable all ports, protocols, and network services other than those required or specifically permitted by this Section. Services to be disabled include but are not limited to: FTP, Telnet, SSH, and HTTP. When disabling of ports, protocols and services is not supported by a product, obtain an exception from this requirement prior to using the product and document non-compliance on the Product Data Sheets and As-Built drawings.
- b. Change the default passwords in all Control Hardware which have passwords. Coordinate new passwords with the HVAC shop supervisor.

3.6 INTEGRATION OF FIELD CONTROL SYSTEMS

Fully integrate the field control systems in accordance with the following three step sequence and as specified and shown.

STEP 1: Install and configure Control Hardware as necessary to connect the field control system to the FPOC, which is part of the UMCS IP network, and to provide control protocol translation and supervisory functionality.

STEP 2: Add Field Control System to M&C Software: Perform system discovery, system database merges, or any other actions necessary to allow M&C Software access to the field control system.

STEP 3: Configure M&C Software to provide monitoring and control of the field control system, including but not limited to the creation of system displays and the configuration of scheduling, alarming, and trending.

3.6.1 Integration Step 1: Install Control Hardware

Install Control Hardware as specified at the FPOC location as shown to connect the field control system to the UMCS IP network via the FPOC and, if necessary, to provide control protocol translation and supervisory functionality. Coordinate all connections and other activities related to an FPOC with **Contracting Officer's Representative**. Depending on the field control system media and protocol this must be accomplished through one of the following:

- a. Connect the existing field control network hardware at the FPOC location to the FPOC.
- b. Install a **Control Protocol Gateway** connected to both the field control network and the FPOC.
- c. Install a **Control Protocol Router** connected to both the field control network and the FPOC.

- c. Install a Control Protocol Gateway connected to the field control network. Then install a Control Protocol Router connected to both the Control Protocol Gateway and the FPOC.

In addition, for integration of field control systems via ASHRAE 135, also install a BACnet Supervisory Controller as needed to implement scheduling, alarming and trending in the field control system. The BACnet supervisory controller may be the same device as the control protocol gateway or router.

3.6.1.1 Installation of Control Protocol Gateway

If the field control system uses a protocol which is not supported by the M&C Software, install a gateway to convert the field control system protocol to **ASHRAE 135**, or to **MODBUS Protocol/MODBUS TCP/IP**, . Install additional field control system network media and hardware as needed to connect the Gateway to the field control system. Connect the Gateway according to one of the two following methods:

- a. Connect the Gateway to the field control network and to the FPOC. .
- b. Connect the Gateway to the field control network and to a BACnet/IP Router, or to a Modbus/IP Router installed as specified.

Create and configure points and establish network communication between the Control Protocol Gateway and the field control system to provide points from the field control system to the M&C software.

3.6.1.2 Installation of Control Protocol Router

If there is not an existing connection between the FPOC and the field control network, install a BACnet/IP Router, or a Modbus/IP Router to connect the field control network to the FPOC. Install additional field control system network media as needed to connect the Router to the field control system.

3.6.1.3 Installation of BACnet Supervisory Controller

If required for implementation of scheduling, alarming and trending, install a BACnet Supervisory Controller connected to the building control system IP network and configure it to provide scheduling, alarming and trending functions for the field control system. When the BACnet Supervisory Controller is the same device as a control protocol router or gateway, install it in accordance with the installation requirements for a router or gateway.

3.6.2 Integration Step 2: Add Field Control System to M&C Software

Perform system discovery, system database merges, or any other actions necessary to allow M&C Software access to points and data in the field control system.

3.6.2.1 Integration of Field Control Systems Via ASHRAE 135

Use the M&C Software to fully discover the field control system. Full discovery of a field control system includes but is not limited to discovery of all **ASHRAE 135** devices, all standard **ASHRAE 135** Objects and Properties of each device, and all standard **ASHRAE 135** services supported by each device.

3.6.2.2 Integration of Field Control Systems Via Modbus

Using the contract document Points Schedule, field control system documentation Points Schedules, make all points from the field control system available in the M&C Software.

3.6.2.3 Coordination with COMM Operations lead

Integration of Field Control Systems Via Other (non-ASHRAE 135, non-Modbus) Protocols. Perform all actions necessary to make all points from the field control system available in the M&C Software.

3.6.3 Integration Step 3: Configure M&C Software

Configure M&C Software to provide monitoring and control of the field control system, including but not limited to the creation of system displays and the configuration of scheduling, alarming, and trending.

3.6.3.1 Configure M&C Software Communication

Create and configure points and establish network communication between M&C Software and Field Control Systems as specified to support M&C Software functionality:

- a. Update points on currently active displays via polling as necessary to meet M&C Software display refresh requirements.
- b. Send points used for overrides to the device receiving the override as shown on the Points Schedule. For BACnet systems write operator overrides with a priority of 8 and demand limiting overrides with a priority of 10.
- c. For Notification Class Objects used for Alarms, configure the Recipient_List Property to point to the appropriate M&C Software process. Use the ConfirmedEventNotification service for events from ASHRAE 135 field control systems used for alarms. Poll points from MODBUS Protocol/MODBUS TCP/IP field control systems used for alarms at 5 minute intervals.
- d. Update points used for currently active trends via polling as necessary to meet trend interval requirements.
- e. Send points used for scheduling to the field control system with a maximum time between subsequent transmissions of the point of 30 minutes. .

3.6.3.2 Configure M&C Software Functionality

Fully configure M&C Software functionality using the M&C Software capabilities specified in PART 2 of this Section.

- a. Create System Displays using the sample displays, including overrides, as shown on the Points Schedule and as specified. Label all points on displays with the point name as shown on the Points Schedule. Configure user permissions for access to and executions of action using graphic pages. Coordinate user permissions with the COMM

Operations lead through the Contracting Officer's Representative shop supervisor

- b. Configure alarm generation and alarm handling as shown on the Points Schedule, as shown on the Alarm Routing Schedule, and as specified. Create and configure Objects in BACnet Supervisory Controllers and in the field control system to support alarming as shown on the Points Schedule and as specified. Alarm events with priority 112 are critical and events with priority 224 are non-critical. For alarm events with other priorities, treat events with priorities of 200 or above as non-critical, and all others as critical. For alarms requiring notification via text message or e-mail, configure the alarm notification to use the specified Government furnished SMTP server to send the alarm notification.

- c. Configure scheduling as indicated and as shown on the points schedule. Configure M&C Software scheduling functionality to schedule Modbus systems. Create and configure Schedule Objects in BACnet Supervisory Controllers or in the field control system.

Create and configure displays for configuration of M&C Software schedules and Schedule Objects in the field control system. Label schedules and scheduled points with full English-language descriptors. Provide a separate configuration capability for each schedule. A single configuration display may be used to configured multiple schedules, provided that each schedule is separately configurable from the display.

- d. Create M&C Software trends for required points as shown on the Points Schedule and as specified. Create and configure Trend Objects in BACnet Supervisory Controllers and in the field control system as shown on the Points Schedule and as specified. Trend points at 1 minute intervals.

Create and configure displays for creation and configuration of trends and for display of all trended points.

- e. Configure Demand Limiting as shown on the Demand Limit Schedule and Points Schedule and as specified.
- f. Configure M&C Software standard reports.

3.7 START-UP AND START-UP TESTING

Test all equipment and perform all other tests necessary to ensure the system is installed and functioning as specified. Prepare a Start-Up and Start-Up Testing Report documenting all tests performed and their results and certifying that the system meets the requirements specified in the contract documents.

3.8 PERFORMANCE VERIFICATION TEST (PVT)

3.8.1 PVT Phase I Procedures

Provide PVT Procedures which include:.

- a. Network bandwidth usage and available bandwidth (throughput) measurements. Network bandwidth usage must reference the normal usage network Bandwidth Calculations.

- b. Test System Reaction during PVT: The total system response time from initiation of a control action command from the workstation, to display of the resulting status change on the workstation must not exceed 20 seconds under system normal heavy load conditions assuming a zero response time for operation of the node's control device.
- c. Verification of IP Connectivity.
- d. Verification of configuration of M&C Software functionality.

3.8.2 PVT Phase I

Demonstrate compliance of the control system with the contract documents. Using test plans and procedures previously approved by the Government, demonstrate all physical and functional requirements of the project. Upon completion of PVT Phase I and as specified, prepare and submit the [PVT Phase I Report](#) documenting all tests performed during the PVT and their results. In the PVT report, include all tests in the PVT Procedures and any other testing performed during the PVT. Document failures and repairs with test results.

3.8.3 PVT Phase II

Include Basic Training as part of PVT Phase II. Failures or deficiencies of the UMCS during Basic Training are considered PVT failures. Upon completion of PVT Phase II, and as specified, prepare and submit the [PVT Phase II Report](#) documenting any failures which occurred and repairs performed during PVT Phase II.

3.9 MAINTENANCE AND SERVICE

Perform inspection, testing, cleaning, and part or component replacement as specified and as required to maintain the warranty. Work includes providing necessary preventive and unscheduled maintenance and repairs to keep the UMCS operating as specified, and accepted by the Government, and other services as specified. Perform work in compliance with manufacturer's recommendations and industry standards. Provide technical support via telephone during regular working hours.

3.9.1 Work Coordination

Schedule and arrange work to cause the least interference with the normal Government business and mission. In those cases where some interference may be essentially unavoidable, coordinate with the Government to minimize the impact of the interference, inconvenience, equipment downtime, interrupted service and personnel discomfort.

3.9.2 Work Control

Upon completion of work on a system or piece of equipment, that system or piece of equipment must be free of missing components or defects which would prevent it from functioning as originally intended and designed. Replacements must conform to the same specifications as the original equipment. During and at completion of work, do not allow debris to spread unnecessarily into adjacent areas nor accumulate in the work area itself.

3.9.3 Working Hours

Working hours are from 7:30 A.M. to 4:00 P.M. local time Mondays through Fridays except Federal holidays.

3.9.4 Replacement, Modernization, Renovation

The Government may replace, renovate, or install new equipment as part of the UMCS at Government expense and by means not associated with this contract without voiding the system warranty. Replaced, improved, updated, modernized, or renovated systems and equipment interfaced to the system may be added to the Contractor's maintenance and service effort as a modification.

3.9.5 Access To UMCS Equipment

Access to UMCS equipment must be in accordance with the following:

- a. Coordinate access to facilities and arrange that they be opened and closed during and after the accomplishment of the work effort. For access to a controlled facility contact the Government for assistance.
- b. The Government may provide keys for access to UMCS equipment where the Government determines such key issuance is appropriate. Establish and implement methods of ensuring that keys issued by the Government are not lost or misplaced, are not used by unauthorized persons, and are not duplicated.
- c. The Government may provide passwords or issue Common Access Cards (CAC) for access to UMCS computer equipment where the Government determines such issuance is appropriate. Establish and implement methods of ensuring that passwords and Common Access Cards issued by the Government are not used by unauthorized persons.

3.9.6 Records, Logs, and Progress Reports

Keep records and logs of each task, and organize cumulative chronological records for each major component, and for the complete system. Maintain a continuous log for the UMCS. Keep complete logs and be available for inspection on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the UMCS.

3.9.7 Preventive Maintenance Requirements

Perform maintenance procedures as described below, or more often if required by the equipment manufacturer.

3.9.7.1 Preventive Maintenance Work Plan

Prepare a Preventive Maintenance Work Plan detailing all required preventive maintenance. Obtain Government approval of the Work Plan as specified in paragraph PROJECT SEQUENCING. If it is necessary to reschedule maintenance, make a written request to the Government detailing the reasons for the proposed change at least five days prior to the originally scheduled date. Scheduled dates will be changed only with the prior written approval of the Government.

3.9.8 Service Call Reception

- a. A Government representative will advise the Contractor by phone or in person of all maintenance and service requests, as well as the classification of each based on the definitions specified. A description of the problem or requested work, date and time notified, location, classification, and other appropriate information will be placed on a Service Call Work Authorization Form by the Government.
- b. Submit procedures for receiving and responding to service calls 24 hours per day, seven days a week, including weekends and holidays. Provide a single telephone number for receipt of service calls during regular working hours; service calls are to be considered received at the time and date the telephone call is placed by the authorized Government representative.
- c. Separately record each service call request, as received on the Service Call Work Authorization form and complete the Service Call Work Authorization form for each service call. Include the following information in the completed form: the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion.
- d. Respond to each service call request within two working hours. Provide the status of any item of work within four hours of the inquiry during regular working hours, and within 16 hours after regular working hours or as needed to meet the Equipment Repair requirements as specified.

3.9.9 Service Call Work Warranty

Provide a 1 year unconditional warranty on service call work which includes labor and material necessary to restore the equipment involved in the initial service call to a fully operable condition. In the event that service call work causes damage to additional equipment, restore the system to full operation without cost to the Government. Provide response times for service call warranty work equivalent to the response times required by the initial service call.

3.9.10 System Modifications

Make recommendations for system modification in writing to the Government. Do not make system modifications without prior approval of the Government. Incorporate any modifications made to the system into the Operations and Maintenance Instructions, and any other documentation affected. Make available to the Government software updates for all software furnished under this specification during the life of this contract. Schedule at least one update near the end of the contract period, at which time make available the latest released version of all software provided under this specification, and install and validate it upon approval by the Government.

3.10 TRAINING

Conduct training courses for designated personnel in the maintenance, service, and operation of the system as specified, including specified

hardware and software. The training must be oriented to the specific system provided under this contract. Provide audiovisual equipment and other training material and supplies required for the training. When training is conducted at Government facilities, the Government reserves the right to record the training sessions for later use. A training day is defined as 8 hours of classroom instruction, excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility. For guidance in planning the required instruction, the Contractor should assume that attendees will be tradesmen such as electricians or boiler operators. Obtain approval of the training schedule from the Government at least 30 days prior to the first day of training.

3.10.1 Training Documentation

Prepare and submit one set of Training manuals for each of [Basic Training Documentation](#), [Advanced Training Documentation](#), and [Refresher Training Documentation](#), where each set of documentation consists of:

3.10.1.1 Course Attendance List

Course Attendance List developed in coordination with and signed by the HVAC shop supervisor.

3.10.1.2 Training Manuals

Include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson in the training manuals. Where portions of the course material are presented by audiovisuals, include copies of those audiovisuals as a part of the printed training manuals.

3.10.2 Basic Training

Conduct a Basic Training course at the project site on the installed system for a period of no less than 2 training days during Phase 2 of the PVT. A maximum of ten personnel will attend this course. Design training targeted towards training personnel in the day-to-day operation and basic maintenance of the system. Upon completion of this course, each student, using appropriate documentation, should be able to start the system, operate the system, recover the system after a failure, perform routine maintenance and describe the specific hardware architecture and operation of the system. Include the following topics at a minimum:

- a. General system architecture.
- b. Functional operation of the system, including workstations and system navigation.
- c. System start-up procedures.
- d. Failure recovery procedures.
- e. Schedule configuration.
- f. Trend configuration.
- g. Perform point overrides and override release.

- h. Reports generation.
- i. Alarm reporting and acknowledgements.
- j. Diagnostics.
- k. Historical files.
- l. Maintenance procedures:
 - (1) Physical layout of each piece of hardware.
 - (2) Troubleshooting and diagnostic procedures.
 - (3) Preventive maintenance procedures and schedules.

3.10.3 Advanced Training

Conduct an Advanced Operator Training course at the project site for a period of not less than **two** days. A maximum of ten personnel will attend this course. Structure the course to consist of "hands-on" training under the constant monitoring of the instructor. Include training on the M&C Software, and the **BACnet Network Browser**. Upon completion of this course, the students should be fully proficient in the operation and management of all system operations and must be able to perform all tasks required to integrate a field control system into the UMCS. Report the skill level of each student at the end of this course. Include the following topics at a minimum:

- a. A review of all topics in Basic Training
- b. Using the **BACnet Network Browser for network discovery**
- c. M&C Software configuration, including but not limited to: creating and editing system displays, alarms, schedules, trends, demand limiting and calculations.

3.10.4 Refresher Training

Conduct a Refresher Training course at the project site for a period of two training days when approved by the Government and as specified in paragraph PROJECT SEQUENCING. A maximum of ten personnel will attend the course. Structure the course to address specific topics that the students need to discuss and to answer questions concerning the operation of the system. Upon completion of the course, the students should be fully proficient in system operation and have no unanswered questions regarding operation of the installed UMCS. Correct any system failures discovered during the Refresher Training at no cost to the Government.

APPENDIX A

<u>QC CHECKLIST</u>		
This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such.		
This checklist is for (check one:)		
☐	Pre-Construction QC Checklist Submittal (Items 1-2)	()
☐	Post-Construction QC Checklist Submittal (Items 1-6)	()
☐	Close-out QC Checklist Submittal (Items 1-14)	()
Instructions: Initial each item in the space provided (____) verifying that the requirement has been met.		
Verify the following items for Pre-Construction, Post-Construction and Closeout QC Checklist Submittals:		
1	Contractor Design Drawing Riser Diagram includes location and types of all Control Hardware and Computer Hardware.	____
2	M&C Software supports , and ASHRAE 135, and MODBUS Protocol/ MODBUS TCP/IP . M&C Software is BTL Listed as a B-AWS.	____
Verify the following items for Post-Construction and Closeout QC Checklist Submittal:		
3	Communication between the M&C Software and ASHRAE 135 field control systems uses only ASHRAE 135. Communication between the M&C Software and MODBUS Protocol/MODBUS TCP/IP field control systems uses only MODBUS Protocol/MODBUS TCP/IP.	____

<u>QC CHECKLIST</u>		
4	Connections to non-ASHRAE 135, non-Modbusfield control systems are via a Gateway from the field control system to ASHRAE 135, or to Modbus or via a UMCS supported protocol without the use of a hardware Gateway.	____
5	Computer workstations and servers are installed as shown on the UMCS Riser Diagram.	____
6	Training schedule and course attendee lists have been developed and coordinated with shops and submitted.	____
Verify the following items for Closeout QC Checklists Submittal:		
7	All points in field control systems have been discovered and are available at the M&C Software.	____
8	All software has been licensed to the Government.	____
9	M&C software monitoring displays have been created for all building systems, including all override and display points indicated on Points Schedule drawings.	____
10	Final As-built Drawings accurately represent the final installed system.	____
11	Default trends have been set up (per Points Schedule drawings).	____
12	Scheduling has been configured at the M&C Software (per Occupancy Schedule drawing).	____
13	O&M Instructions have been completed and submitted.	____

<u>QC CHECKLIST</u>		
14	Basic Operator and Advanced Training courses have been completed.	____

(QC Representative Signature)		(Date)

-- End of Section --

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SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM

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 NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM B1 (2013) Standard Specification for Hard-Drawn Copper Wire

ASTM B8 (2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81 (2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA NEIS 1 (2015) Standard for Good Workmanship in Electrical Construction

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1 (2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)

ANSI C80.3	(2020) American National Standard for Electrical Metallic Tubing (EMT)
ANSI C80.5	(2020) American National Standard for Electrical Rigid Aluminum Conduit
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices

NEMA WD 6 (2016) Wiring Devices Dimensions
Specifications

NEMA Z535.4 (2011; R 2017) Product Safety Signs and
Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020;
ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA
20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA
20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA
20-11; TIA 20-12; TIA 20-13; TIA 20-14;
TIA 20-15; TIA 20-16; ERTA 20-4 2022)
National Electrical Code

NFPA 70E (2021) Standard for Electrical Safety in
the Workplace

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568.1 (2020e) Commercial Building
Telecommunications Infrastructure Standard

TIA-569 (2019e) Telecommunications Pathways and
Spaces

TIA-607 (2019d) Generic Telecommunications Bonding
and Grounding (Earthing) for Customer
Premises

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431 Energy Efficiency Program for Certain
Commercial and Industrial Equipment

29 CFR 1910.147 The Control of Hazardous Energy (Lock
Out/Tag Out)

29 CFR 1910.303 Electrical, General

UNDERWRITERS LABORATORIES (UL)

UL 1 (2005; Reprint Jan 2020) UL Standard for
Safety Flexible Metal Conduit

UL 6 (2007; Reprint Sep 2019) UL Standard for
Safety Electrical Rigid Metal Conduit-Steel

UL 6A (2008; Reprint Mar 2021) UL Standard for
Safety Electrical Rigid Metal Conduit -
Aluminum, Red Brass, and Stainless Steel

UL 20 (2018; Reprint Jan 2021) UL Standard for
Safety General-Use Snap Switches

UL 44 (2018; Reprint May 2021) UL Standard for
Safety Thermoset-Insulated Wires and Cables

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint Jul 2020) UL Standard for Safety Panelboards
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 248-4	(2010; Reprint Apr 2019) Low-Voltage Fuses - Part 4: Class CC Fuses
UL 248-8	(2011; Reprint Aug 2020) Low-Voltage Fuses - Part 8: Class J Fuses
UL 248-10	(2011; Reprint Aug 2020) Low-Voltage Fuses - Part 10: Class L Fuses
UL 248-12	(2011; Reprint Aug 2020) Low Voltage Fuses - Part 12: Class R Fuses
UL 248-15	(2018) Low-Voltage Fuses - Part 15: Class T Fuses
UL 360	(2013; Reprint Aug 2021) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Sep 2021) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing

and Cable Fittings

UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Mar 2021) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 845	(2021) UL Standard for Safety Motor Control Centers
UL 854	(2020) Standard for Service-Entrance Cables
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 870	(2016; Reprint Mar 2019) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors
UL 1063	(2017; Reprint Jun 2020) UL Standard for Safety Machine-Tool Wires and Cables
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021) UL Standard for Safety Surge Protective Devices
UL 1660	(2019) Liquid-Tight Flexible Nonmetallic Conduit
UL 1699	(2017; Reprint Feb 2022) UL Standard for Safety Arc-Fault Circuit-Interrupters
UL 4248-1	(2022) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2018) UL Standard for Safety Fuseholders - Part 12: Class R

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms

used in these specifications, and on the drawings, are as defined in
IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Panelboards; G

Transformers; G

Busway; G

Cable Trays; G

Motor Control Centers; G

Wireways; G

Marking Strips Drawings; G

SD-03 Product Data

Receptacles; G

Circuit Breakers; G

Switches; G

Transformers; G

Enclosed Circuit Breakers; G

Motor Controllers; G

Combination Motor Controllers; G

Manual Motor Starters; G

Metering; G

Secondary Bonding Busbar; G

Surge Protective Devices; G

Cable Trays; G

SD-06 Test Reports

600-volt Wiring Test; G

Grounding System Test; G

Transformer Tests; G

Ground-fault Receptacle Test; G

Arc-fault Receptacle Test; G

SD-07 Certificates

Fuses; G

SD-09 Manufacturer's Field Reports

Transformer Factory Tests

1.4 QUALITY ASSURANCE

1.4.1 Fuses

Submit coordination data as specified in paragraph, FUSES of this section.

1.4.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" 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. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated. NECA NEIS 1 shall be considered the minimum standard for workmanship.

1.4.3 Standard Products

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 and:

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
- b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3.1 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.

1.4.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.5 MAINTENANCE

1.6 WARRANTY

Provide equipment items supported by service organizations that 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.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

As a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70 for all materials, equipment, and devices.

2.2 CONDUIT AND FITTINGS

Conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6.

2.2.1.2 Rigid Aluminum Conduit

ANSI C80.5, UL 6A.

2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-40 in accordance with NEMA TC 2, UL 651.

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.5 Plastic-Coated Rigid Steel and IMC Conduit

NEMA RN 1, Type 40(40 mils thick).

2.2.6 Flexible Metal Conduit

UL 1, limited to 6 feet.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360, limited to 6 feet.

2.2.7 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B. Ferrous fittings: cadmium- or zinc-coated in accordance with

UL 514B.

2.2.7.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.7.2 Fittings for EMT

Steel compression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC, and UL 514B.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 OUTLET BOXES AND COVERS

UL 514A, cadmium- or zinc-coated, if ferrous metal. UL 514C, if nonmetallic.

2.3.1 Outlet Boxes for Telecommunications System

Provide the following:

- a. Standard type 4 inches square by 2 1/8 inches deep.
- b. Outlet boxes for wall-mounted telecommunications outlets: 4 by 2 1/8 by 2 1/8 inches deep.
- c. Depth of boxes: large enough to allow manufacturers' recommended conductor bend radii.
- d. Outlet boxes for fiber optic telecommunication outlets: include a minimum 3/8 inch deep single or two gang plaster ring as shown and installed using a minimum one inch conduit system.

2.4 CABINETS, JUNCTION BOXES, AND PULL BOXES

UL 50; volume greater than 100 cubic inches, NEMA Type 1 enclosure; sheet steel, hot-dip, zinc-coated. Where exposed to wet, damp, or corrosive environments, NEMA Type 3R.

2.5 WIRES AND CABLES

Provide wires and cables in accordance applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 12 months prior to date of delivery to site.

2.5.1 Conductors

Provide the following:

- a. Conductor sizes and capacities shown are based on copper, unless indicated otherwise.

- b. Conductors No. 8 AWG and larger diameter: stranded.
- c. Conductors No. 10 AWG and smaller diameter: solid.
- d. Conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3: stranded unless specifically indicated otherwise.
- e. All conductors: copper.

2.5.1.1 Minimum Conductor Sizes

Provide minimum conductor size in accordance with the following:

- a. Branch circuits: No. 12 AWG.
- b. Class 1 remote-control and signal circuits: No. 14 AWG.
- c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.
- d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.
- e. Digital low voltage lighting control (DLVLC) system at 24 Volts or less: Category 5 UTP cables in EMT conduit.

2.5.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

2.5.2.1 Ground and Neutral Conductors

Provide color coding of ground and neutral conductors as follows:

- a. Grounding conductors: Green.
- b. Neutral conductors: White.
- c. Exception, where neutrals of more than one system are installed in same raceway or box, other neutrals color coding: white with a different colored (not green) stripe for each.

2.5.2.2 Ungrounded Conductors

Provide color coding of ungrounded conductors in different voltage systems as follows:

- a. 208/120 volt, three-phase
 - (1) Phase A - black
 - (2) Phase B - red
 - (3) Phase C - blue
- b. 480/277 volt, three-phase
 - (1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

2.5.3 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts, Type THWN/THHN conforming to UL 83 or Type XHHW or RHW conforming to UL 44, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83. Where equipment or devices require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.5.4 Bonding Conductors

ASTM B1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.5.4.1 Telecommunications Bonding Backbone (TBB)

Provide a copper conductor TBB in accordance with TIA-607 with No. 6 AWG minimum size, and sized at 2 kcmil per linear foot of conductor length up to a maximum size of 750 kcmil. Provide insulated TBB with insulation as specified in the paragraph INSULATION and meeting the fire ratings of its pathway.

2.5.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications main grounding busbar (PBB) and the electrical service ground in accordance with TIA-607. Size the bonding conductor for telecommunications the same as the TBB.

2.5.5 Service Entrance Cables

Service Entrance (SE) and Underground Service Entrance (USE) Cables, UL 854.

2.6 SPLICES AND TERMINATION COMPONENTS

UL 486A-486B for wire connectors and UL 510 for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires: insulated, pressure-type in accordance with UL 486A-486B or UL 486C (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

2.7 DEVICE PLATES

Provide the following:

- a. UL listed, one-piece device plates for outlets to suit the devices installed.
- b. For metal outlet boxes, plates on unfinished walls: zinc-coated sheet steel or cast metal having round or beveled edges.

- c. For nonmetallic boxes and fittings, other suitable plates may be provided.
- d. Plates on finished walls: nylon or lexan, minimum 0.03 inch wall thickness and same color as receptacle or toggle switch with which they are mounted.
- f. Screws: machine-type with countersunk heads in color to match finish of plate.
- g. Sectional type device plates are not be permitted.
- h. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.8 SWITCHES

2.8.1 Toggle Switches

NEMA WD 1, UL 20, single pole, double pole, three-way, totally enclosed with bodies of thermoplastic or thermoset plastic and mounting strap with grounding screw. Include the following:

- a. Handles: white thermoplastic.
- b. Wiring terminals: screw-type, side-wired or of the solderless pressure type having suitable conductor-release arrangement.
- c. Contacts: silver-cadmium and contact arm - one-piece copper alloy.
- d. Switches: rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

2.8.2 Switch with Red Pilot Handle

NEMA WD 1. Provide the following:

- a. Pilot lights that are integrally constructed as a part of the switch's handle.
- b. Pilot light color: red and illuminate whenever the switch is closed or "on".
- c. Pilot lighted switch: rated 20 amps and 120 volts or 277 volts as indicated.
- d. The circuit's neutral conductor to each switch with a pilot light.

2.8.3 Breakers Used as Switches

For 120- and 277-Volt fluorescent fixtures, mark breakers "SWD" in accordance with UL 489.

2.8.4 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Utilize Class R fuseholders and fuses for fused switches, unless indicated otherwise. Provide horsepower rated for switches serving as the

motor-disconnect means. Provide switches in NEMA 1 3R , enclosure per
NEMA ICS 6.

2.9 FUSES

NEMA FU 1. Provide complete set of fuses for each fusible switch panel and control center. Coordinate time-current characteristics curves of fuses serving motors or connected in series with circuit breakers or other circuit protective devices for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

2.9.1 Fuseholders

Provide in accordance with **UL 4248-1.**

2.9.2 Cartridge Fuses, Current Limiting Type (Class R)

UL 248-12, Class RK-1 RK-5 time-delay type. Provide only Class R associated fuseholders in accordance with **UL 4248-12.**

2.9.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 248-8, **UL 248-10**, **UL 248-4**, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.9.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 248-15, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.10 RECEPTACLES

Provide the following:

- a. **UL 498**, general purpose specification grade, grounding-type. Residential grade receptacles are not acceptable.
- b. Ratings and configurations: as indicated.
- c. Bodies: white as per **NEMA WD 1.**
- d. Face and body: thermoplastic supported on a metal mounting strap.
- e. Dimensional requirements: per **NEMA WD 6.**
- f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.
- g. Grounding pole connected to mounting strap.
- h. The receptacle: containing triple-wipe power contacts and double or triple-wipe ground contacts.

2.10.1 Split Duplex Receptacles

Provide separate terminals for each ungrounded pole. One receptacle must be controlled separately.

2.10.2 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations" with integral GFCI protection. Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, polycarbonate, UV resistant/stabilized cover plate.

2.10.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak when the current to ground is 6 milliamperes or higher, and tripping per requirements of UL 943 for Class A ground-fault circuit interrupter devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.10.4 Tamper-Resistant Receptacles

Provide duplex receptacle with mechanical sliding shutters that prevent the insertion of small objects into its contact slots.

2.10.5 Arc-Fault Circuit Interrupter Receptacles

UL 1699, duplex type for mounting in standard outlet box. Provide device capable of detecting series arcing current when the current to ground is 5 amperes or higher, and tripping per requirements of UL 1699.

2.11 PANELBOARDS

Provide panelboards in accordance with the following:

- a. UL 67 and UL 50.
- b. Panelboards for use as service disconnecting: additionally conform to UL 869A.
- c. Panelboards: circuit breaker-equipped.
- d. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.
- e. Where "space only" is indicated, make provisions for future installation of breaker sized as indicated.
- f. Directories: indicate load served by each circuit of panelboard.
- g. Directories: indicate source of service (e.g. upstream panel, switchboard, motor control center) to panelboard.
- h. Type directories and mount in holder behind transparent protective covering.
- i. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.11.1 Enclosure

Provide panelboard enclosure in accordance with the following:

- a. **UL 50.**
- b. Cabinets mounted outdoors or flush-mounted: hot-dipped galvanized after fabrication .
- c. Cabinets: painted in accordance with paragraph PAINTING.
- d. Outdoor cabinets: NEMA 3R raintight with a removable steel plate **1/4 inch** thick in the bottom for field drilling for conduit connections.
- e. Front edges of cabinets: form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front.
- f. All cabinets: fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than **1/8 inch**.
- g. Holes: provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a **1/2 inch** clear space between the back of the cabinet and the wall surface.
- h. Flush doors: mounted on hinges that expose only the hinge roll to view when the door is closed.
- i. Each door: fitted with a combined catch and lock latch.
- j. Keys: two provided with each lock, with all locks keyed alike.
- k. Finished-head cap screws: provided for mounting the panelboard fronts on the cabinets.

2.11.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per **UL 67** for connecting grounding conductors; bond to steel cabinet.

2.11.2.1 Panelboard Neutrals for Non-Linear Loads

Provide in accordance with the following:.

- a. UL listed, with panelboard type specifically UL heat rise tested for use on non-linear loads.
- b. Panelboard: heat rise tested in accordance with **UL 67**, except with the neutral assembly installed and carrying 200 percent of the phase bus current during testing.
- c. Verification of the testing procedure: provided upon request.
- d. Two neutral assemblies paralleled together with cable is not

acceptable.

- e. Nameplates for panelboard rated for use on non-linear loads: marked "SUITABLE FOR NON-LINEAR LOADS" and in accordance with paragraph FIELD FABRICATED NAMEPLATES.
- f. Provide a neutral label with instructions for wiring the neutral of panelboards rated for use on non-linear loads.

2.11.3 Circuit Breakers

UL 489, thermal magnetic-type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker will be mounted. Breaker terminals: UL listed as suitable for type of conductor provided. Series rated circuit breakers and plug-in circuit breakers are unacceptable.

2.11.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.11.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with auto-monitoring (self-test) and lockout features, "push-to-test" button, visible indication of tripped condition, and ability to detect and trip when current imbalance is 6 milliamperes or higher per requirements of UL 943 for Class A ground-fault circuit interrupter devices.

2.11.3.3 Arc-Fault Circuit Interrupters

UL 489, UL 1699 and NFPA 70. Molded case circuit breakers: rated as indicated. Two pole arc-fault circuit-interrupters: rated 120/240 volts. The provision of (two) one pole circuit breakers for shared neutral circuits in lieu of (one) two pole circuit breaker is unacceptable. Provide with "push-to-test" button.

2.11.4 400 Hz Panelboard and Breakers

Provide panelboards and breakers for use on 400 Hz systems rated and labeled "400 Hz."

2.11.5 Branch Circuit Monitoring Panelboards

Provide a microprocessor-based panelboard monitoring system having the following features:

- a. ANSI C12.1 and IEC 62053-21 Class 1 energy revenue metering accuracy.
- b. Direct reading metered or calculated values for up to forty-two branch circuits.
- c. Monitored values at the branch circuit level for current (A), power (kW), and energy (kWh).
- d. Four user-configurable alarm thresholds.

- e. Communications with building automation system using Modbus RTU protocol via RS-485 cable connection.

2.12 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

Motor short-circuit protectors, also called motor circuit protectors (MCPs): [UL 508](#) and [UL 489](#), and provided as shown. Provide MSCPs that consist of an adjustable instantaneous trip circuit breaker used only in conjunction with a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection. Rate MSCPs in accordance with the requirements of [NFPA 70](#).

2.13 TRANSFORMERS

Provide transformers in accordance with the following:

- a. [NEMA ST 20](#), general purpose, dry-type, self-cooled, ventilated.
- b. Provide transformers in NEMA 1 3R enclosure.
- c. Taps for transformers 15 kVA and larger: Two 2.5 percent taps Full Capacity Above Nominal (FCAN) and two 2.5 percent taps Full Capacity Below Nominal (FCBN) .
- d. Transformer insulation system:
 - (1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 115 degrees C under full-rated load in maximum ambient of 40 degrees C.
 - (2) 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 80 degrees C under full-rated load in maximum ambient of 40 degrees C.
- f. Transformer of 115 degrees C temperature rise: capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating.

2.13.1 Specified Transformer Efficiency

Transformers, indicated and specified with: 480V primary, 80 degrees C or 115 degrees C temperature rise, kVA ratings of 37.5 to 100 for single phase or 30 to 500 for three phase, energy efficient type. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in [10 CFR 431](#), Subpart K.

2.14 MOTORS

Provide motors in accordance with the following:

- a. [NEMA MG 1](#) FIRE PUMPS.
- b. Hermetic-type sealed motor compressors: Also comply with [UL 984](#).
- c. Provide the size in terms of [HP](#), or kVA, or full-load current, or a combination of these characteristics, and other characteristics, of each motor as indicated or specified.

- d. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters.
- e. Rate motors for operation on 208-volt, 3-phase circuits with a terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits with a terminal voltage rating of 460 volts.
- f. Use motors designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating.
- g. Unless otherwise indicated, use continuous duty type motors if rated 1 HP and above.
- h. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.
- i. Use Inverter-Duty motors designed to operate with adjustable speed drive (ASD).

2.14.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors: high efficiency types are not acceptable. In exception, for special purpose motors and motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.14.2 Premium Efficiency Polyphase and Single-Phase Motors

Select polyphase and continuous-duty single phase motors based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10 and NEMA MG 11. In addition, continuous rated, polyphase squirrel-cage medium induction motors must meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.14.3 Motor Sizes

Provide size for duty to be performed, not exceeding the full-load nameplate current rating when driven equipment is operated at specified capacity under most severe conditions likely to be encountered. When motor size provided differs from size indicated or specified, make adjustments to wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

2.14.4 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 using adjustable speed drive (ASD) manufacturer required wiring type and length , 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 as specified herein. Power wiring and conduit: conform to the requirements specified herein. Control wiring: provided under, and conform to, the requirements of the section specifying the associated equipment.

2.15 MOTOR CONTROLLERS

Provide motor controllers in accordance with the following:

- a. UL 508, NEMA ICS 1, and NEMA ICS 2.
- b. Provide controllers with thermal overload protection in each phase, and one spare normally open auxiliary contact, and one spare normally closed auxiliary contact.
- c. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage.
- d. Provide protection for motors from immediate restart by a time adjustable restart relay.
- e. When used with pressure, float, or similar automatic-type or maintained-contact switch, provide a hand/off/automatic selector switch with the controller.
- f. Connections to selector switch: wired such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position.
- g. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices: connected in motor control circuit in "hand" and "automatic" positions.
- h. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device: made in accordance with indicated or manufacturer's approved wiring diagram.
- j. Provide a disconnecting means, capable of being locked in the open position, for the motor that is located in sight from the motor location and the driven machinery location. As an alternative, provide a motor controller disconnect, capable of being locked in the open position, to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location.
- k. Overload protective devices: provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case.
- l. Cover of combination motor controller and manual switch or circuit breaker: interlocked with operating handle of switch or circuit breaker so that cover cannot be opened unless handle of switch or circuit breaker is in "off" position.
- m. Minimum short circuit withstand rating of combination motor

controller: 65k rms symmetrical amperes.

2.15.1 Control Wiring

Provide control wiring in accordance with the following:

- a. All control wire: stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44, or Type MTW meeting UL 1063, and passing the VW-1 flame tests included in those standards.
- b. Hinge wire: Class K stranding.
- c. Current transformer secondary leads: not smaller than No. 10 AWG.
- d. Control wire minimum size: No. 14 AWG.
- e. Power wiring for 480-volt circuits and below: the same type as control wiring with No. 12 AWG minimum size.
- f. Provide wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.15.2 Control Circuit Terminal Blocks

Provide control circuit terminal blocks in accordance with the following:

- a. NEMA ICS 4.
- b. Control circuit terminal blocks for control wiring: molded or fabricated type with barriers, rated not less than 600 volts.
- c. Provide terminals with removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts.
- d. Terminals: not less than No. 10 in size with sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal.
- e. Terminal arrangement: subject to the approval of the Contracting Officer with not less than four spare terminals or 10 percent, whichever is greater, provided on each block or group of blocks.
- f. Modular, pull apart, terminal blocks are acceptable provided they are of the channel or rail-mounted type.
- g. Submit data showing that any proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.15.2.1 Types of Terminal Blocks

- a. Short-Circuiting Type: Short-circuiting type terminal blocks: furnished for all current transformer secondary leads with provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks: comply with the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

- b. Load Type: Load terminal blocks rated not less than 600 volts and of adequate capacity: provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. Provide terminals of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Provide each connected terminal with the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.15.3 Control Circuits

Control circuits: maximum voltage of 120 volts derived from control transformer in same enclosure. Transformers: conform to **UL 506**, as applicable. Transformers, other than transformers in bridge circuits: provide primaries wound for voltage available and secondaries wound for correct control circuit voltage. Size transformers so that 80 percent of rated capacity equals connected load. Provide disconnect switch on primary side. Provide fuses in each ungrounded primary feeder. Provide one fused secondary lead with the other lead grounded.

2.15.4 Enclosures for Motor Controllers

NEMA ICS 6.

2.15.5 Multiple-Speed Motor Controllers and Reversible Motor Controllers

Across-the-line-type, electrically and mechanically interlocked. Multiple-speed controllers: include compelling relays and multiple-button, station-type with pilot lights for each speed.

2.15.6 Pushbutton Stations

Provide with "start/stop" momentary contacts having one normally open and one normally closed set of contacts, and red lights to indicate when motor is running. Stations: heavy duty, oil-tight design.

2.15.7 Pilot and Indicating Lights

Provide LED cluster lamps.

2.16 **MANUAL MOTOR STARTERS** (MOTOR RATED SWITCHES)

SingleDoubleThree pole designed for surface mounting with overload protection and pilot lights.

2.16.1 Pilot Lights

Provide yoke-mounted, seven element LED cluster light module. Color: green red amber in accordance with **NEMA ICS 2.**

2.17 **MOTOR CONTROL CENTERS**

Submit wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories,

pipng, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices.

Provide motor control centers in accordance with the following:

- a. [UL 845](#), [NEMA ICS 2](#), [NEMA ICS 3](#).
- b. Wiring: Class I, Type A, in NEMA Type 1 enclosure.
- c. Provide control centers suitable for operation on [480-volt](#), [3-phase](#), [3-wire](#), [60 Hz](#) system with minimum short-circuit withstand and interrupting rating of 65,000 amperes rms symmetrical.
- d. Incoming power feeder: cable entering at the top of enclosure and terminating on terminal lugs.
- f. Arrange busing so that control center can be expanded from both ends.
- g. Interconnecting wires: copper.
- h. Terminal blocks: plug-in-type so that controllers may be removed without disconnecting individual control wiring.

2.17.1 Bus Systems

Provide the following bus systems. Power bus: be braced to withstand fault current of 65,000 amperes rms symmetrical. Wiring troughs: isolated from horizontal and vertical bus bars.

2.17.1.1 Horizontal and Main Buses

Horizontal bus: continuous current rating of 600 amperes. Main bus: copper, silver-plated enclosed in isolated compartment at top of each vertical section. Main bus: isolated from wire troughs, starters, and other areas.

2.17.1.2 Ground Bus

Copper ground bus: provided full width of motor control center and equipped with necessary lugs.

2.17.2 Combination Motor Controllers

[UL 508](#) and other requirements in paragraph, MOTOR CONTROLLERS. Provide in controller a molded case circuit breaker. Circuit breakers for combination controllers: thermal magnetic.

2.18 LOCKOUT REQUIREMENTS

Provide circuit breakers, disconnecting means, and other devices that are electrical energy-isolating 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](#), [NFPA 70E](#) and [29 CFR 1910.303](#). Comply with requirements of Division 23, "Mechanical" for mechanical isolation of machines and other equipment.

2.19 GROUNDING AND BONDING EQUIPMENT

2.19.1 Ground Rods

UL 467. Ground rods: cone pointed solid copper, with minimum diameter of **3/4 inch** and minimum length **10 feet**. Sectional type rods may be used for rods 20 feet or longer.

2.19.2 Ground Bus

Copper ground bus: provided in the electrical equipment rooms as indicated.

2.19.3 Secondary Bonding Busbar

Provide corrosion-resistant grounding busbar suitable for indoor installation in accordance with **TIA-607**. Busbars: plated for reduced contact resistance. If not plated, clean the busbar prior to fastening the conductors to the busbar and apply an anti-oxidant to the contact area to control corrosion and reduce contact resistance. Provide a Primary bonding busbar (PBB) in the telecommunications entrance facility and a Secondary bonding busbar (SBB) in all other telecommunications rooms and equipment rooms. The Primary bonding busbar (PBB) and the Secondary bonding busbar (SBB): sized in accordance with the immediate application requirements and with consideration of future growth. Provide Secondary bonding busbars with the following:

- a. Predrilled copper busbar provided with holes for use with standard sized lugs,
- b. Minimum dimensions of **0.25 in** thick by **4 in** wide for the PBB and **2 in** wide for SBBs with length as indicated;
- c. Listed by a nationally recognized testing laboratory.

2.20 MANUFACTURER'S NAMEPLATE

Provide on each item of equipment 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.

2.21 FIELD FABRICATED NAMEPLATES

Provide field fabricated nameplates in accordance with the following:

- a. **ASTM D709.**
- b. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings.
- c. Each nameplate inscription: identify the function and, when applicable, the position.
- d. Nameplates: melamine plastic, **0.125 inch** thick, white with black center core.

- f. Surface: matte finish. Corners: square. Accurately align lettering and engrave into the core.
- g. Minimum size of nameplates: one by 2.5 inches.
- h. Lettering size and style: a minimum of 0.25 inch high normal block style.

2.22 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.23 FIRESTOPPING MATERIALS

Provide firestopping around electrical penetrations in accordance with Section 07 84 00 FIRESTOPPING.

2.24 WIREWAYS

UL 870. Material: steel epoxy painted 16 gauge for heights and depths up to 6 by 6 inches, and 14 gauge for heights and depths up to 12 by 12 inches. Provide in length required for the application with hinged- cover NEMA 1 enclosure per NEMA ICS 6.

2.25 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance, load centers, panelboards, MCC. Provide surge protectors in a NEMA 1 and 3R enclosure per NEMA ICS 6. SPD must have the same short-circuit current rating as the protected equipment and must not be installed at a point of system where the available fault current is in excess of that rating. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker. Submit performance and characteristic curves.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Phase to phase (L-L)
Each phase to neutral (L-N)
Neutral to ground (N-G)

SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G) and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G).

Provide SPDs per NFPA 780 for the lightning protection system.

Maximum L-N, and N-G Voltage Protection Rating:

600V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-G Protection Rating:
700V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 208Y/120V, three phase system
1,800V for 480Y/277V, three phase system

Provide SPDs. Maximum L-N, L-G, and N-G Voltage Protection Rating:

700V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 208Y/120V, three phase system
2,000V for 480Y/277V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120 percent of nominal voltage for 240 volts and below; 115 percent of nominal voltage above 240 volts to 480 volts.

Provide EMI/RFI filtering per [UL 1283](#) for each mode with the capability to attenuate high frequency noise. Minimum attenuation: 20db.

2.26 FACTORY APPLIED FINISH

Provide factory-applied finish on electrical equipment in accordance with the following:

- a. [NEMA 250](#) corrosion-resistance test and the additional requirements as specified herein.
- b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.
- c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.
- d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.
- e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.
- f. Equipment located indoors: ANSI Light Gray, and equipment located outdoors: ANSI Light Gray.
- g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.27 SOURCE QUALITY CONTROL

2.27.1 Transformer Factory Tests

Submittal: include routine NEMA ST 20 transformer test results on each transformer and also provide the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

2.28 COORDINATED POWER SYSTEM PROTECTION

Prepare analyses as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations and ducts, plenums and other air-handling spaces: conform to requirements of NFPA 70 and IEEE C2 and to requirements specified herein.

3.1.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.1.2 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.1.2.1 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, label each enclosure, new and existing, as one of several enclosures containing service entrance disconnect devices. Label, at minimum: indicate number of service disconnect devices housed by enclosure and indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure: provided only as permitted by NFPA 70.

3.1.3 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Shared neutral, or multi-wire branch circuits, are not permitted with arc-fault circuit interrupters. Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors

in accordance with Section 07 84 00 FIRESTOPPING.

3.1.3.1 Pull Wire

Install pull wires in empty conduits. Pull wire: plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

3.1.4 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.

3.1.4.1 Restrictions Applicable to Aluminum Conduit

- a. Do not install underground or encase in concrete or masonry.
- b. Do not use brass or bronze fittings.
- c. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.2 Restrictions Applicable to EMT

- a. Do not install underground.
- b. Do not encase in concrete, mortar, grout, or other cementitious materials.
- c. Do not use in areas subject to physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.
- d. Do not use in hazardous areas.
- e. Do not use outdoors.
- f. Do not use in fire pump rooms.
- g. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.3 Restrictions Applicable to Nonmetallic Conduit

- a. PVC Schedule 40.
 - (1) Do not use where subject to physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, fire pump rooms, and where restrictions are applying to both PVC Schedule 40 and PVC Schedule 80.
 - (2) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.
- b. PVC Schedule 40 and Schedule 80.

- (1) Do not use where subject to physical damage, including but not limited to, hospitals, power plant, missile magazines, and other such areas.
- (2) Do not use in hazardous (classified) areas.
- (3) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

3.1.4.4 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.5 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40
Plastic coating: extend minimum 6 inches above floor.

3.1.4.6 Conduit Installed Under Floor Slabs

Conduit run under floor slab: located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier. Use NECA NEIS 1 Table 2a (Minimum Raceway Spacing) to determine under floor slab conduit spacing unless greater spacing is required elsewhere in this section.

3.1.4.7 Conduit Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab. Where conduit rises through slab-on grade, seal all electrical penetrations to address radon mitigation and prevent infiltration of air, insects, and vermin.

3.1.4.8 Conduit Installed in Concrete Floor Slabs

Rigid steel; steel IMC; fiberglass, or PVC, Type EPC-40. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends must not be visible above finish slab. Increase slab thickness as necessary to provide minimum one inch cover over conduit. Where embedded conduits cross building expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings must allow horizontal and vertical movement of raceway. Conduit larger than one inch trade size: installed parallel with or at right angles to main reinforcement; when at right angles to reinforcement, install conduit close to one of supports of slab. Where nonmetallic conduit is used, convert raceway to plastic coated rigid steel or plastic coated steel IMC before rising above floor, unless specifically indicated.

3.1.4.9 Stub-Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment

in rigid steel conduit, except that flexible metal conduit may be used **6 inches** above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.4.10 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Plastic cable ties are not acceptable. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners. Provide vibration resistant and shock-resistant fasteners attached to concrete ceiling. Do not cut main reinforcing bars for any holes cut to depth of more than **1 1/2 inches** in reinforced concrete beams or to depth of more than **3/4 inch** in concrete joints. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems: supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Do not share supporting means between electrical raceways and mechanical piping or ducts. Coordinate installation with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Support exposed risers in wire shafts of multistory buildings by U-clamp hangers at each floor level and at **10 foot** maximum intervals. Where conduit crosses building expansion joints, provide suitable watertight expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than **2 1/2 inches** inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.4.11 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.1.4.12 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by **NFPA 70**, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Provide locknuts with sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by **NFPA 70**.

3.1.4.13 Flexible Connections

Provide flexible steel conduit between **3 and 6 feet** in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit

to allow 20 percent slack. Minimum flexible steel conduit size: 1/2 inch diameter. Provide liquid tight flexible nonmetallic conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections. Plastic cable ties are not acceptable as a support method.

3.1.4.14 Telecommunications and Signal System Pathway

Install telecommunications pathway in accordance with TIA-569.

- a. Horizontal Pathway: Telecommunications pathways from the work area to the telecommunications room: installed and cabling length requirements in accordance with TIA-568.1. Size conduits, wireways, and cable trays in accordance with TIA-569.
- b. Backbone Pathway: Telecommunication pathways from the telecommunications entrance facility to telecommunications rooms, and, telecommunications equipment rooms (backbone cabling): installed in accordance with TIA-569. Size conduits, wireways, and cable trays for telecommunications risers in accordance with TIA-569.

3.1.5 Busway Installation

Comply at minimum with NFPA 70. Install busways parallel with or at right angles to ceilings, walls, and structural members. Support busways at 5 foot maximum intervals, and brace to prevent lateral movement. Provide fixed type hinges on risers; spring-type are unacceptable. Provide flanges where busway makes penetrations through walls and floors, and seal to maintain smoke and fire ratings. Provide waterproof curb where busway riser passes through floor. Seal gaps with fire-rated foam and caulk. Provide expansion joints, but only where bus duct crosses building expansion joints. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.6 Cable Tray Installation

Install and ground in accordance with NFPA 70. In addition, install and ground telecommunications cable tray in accordance with TIA-569, and TIA-607. Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Cable tray and tray supports must not partially nor completely obstruct access to the room. Support in accordance with manufacturer recommendations but at not more than 6 foot intervals. Coat contact surfaces of aluminum connections with an antioxidant compound prior to assembly. Adjacent cable tray sections: bonded together by connector plates of an identical type as the cable tray sections. For grounding of cable tray system provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section, except use No. 1/0 aluminum wire if cable tray is aluminum. Terminate cable trays 10 inches from both sides of smoke and fire partitions. Install conductors run through smoke and fire partitions in 4 inch rigid steel conduits with grounding bushings, extending 12 inches beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. Firestop penetrations in accordance with Section 07 84 00, FIRESTOPPING. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.7 Telecommunications Cable Support Installation

Install open top and closed ring cable supports on 4 ft to 5 ft centers to adequately support and distribute the cable's weight. Use these types of supports to support a maximum of 50 0.25 in diameter cables. Install suspended cables with at least 3 in of clear vertical space above the ceiling tiles and support channels (T-bars). Open top and closed ring cable supports: suspended from or attached to the structural ceiling or walls with hardware or other installation aids specifically designed to support their weight.

3.1.8 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways: cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when surface mounted on interior walls exposed up to 7 feet above floors and walkways, and when specifically indicated. Boxes in other locations: sheet steel, except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic conduit system. Provide each box with volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures: minimum 4 inches square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls: square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; provide readily removable fixtures for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.8.1 Boxes

Boxes for use with raceway systems: minimum 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets: minimum 4 inches square, except that 4 by 2 inch boxes may be used where only one raceway enters outlet. Telecommunications outlets: a minimum of 4 inches square by 2 1/8 inches deep. Mount outlet boxes flush in finished walls.

3.1.8.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, and compatible with nonmetallic raceway systems, except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate

clearly electrical characteristics, circuit number, and panel designation.

3.1.8.3 Extension Rings

Extension rings are not permitted for new construction. Use only on existing boxes in concealed conduit systems where wall is furred out for new finish.

3.1.9 Mounting Heights

Mount panelboards, enclosed circuit breakers, motor controller and disconnecting switches so height of center of grip of the operating handle of the switch or circuit breaker at its highest position is maximum 79 inches above floor or working platform or as allowed in Section 404.8 per NFPA 70. Mount lighting switches. Mount receptacles and telecommunications outlets 18 inches above finished floor, unless otherwise indicated. Mount other devices as indicated. Measure mounting heights of wiring devices and outlets to center of device or outlet.

3.1.10 Nonmetallic Sheathed Cable Installation

Where possible, install cables concealed behind ceiling or wall finish. Thread cables through holes bored on approximate centerline of wood members; notching of end surfaces is not permitted. Provide sleeves through concrete or masonry for threading cables. Install exposed cables parallel to or at right angles to walls or structural members. Protect exposed nonmetallic sheathed cables less than 4 feet above floors from mechanical injury by installation in conduit or tubing. When cable is used in metal stud construction, insert plastic stud grommets in studs at each point through which cable passes, prior to installation of cable.

3.1.11 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Identify control circuit terminations in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.1.11.1 Marking Strips

Provide marking strips for identification of power distribution, control, data, and communications cables in accordance with the following:

- a. Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations.
- b. Use permanent ink for the wire numbers
- c. Provide reversible marking strips to permit marking both sides, or provide two marking strips with each block.
- d. Size marking strips to accommodate the two sets of wire numbers.

- e. Assign a device designation in accordance with NEMA ICS 1 to each device to which a connection is made. Mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams.
- f. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations.
- g. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.1.12 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller diameter with insulated, pressure-type connector. Make splices in conductors No. 8 AWG and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

3.1.12.1 Splices of Aluminum Conductors

Make with solderless circumferential compression-type, aluminum-bodied connectors UL listed for AL/CU. Remove surface oxides from aluminum conductors by wire brushing and immediately apply oxide-inhibiting joint compound and insert in connector. After joint is made, wipe away excess joint compound, and insulate splice.

3.1.13 Terminating Aluminum Conductors

3.1.13.1 Termination to Copper Bus

Terminate aluminum conductors to copper bus either by: (a) inline splicing a copper pigtail, of ampacity at least that of aluminum conductor, or (b) utilizing circumferential, compression-type, aluminum-bodied terminal lug UL listed for AL/CU, and steel Belleville cadmium-plated hardened steel spring washers, flat washers, bolts, and nuts. Carefully install Belleville spring washers with crown up toward nut or bolt head, with concave side of Belleville bearing on heavy-duty, wide series flat washer of larger diameter than Belleville. Tighten nuts sufficiently to flatten Belleville, and leave in position. Lubricate hardware with joint compound prior to making connection. Wire brush and apply joint compound to conductor prior to inserting in lug.

3.1.13.2 Termination to Aluminum Bus

Terminate aluminum conductors to aluminum bus by using aluminum nuts, bolts, washers, and compression lugs. Wire brush and apply joint compound to conductor prior to inserting in lug. Lubricate hardware with joint compound prior to making connection. When bus contact surface is unplated, scratch-brush and coat with joint compound, without grit.

3.1.14 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of $1/16$ inch. Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.1.15 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.16 Grounding and Bonding

Provide in accordance with NFPA 70. Ground exposed, non-current-carrying metallic parts of electrical equipment, access flooring support system, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, grounding conductor of nonmetallic sheathed cables, and neutral conductor of wiring systems. Make ground connection to driven ground rods on exterior of building. Bond additional driven rods together with a minimum of 4 AWG soft bare copper wire buried to a depth of at least 12 inches. Interconnect all grounding media in or on the structure to provide a common ground potential. This includes lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Make interconnection to the gas line on the customer's side of the meter. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system. In addition to the requirements specified herein, provide telecommunications grounding in accordance with TIA-607. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.16.1 Ground Rods

Provide ground rods and measure the resistance to ground using the fall-of-potential method described in IEEE 81. Do not exceed 25 ohms under normally dry conditions for the maximum resistance of a driven ground. If this resistance cannot be obtained with a single rod, 2 additional rods, spaced on center. Spacing for additional rods must be a minimum of 10 feet. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer who will decide on the number of ground rods to add.

3.1.16.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required, by exothermic weld or high compression connector.

- a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

- b. Make high compression connections using a hydraulic or electric compression tool to provide the correct circumferential pressure. Provide tools and dies as recommended by the manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.16.3 Ground Bus

Provide a copper ground bus in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of transformer neutrals and other electrical equipment: effectively grounded by bonding to the ground bus. Bond the ground bus to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 4 inches above the floor. Make connections and splices of the brazed, welded, bolted, or pressure-connector type, except use pressure connectors or bolted connections for connections to removable equipment. For raised floor equipment rooms in computer and data processing centers, provide a minimum of four, one at each corner, ground buses connected to the building grounding system. Use bolted connections in lieu of thermoweld, so they can be changed as required by additions and alterations.

3.1.16.4 Resistance

Maximum resistance-to-ground of grounding system: do not exceed 5 ohms under dry conditions. Where resistance obtained exceeds 5 ohms, contact Contracting Officer for further instructions.

3.1.16.5 Telecommunications System

Provide telecommunications grounding in accordance with the following:

- a. Telecommunications Grounding Busbars: Provide a Primary bonding busbar (PBB) in the telecommunications entrance facility. Install the PBB as close to the electrical service entrance grounding connection as practicable. Provide a Secondary bonding busbar (SBB) in all other telecommunications rooms and telecommunications equipment rooms. Install the SBB as close to the telecommunications room panelboard as practicable, when equipped. Where a panelboard for telecommunications equipment is not installed in the telecommunications room, locate the SBB near the backbone cabling and associated terminations. In addition, locate the SBB to provide for the shortest and straightest routing of the grounding conductors. Where a panelboard for telecommunications equipment is located within the same room or space as a SBB, bond that panelboard's alternating current equipment ground (ACEG) bus (when equipped) or the panelboard enclosure to the SBB. Install Secondary bonding busbars to maintain clearances as required by NFPA 70 and insulated from its support. A minimum of 2 inches separation from the wall is recommended to allow access to the rear of the busbar and adjust the mounting height to accommodate overhead or underfloor cable routing.
- b. Telecommunications Bonding Conductors: Provide main telecommunications service equipment ground consisting of separate bonding conductor for telecommunications, between the PBB and readily accessible grounding connection of the electrical service. Grounding and bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place grounding and bonding conductors in ferrous metallic conduit that exceeds 3 feet in length, bond the

conductors to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum. Provide a telecommunications bonding backbone (TBB) that originates at the PBB extends throughout the building using the telecommunications backbone pathways, and connects to the SBBs in all telecommunications rooms and equipment rooms. Install the TBB conductors such that they are protected from physical and mechanical damage. The TBB conductors should be installed without splices and routed in the shortest possible straight-line path. Make the bonding conductor between a TBB and a SBB continuous. Where splices are necessary, the number of splices should be a minimum. Make the splices accessible and located in telecommunications spaces. Connect joined segments of a TBB using exothermic welding, irreversible compression-type connectors, or equivalent. Install all joints to be adequately supported and protected from damage. Whenever two or more TBBs are used within a multistory building, bond the TBBs together with a grounding equalizer (GE) at the top floor and at a minimum of every third floor in between. Do not connect the TBB and GE to the pathway ground, except at the PBB or the SBB.

- c. Telecommunications Grounding Connections: Telecommunications grounding connections to the PBB: utilize listed compression two-hole lugs, exothermic welding, suitable and equivalent one hole non-twisting lugs, or other irreversible compression type connections. Bond all metallic pathways, cabinets, and racks for telecommunications cabling and interconnecting hardware located within the same room or space as the PBB to the PBB. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; bond each PBB to the vertical steel metal frame using a minimum No. 6 AWG conductor. Where the metal frame is external to the room and readily accessible, bond the metal frame to the SBB or PBB with a minimum No. 6 AWG conductor. When practicable because of shorter distances and, where horizontal steel members are permanently electrically bonded to vertical column members, the SBB may be bonded to these horizontal members in lieu of the vertical column members. All connectors used for bonding to the metal frame of a building must be listed for the intended purpose.

3.1.17 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications and are provided under the section specifying the associated equipment.

3.1.18 Government-Furnished Equipment

Contractor make connections to Government-furnished equipment to make equipment operate as intended, including providing miscellaneous items such as plugs, receptacles, wire, cable, conduit, flexible conduit, and outlet boxes or fittings.

3.1.19 Repair of Existing Work

Perform repair of existing work, demolition, and modification of existing electrical distribution systems as follows:

3.1.19.1 Workmanship

Lay out work in advance. Exercise care where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for proper installation, support, or anchorage of conduit, raceways, or other electrical work. Repair damage to buildings, piping, and equipment using skilled craftsmen of trades involved.

3.1.19.2 Existing Concealed Wiring to be Removed

Disconnect existing concealed wiring to be removed from its source. Remove conductors; cut conduit flush with floor, underside of floor, and through walls; and seal openings.

3.1.19.3 Removal of Existing Electrical Distribution System

Removal of existing electrical distribution system equipment includes equipment's associated wiring, including conductors, cables, exposed conduit, surface metal raceways, boxes, and fittings, back to equipment's power source as indicated.

3.1.19.4 Continuation of Service

Maintain continuity of existing circuits of equipment to remain. Maintain existing circuits of equipment energized. Restore circuits wiring and power which are to remain but were disturbed during demolition back to original condition.

3.1.20 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet avoiding 90 degree bends. Do not locate surge protective devices inside a panelboard or switchboard enclosure.

3.2 FIELD FABRICATED 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. Space the signs in accordance with NFPA 70E.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting: as specified in Section 09 90 00 PAINTS AND COATINGS.

3.5 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer 5 working days notice prior to each test s. Where applicable, test electrical equipment in accordance with NETA ATS.

3.5.1 Devices Subject to Manual Operation

Operate each device subject to manual operation at least five times, demonstrating satisfactory operation each time.

3.5.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of 1,000 volts DC for 600 volt rated wiring and 500 volts DC for 300 volt rated wiring per [NETA ATS](#) to provide direct reading of resistance. All existing wiring to be reused must also be tested.

3.5.3 Transformer Tests

Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in [NETA ATS](#). Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

3.5.4 Ground-Fault Receptacle Test

Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in [UL 943](#).

3.5.5 Arc-Fault Receptacle Test

Test arc-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in [UL 1699](#).

3.5.6 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to Contracting Officer, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

3.5.7 Watthour Meter

a. Visual and mechanical inspection

- (1) Examine for broken parts, shipping damage, and tightness of connections.
- (2) Verify that meter type, scales, and connections are in accordance with approved shop drawings.

b. Electrical tests

- (1) Determine accuracy of meter.
- (2) Calibrate watthour meters to one-half percent.
- (3) Verify that correct multiplier has been placed on face of meter, where applicable.

3.5.8 Phase Rotation Test

Perform phase rotation test to ensure proper rotation of service power prior to operation of new or reinstalled equipment using a phase rotation meter. Follow the meter manual directions performing the test.

-- End of Section --

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SECTION 26 27 13.10 30

ELECTRIC METERS

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.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

- IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
- IEEE C2 (2023) National Electrical Safety Code
- IEEE C37.90.1 (2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
- IEEE C57.13 (2016) Standard Requirements for Instrument Transformers

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

- IEC 61000-4-5 (2017) Electromagnetic Compatibility (EMC) - Part 4-5: Testing and Measurement Techniques - Surge Immunity Test
- IEC 62053-22 (2020) Electricity Metering Equipment (A.C.) - Particular Requirements - Part 22: Static Meters for Active Energy (Classes 0,2 S and 0,5 S)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- ANSI C12.18 (2006; R 2016) Protocol Specification for ANSI Type 2 Optical Port
- ANSI C12.20 (2015; E 2018) Electricity Meters - 0.1, 0.2, and 0.5 Accuracy Classes
- ANSI C62.61 (1993) American National Standard for Gas Tube Surge Arresters on Wire Line Telephone Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 70 (2023) National Electrical Code

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms

used in this specification and on the drawings are as defined in IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

- a. Provide the following in the maintenance manual:
 1. Condensed description of how the equipment operates.
 2. Block diagram indicating major assemblies.
 3. Troubleshooting information
 4. Preventive maintenance.
 5. Spare parts information.
- b. Provide operation and maintenance manuals required by submittal item "SD-10 Operation and Maintenance Data."

SD-02 Shop Drawings

SD-03 Product Data

Power Meters; G

Current Transformers; G

Potential Transformer; G

Communications Module; G

Protocol Modules; G

Data Recorder; G

Modem; G

Include manufacturer's information for each component, device, and accessory provided with the meter, protocol module or communications module.

SD-06 Test Reports

Acceptance Checks and Tests; G

SD-10 Operation and Maintenance Data

Power Meters; G

Communications Module; G

Protocol Modules; G

Data Recorder; G

Modem; G

SD-11 Closeout Submittals

System Function Verification; G

1.4 QUALITY ASSURANCE

1.4.1 Installation Drawings

Drawings indicate but are not limited to the following:

- a. Elementary diagrams and wiring diagrams with terminals identified of advanced meter, current transformers, potential transformers, protocol modules, communications modules, Ethernet connections,.
- b. One-line diagram, including meters, switch(es), current transformers, potential transformers, protocol modules, communications modules, Ethernet connections, and fuses.

1.4.2 Standard Products

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. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Provide product that has 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 must 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 this section.

1.4.3 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.

1.4.4 Material and Equipment Manufacturing Data

Do not use products manufactured more than 2 years prior to date of delivery to site, unless specified otherwise.

1.5 WARRANTY

Provide equipment items 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 SYSTEM DESCRIPTION

1.6.1 System Requirements

The metering and reading system, consisting of commercial, off-the-shelf meters, [protocol modules](#), communications modules, and communication

channels, will be used to record the electricity consumption and other values as described in the sections that follow and as shown on the drawings.

1.6.2 Selection Criteria

Metering components are part of a system that includes the physical meter, [data recorder](#) function and communications ([modem](#)) method. Include sufficient metering components to measure the electrical parameters identified and to store and communicate the values as required in the following sections for every building site identified. Verify that the metering system installed on any building site is compatible with the facility-wide communication and meter-reading protocol system.

PART 2 PRODUCTS

2.1 POWER METERS

2.1.1 Physical and Common Requirements

- a. Install metering system components according to the Metering System Schedule shown on the drawings.
- c. Power meter must be panel-mounted design. Furnish meters that are semi-flush, back-connected, dustproof, draw-out switchboard type. Provide cases with window removable covers capable of being sealed against tampering. Meters must be of a type that can be withdrawn through approved sliding contacts from fronts of panels or doors without opening current-transformer secondary circuits, disturbing external circuits, or requiring disconnection of any meter leads. Incorporate necessary test devices within each meter and provide means for testing either from an external source of electric power or from associated instrument transformers or bus voltage.
- d. If existing meter base is usable, the meter base determines meter form factor. If a new meter is being installed, use meter and base form factor of [9S](#).
- f. Provide meter consisting of a Class 20, transformer rated design.
- g. Provide meter that is rated for use at temperature from [-40 degrees Centigrade to +70 degrees Centigrade](#).
- h. Meter must have NEMA 3R enclosure for surface mounting.
- i. Surge withstand must conform to [IEEE C37.90.1](#).
- j. Provide meter with a standard 4 -year warranty.
- k. Provide meter in compliance with [IEC 62053-22](#) (Part 21: Static Meter for Active Energy, classes 0.2S and 0.5S), certified by a qualified third party test laboratory.

2.1.2 Voltage Requirements

- a. Furnish meter that is capable of connection to the service voltage phases and magnitude being monitored. If the meter is not rated for the service voltage, provide suitable potential transformers to send

an acceptable voltage to the meter.

- b. Provide meter that is capable of connection to the service voltage indicated in the Metering System Schedule:
- c. Provide meter that accepts independent voltage inputs from each phase and is auto-ranging over the full range of input voltages.
- d. Optically isolate voltage input to 2500 volts DC from signal and communications outputs. Use components meeting or exceeding [IEEE C37.90.1](#) (Surge Withstand Capability).
- e. The Contractor is responsible for determining the actual voltage ratio of each [potential transformer](#). Provide transformer conforming to [IEEE C57.13](#) and the following requirements.
 - 1. Type: Dry type, of two-winding construction.
 - 2. Weather: Outdoor or Indoor rated for the application.
 - 3. Frequency: Nominal 60Hz, 50Hz for those bases that operate on 50Hz.
 - 4. Accuracy: Plus or minus 0.3% at 60Hz or 0.3% for those systems that operate at 50Hz.

2.1.3 [Current](#) Requirements

- a. Accept independent current inputs from each phase. Install current transformer with a full load rating as shown in the schedule.
- b. Provide single ratio current transformer with an Accuracy Class of 1.2 with a maximum error of +/- 1.2% at 5.0 amps.
- c. Current transformer must have:
 - 1. Insulation Class: Provide 600 volt and below current transformers rated at 10 KV BIL. Provide current transformers for 2400 and 4160 volt service rated at 25 KV BIL.
 - 2. Frequency: Nominal 60Hz, 50Hz for bases that operate on 50Hz.
 - 3. Burden: Select burden class for the load.
 - 4. Phase Angle Range: 0 to 60 degrees.
- d. Provide meter that accepts current input from standard instrument transformers (5A secondary current transformers.)
- e. Current inputs must have a continuous rating in accordance with [IEEE C57.13](#).
- f. Provide multi-ratio current transformer where indicated with a top range equal to or greater than the actual load. The Contractor is responsible for determining the actual ratio of each transformer. Provide current transformer conforming to [IEEE C57.13](#).

2.1.4 Electrical Measurements

Measure and report the following quantities:

- a. Kilowatt-hours ("kWh" in Metering Systems Schedule) of consumption. Cumulative.
- b. Kilowatts of demand ("kW" in Metering Systems Schedule). Peak average over a selectable demand interval between 5 and 60 minutes (typically 15 minutes).
- c. Reactive power ("kVAR" in Metering Systems Schedule). Measured over the same interval as the peak kW reading.
- d. Power factor ("PF" in Metering Systems Schedule). Measured over the same interval as the peak kW reading.
- e. Time of use consumption ("TOU" in Metering Systems Schedule). Kilowatt-hours recorded separately for each period set by programming into the meter. Time periods must be capable of being changed without removal from service. The meter must internally record and store Time of Use data.
 - 1. Four (4) minimum TOU Rates (Registers)
 - 2. Twenty (20) Year Calendar
 - 3. Two (2) minimum seasons per year
- f. Interval recording ("IR" in Metering Systems Schedule). Record kilowatt-hours for each 15 minute interval and accumulate for 30 days. Memory for recording the interval readings must be internal to the meter and ANSI C12.19 compliant. Provide time-stamped readings for every measured parameter.
- g. Meter readings must be true RMS.

2.1.5 Meter Accuracy

Provide the following accuracies. Measure accuracies as percent of reading at standard meter test points.

- a. Provide power meter meeting ANSI C12.20 for Class 0.2 and IEC 62053-22 accuracy requirements.

2.1.6 An on the Meter Display, Output and Reading Capabilities

Include the following output signals.

- a. The meter will have a face display plate and will display every electrical parameter indicated to be recorded. Do not require meters to indicate interval data collected in a data logger with a communications output feature. Display peak values, instantaneous and cumulative values.
- b. Include optical output port capable of 9600 bps communication with a hand-held reading device. Provide optical device that is compatible with ANSI C12.18
- c. Include output options for analog milliamp signals.
- d. Provide meter with two channels of analog output, 0-1mA or 4-20mA, for

positive and negative watt/hour readings.

- e. Include output option for pulse output. KYZ pulse output related to kWatts/HR.
- f. Provide meter with two form C, dry contact relay outputs for alarm or control.

2.1.7 Installation Methods

- a. Transformer mounted (XFMR)
 - 1. Locate meter base outside on the secondary side of the pad-mounted transformer.
- b. Stand-mounted adjacent to transformer ("STAND" in Metering Systems Schedule)
 - 1. Mount meter base on a structural steel pole approximately 4 feet from the transformer pad. See detail on the drawings.
- c. Building mounted ("BLDG" in Metering Systems Schedule)
 - 1. Mount meter base on the side of the existing building near the service entrance. See detail on the drawings.
- d. Panel mounted. ("PNL" in Metering Systems Schedule)
 - 1. Mount meter where directed. See detail on the drawings.
- e. Common features.
 - 1. PTs (if required for proper voltage range) and physically connect CTs to the service entrance cables inside the service entrance disconnect enclosure.

2.1.8 Disconnecting Switches

- a. Provide disconnecting wiring blocks between the current transformer and the meter. Build a shorting mechanism into the wiring block to allow the current transformer wiring to be changed without removing power to the transformer. Locate the wiring blocks where they are accessible without the necessity of disconnecting power to the transformer. For multi-ratio current transformers, provide a shorting block from each tap to the common lead.
- b. Equip voltage-monitoring circuits with disconnect switches to isolate the meter base or socket from the voltage source.

2.1.9 Meter Programming

- a. Provide power meter that is programmable by software supplied by the meter manufacturer.
- b. Provide user-friendly software with Windows-compatible interface.
- c. Operate software on Windows operating systems.
- d. Provide software that allows the user to configure the meter,

troubleshoot meter, query and display meter parameters and configuration data and stored values.

- e. Provide meter firmware that is upgradeable through one of the communications ports without removing the unit from service.

2.2 COMMUNICATIONS

2.2.1 Communications Methods

2.2.1.1 Optical Port

Communicate with a hand-held reading device according to the following requirements.

- a. Communications standards

- 1. ANSI C12.18
- 2. MV90 protocol
- 3. ANSI C12.20

- b. Read operations

- 1. Current kWh values
- 2. Demand (kW) values since last reset
- 3. Last reset value
- 4. Meter status
- 5. Load profile

- c. Write operations

- 1. Meter setup

2.2.1.2 Serial Port

Provide serial port for connection to modem module where required in this specification.

- a. On-Board serial port types

- 2. \

2.2.1.3 Ethernet

For those meters using the Ethernet, send logged information using open standard Internet Protocols.

- a. On-board Ethernet port support

- 1. HTTP
- 2. SMTP

(a) Modbus

b. Distribute stored data by

1. FTP
2. E-Mail

(a) On-board web server

2.2.2 Communications Protocols and Methods

Use communications protocols and methods that are native to the meter. Provide [communications module\(s\)](#) as required to accomplish the following.

- a. Include an IR port ("IR" in Metering Systems Schedule) for communication to external devices such as handheld readers that support a minimum speed of 9600 baud.
- b. Include one or RS-485 ("RS485" in Metering Systems Schedule) digital communication port. Provide user configurable port with regard to speed, protocol, address, and other communications parameters that support a minimum communication speed of 9600 baud for the RS232 port.
- c. Provide meter with a port that can be configured as a
- d. Auto Answer minimum 1200 baud internal modem ("A56K" in Metering Systems Schedule). Include automatic data buffering to provide faster, more reliable communications and the ability to automatically answer on a connected line.
- e. Equip meter with one pulse output channel ("Pulse" in Metering Systems Schedule) that can be configured for operation as KYZ pulse output.

2.2.3 Communications Channels Surge Protection

Protect communications equipment against surges induced on its communications channels. Protect communication interfaces to all field equipment to meet the requirements of [IEEE C37.90.1](#) or the requirements of [IEC 61000-4-5](#), test level 4, while the equipment is operating. Do not use fuses for surge protection. For metallic cables and conductors which serve as communications channels between buildings, install surge protection at equipment rated for the application at each end, within [3 feet](#) of the building cable entrance. Provide surge protectors meeting the requirements of the applicable extension of ANSI C62 (for example, [ANSI C62.61](#)).

2.3 METER DATA PROTOCOL

Provide power meters that have communicating data protocols native or provide in supplemental modules to communicate with the communications methods that follow.

2.3.1 Open Protocol

Support the following open protocols. Verify that the meter native protocol is consistent with the facility data recording and communication and data storage system. Provide additional converters and modules as required for a complete measurement, recording, communicating and data

storage system.

- a. Provide meter that is fully supported by MV-90 software system or existing AMR software that is MV-90 compatible.
- b. For systems that use proprietary software, an alternative, competitive software system must be available.

Systems capable of using more than one brand of commercially available meters are expected. In addition, if proprietary meter reading software is used, meters are to be capable of being read by more than one manufacturer's software.

2.4 SPARE PARTS

2.4.1 Parts List

Provide spare parts as follows:

- a. Power meter - two for each type used.
- b. Current transformer - three for each type used.
- c. Potential transformer - three for each type used.
- d. Communications module - one for each type used.
- e. Protocol module - one for each type used.
- f. Other electronic and power components - one for each type used.

2.5 METERING SYSTEM SCHEDULE

Metering System Schedule is available at

<http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic>

PART 3 EXECUTION

3.1 INSTALLATION

Perform electrical installations conforming to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.1.1 Scheduling of Work and Outages

The Contract Clauses govern regarding permission for power outages, scheduling of work, coordination with Government personnel, and special working conditions.

3.2 FIELD QUALITY CONTROL

3.2.1 Performance of Acceptance Checks and Tests

3.2.1.1 Meter Assembly

- a. Visual and mechanical inspection

1. Compare equipment nameplate data with specification and approved shop drawings.
2. Inspect physical and mechanical condition.
3. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.
4. Verify grounding of metering enclosure.
5. Verify the presence of surge arresters.
6. Verify that the CT ratio and the PT ratio are properly included in the meter multiplier or the programming of the meter.

b. Electrical tests

2. Verify that correct multiplier has been placed on face or meter where applicable.
3. Prior to system acceptance, the Contractor will demonstrate and confirm the meter is properly wired and is displaying correct and accurate electrical information.

3.2.1.2 Current Transformers

a. Visual and mechanical inspection

1. Compare equipment nameplate data with specification and approved shop drawings.
2. Inspect physical and mechanical condition.
3. Verify correct connection.
4. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.
5. Verify that required grounding and shorting connections provide good contact.

b. Electrical tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.
2. Perform insulation-resistance test.
3. Perform a polarity test.
4. Perform a ratio-verification test.

3.2.1.3 Potential Transformers

a. Visual and mechanical inspection

1. PT's are rigidly mounted.

2. PT's are correct voltage.

3. Verify that adequate clearances exist between primary and secondary circuit.

b. Electrical tests

1. Perform a ratio-verification test.

3.2.2 Follow-Up [System Function Verification](#)

Upon completion of acceptance checks and tests, the show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, give the Contracting Officer 5 working days' advance notice of the dates and times of checking and testing.

3.2.3 Training

Conduct a training course for meter configuration, operation, and maintenance of the system as specified. Orient the training for all components and systems installed under this contract. Deliver training manuals for trainees with two additional copies delivered for archiving at the project site. Furnish all audiovisual equipment and all other training materials and supplies. A training day is defined as eight 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. For guidance in planning the required instruction, assume that attendees have a high school education or equivalent, and are familiar with utility systems. Obtain approval of the planned training schedule from the Government at least 30 days prior to the training.

a. Training: Teach the course at the project site within thirty days after completion of the installation for a period of one day(s). A maximum of 6 personnel will attend the course. The training includes:

1. Physical layout of each piece of hardware.
2. Meter configuration, troubleshooting and diagnostics procedures.
3. Repair instructions.
4. Preventive maintenance procedures and schedules.
5. Testing and calibration procedures.

-- End of Section --

SECTION 26 28 01.00 10

COORDINATED POWER SYSTEM PROTECTION

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.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 242 (2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book

IEEE 399 (1997) Brown Book IEEE Recommended Practice for Power Systems Analysis

1.2 SYSTEM DESCRIPTION

The power system covered by this specification consists of: All electrical equipment associated with the BX portion of the facility, including but not limited to Main service disconnects, Main switchboards, Motor control centers, motor controllers, disconnect switches, fuses, circuit breakers, panelboards and ancillary distribution equipment..

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fault Current Analysis

Protective Device Coordination Study

System Coordinator

1.4 QUALITY ASSURANCE

1.4.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis must be accomplished by a registered professional electrical power engineer with a minimum of 3 years of current experience in the coordination of electrical power systems. Submit verification of experience and license number, of a registered Professional Engineer as specified above. Provide experience data consisting of at least five references for work of a magnitude comparable

to this contract, including points of contact, addresses and telephone numbers.

PART 2 PRODUCTS

2.1 COORDINATED POWER SYSTEM PROTECTION

Prepare analyses to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. Include a load flow analysis, a [fault current analysis](#), and a [protective device coordination study](#). Submit the study 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 will be based on recommendations of this study. The Government is not 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. The studies must be performed by a registered professional engineer with demonstrated experience in power system coordination in the last 3 years. Provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.1.1 Scope of Analyses

The fault current analysis and protective device coordination study must begin at: the source bus ([the primary side of the service transformers](#)) and extend down to [all](#) system buses for building/facility 600 volt or [less](#) level distribution buses.

2.1.2 Determination of Facts

Determine and document the time-current characteristics, features, and nameplate data for each existing protective device. Coordinate with the commercial power company for fault current availability at the site.

2.1.3 Single Line Diagram

Prepare a single line diagram to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point must have a unique identifier. If a fault-impedance diagram is provided, show impedance data. Show location of switches, breakers, and circuit interrupting devices on the diagram together with available fault data, and the device interrupting rating.

2.1.4 Fault Current Analysis

2.1.4.1 Method

Perform the fault current analysis in accordance with methods described in [IEEE 242](#), and [IEEE 399](#).

2.1.4.2 Data

Utilize actual data in fault calculations. Bus characteristics and transformer impedance must be those proposed. Document data in the report.

2.1.4.3 Fault Current Availability

Provide balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values at each voltage transformation point and at each power distribution bus. Show the maximum and minimum values of fault available at each location in tabular form on the diagram or in the report.

2.1.5 Coordination Study

Demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. Include a description of the coordination of the protective devices in this project. Provide a written narrative describing: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Provide recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction). Provide composite coordination plots on log-log graph paper.

2.1.6 Study report

- a. Include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.
- b. Include descriptive and technical data for existing devices and new protective devices proposed. Include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.
- c. Document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings; and existing power system data including time-current characteristic curves and protective device ratings and settings.
- d. The report must contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. Include recommended ratings and settings of all protective devices in tabulated form.
- e. Provide the calculation performed for the analyses, including computer analysis programs utilized. Provide the name of the software package, developer, and version number.

PART 3 EXECUTION

Not Used

-- End of Section --

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SECTION 26 29 23

ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS

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.

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)

EN 61800-3 (2017) Requirements for the Control of
Electromagnetic Interference
Characteristics of Subsystems and Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519 (2022) Standard for Harmonic Control in
Electrical Power Systems

IEEE C62.41.1 (2002; R 2008) Guide on the Surges
Environment in Low-Voltage (1000 V and
Less) AC Power Circuits

IEEE C62.41.2 (2002) Recommended Practice on
Characterization of Surges in Low-Voltage
(1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61000-3-12 (2012) Electromagnetic Compatibility (EMC)
- Part 3-12: Limits - Limits for harmonic
currents produced by equipment connected
to public low-voltage systems with input
current >16 A and ≤75 A per phase

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2020) Enclosures for Electrical Equipment
(1000 Volts Maximum)

NEMA ICS 1 (2022) Standard for Industrial Control and
Systems: General Requirements

NEMA ICS 3.1 (2019) Guide for the Application,
Handling, Storage, Installation and
Maintenance of Medium-Voltage AC
Contactors, Controllers and Control Centers

NEMA ICS 6 (1993; R 2016) Industrial Control and
Systems: Enclosures

NEMA ICS 7 (2020) Adjustable-Speed Drives

NEMA ICS 7.2 (2015) Application Guide for AC Adjustable Speed Drive Systems

NEMA MG 1 (2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15 Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 489 (2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

UL 61800-5-1 (2016) Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this section with additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements

1.3.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15 and EN 61800-3 rules and regulations, must be certified to comply with the requirements for class A computing devices and labeled.

1.3.1.2 Electromechanical and Electrical Components

Ensure electrical and electromechanical components of the Adjustable Speed Drive (ASD) do not cause electromagnetic interference to adjacent electrical or electromechanical equipment while in operation.

1.3.2 Electrical Requirements

1.3.2.1 Power Line Surge Protection

IEEE C62.41.1 and IEEE C62.41.2, IEEE 519, IEC 61000-3-12 Control panel must have surge protection, included within the panel to protect the unit from damaging transient voltage surges. Surge protective device must be mounted near the incoming power source and properly wired to all three phases and ground. Fuses must not be used for surge protection.

1.3.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified must be protected against surges induced on control and sensor wiring installed outdoors and as shown. Test the

inputs and outputs in both normal mode and 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.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Schematic Diagrams; G

Interconnecting Diagrams; G

Installation Drawings; G

As-Built Drawings; G

SD-03 Product Data

Adjustable Speed Drives; G

Wires and Cables

Equipment Schedule

SD-06 Test Reports

ASD Test

Performance Verification Tests

Endurance Test

SD-08 Manufacturer's Instructions

Installation instructions

SD-09 Manufacturer's Field Reports

ASD Test Plan; G

Standard Products

SD-10 Operation and Maintenance Data

Adjustable Speed Drives, Data Package 4

1.5 QUALITY ASSURANCE

1.5.1 Schematic Diagrams

Submit diagrams showing circuits and device elements for each replaceable module. Schematic diagrams of printed circuit boards are permitted to group functional assemblies as devices, provided that sufficient information is provided for government maintenance personnel to verify proper operation of the functional assemblies.

1.5.2 Interconnecting Diagrams

Show interconnections between equipment assemblies, and external interfaces, including power and signal conductors. Include for enclosures and external devices.

1.5.3 Installation Drawings

Show floor plan of each site, with ASD's and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes. Submit drawings for government approval prior to equipment construction or integration. Immediately record modifications to original drawings made during installation for inclusion into the [as-built drawings](#).

1.5.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule must provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule must include the total quantity of each item of equipment supplied and data indicating compatibility with motors being driven. For complete assemblies, such as ASD's, provide the serial numbers of each assembly, and a sub-schedule of components within the assembly. Provide recommended spare parts listing for each assembly or component.

1.5.5 Installation Instructions

Provide installation instructions issued by the manufacturer of the equipment, including notes and recommendations, prior to shipment to the site. Provide operation instructions prior to acceptance testing.

1.5.6 Standard Products

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 and:

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
- b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6 DELIVERY AND STORAGE

Store delivered equipment to protect from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.7 WARRANTY

The complete system must be warranted by the manufacturer for a period of one year . Repair or replace any component failing to perform its function as specified and documented at no additional cost to the Government. Items repaired or replaced must be warranted for an additional period of at least one year from the date that it becomes functional again, as specified in FAR 52.246-21 Warranty of Construction.

1.8 MAINTENANCE

1.8.1 Spare Parts

Manufacturers provide spare parts in accordance with recommended spare parts list.

Provide one spare ASD of each model provided for HVAC equipment, fully programmed and ready for back-up operation when connected.

1.8.2 Operation and Maintenance Data

Provide in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Provide service and maintenance information including preventive maintenance, assembly, and disassembly procedures. Include electrical drawings from electrical general sections. Provide additional information necessary to provide complete operation, repair, and maintenance information, detailed to the smallest replaceable unit. Include copies of as-built submittals. Provide routine preventative maintenance instructions, and equipment required. Provide instructions on how to modify program settings, and modify the control program. Provide instructions on drive adjustment, trouble-shooting, and configuration. Provide instructions on process tuning and system calibration.

1.8.3 Maintenance Support

During the warranty period, provide on-site, on-call maintenance services by drive manufacturer's personnel on the following basis: The service must be on a per-call basis with 36 hour response. Contractor is responsible for the maintenance of all hardware and software of the system during the warranty period. Various personnel of different expertise must be sent on-site depending on the nature of the maintenance service required. Costs must include travel, local transportation, living expenses, and labor rates of the service personnel while responding to the service request. The provisions of this Section are not in lieu of, nor relieve the Contractor of, warranty responsibilities covered in this specification. Should the result of the service request be the uncovering of a system defect covered under the warranty provisions, all costs for the call, including the labor necessary to identify the defect, must be borne by the Contractor.

1.8.4 Technical Support

Provide the ASDs with manufacturer's technical telephone support in English, readily available during normal working hours.

PART 2 PRODUCTS

2.1 ADJUSTABLE SPEED DRIVES (ASD)

Provide adjustable speed drive to control the speed of induction motor(s). The ASD must include the following minimum functions, features and ratings.

- a. Input circuit breaker per [UL 489](#) with a minimum of 10,000 amps symmetrical interrupting capacity and door interlocked external operator.
- b. A converter stage per [UL 61800-5-1](#) must change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter must utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter must be insensitive to three phase rotation of the ac line and must not cause displacement power factor of less than .95 lagging under any speed and load condition.
- c. An inverter stage must change fixed dc voltage to variable frequency, variable ac voltage for application to a standard [NEMA MG 1](#) Part 30 motor designed for use with adjustable frequency power supplies. Switch the inverter to produce a sine coded pulse width modulated (PWM) output waveform.
- d. The ASD shall be capable of supplying 110 percent of rated full load current for one minute at maximum ambient temperature.
- e. The ASD must be designed to operate from a [480](#) volt, plus or minus 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.
- f. Acceleration and deceleration time must be independently adjustable from one second to 60 seconds.

Adjust decelerating time by Required deceleration time may be achieved using not only dynamic braking resistor but with other methods described in [NEMA ICS 7.2](#)-2015 paragraph 5.2.5.

- g. Adjustable full-time current limiting must limit the current to a preset value which must not exceed 110 percent of the controller rated current. The current limiting action must maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override must allow starting current to reach 175 percent of controller rated current to maximum starting torque.
- h. The controllers must be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection must be included such that a failure in the controller electronic circuitry must not cause frequency to exceed 110 percent of the maximum controller output frequency selected.
- i. Minimum and maximum output frequency must be adjustable over the following ranges: 1) Minimum frequency 3 Hz to 50 percent of maximum selected frequency; 2) Maximum frequency 40 Hz to 60 Hz.

- j. The controller efficiency at any speed must not be less than 96 percent.
- k. The controllers must be capable of being restarted into a motor coasting in the forward direction without tripping.
- l. Protection of power semiconductor components must be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions must not result in component failure or the need for fuse replacement:
 - (1) Short circuit at controller output
 - (2) Ground fault at controller output
 - (3) Open circuit at controller output
 - (4) Input undervoltage
 - (5) Input overvoltage
 - (6) Loss of input phase
 - (7) AC line switching transients
 - (8) Instantaneous overload
 - (9) Sustained overload exceeding 115 percent of controller rated current
 - (10) Over temperature
 - (11) Phase reversal
- m. Solid state motor overload protection must
- n. Include slip compensation circuit that will sense changing motor load conditions and adjust output frequency to provide speed regulation of **NEMA MG 1** Part 30 designed for use with adjustable frequency power supplies motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.
- o. The ASD must be factoryset for manual restart after the first protective circuit trip for malfunction (overcurrent, undervoltage, overvoltage or overtemperature) or an interruption of power. The ASD must be capable of being set for automatic restart after a selected time delay. If the drive faults again within a specified time period (adjustable 0-60 seconds), a manual restart will be required.
- p. The ASD must include external fault reset capability. All the necessary logic to accept an external fault reset contact must be included.
- q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations. The ASD must have a minimum of three user selectable bandwidths.
- r. Provide properly sized NEMA rated by-pass and isolation contactors to enable operation of motor in the event of ASD failure. Install

mechanical and electrical interlocks between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer. Motor overload and short circuit protective features must remain in use during the bypass mode.

- s. Each individual ASD must meet the following Total Harmonic Distortion (THD) requirements at the input terminals to the factory assembly of the ASD or at the load disconnecting means serving the ASD and filter assembly. These measurements should be taken with the drive set at 90 percent frequency (rpms) and the motor under a minimum of 50 percent demand.

- (1) The Voltage THD should not exceed 2.0 percent THD.
- (2) The Current THD should not exceed 15.0 percent THD.
- (3) If the standard factory ASD does not meet or exceed these requirements the factory must install appropriate equipment (Harmonic Traps, Filters, different Drive technology, etc.) to mitigate the distortion to assure performance of the VFD is within the limits.
- (4) These tests should be performed at the Manufacturers Laboratory facilities and submitted as part of the Product Data Submittals, in order to prevent the necessity of adding mitigation equipment in the field. If the requirements listed above are met, **IEEE 519** will also be met.

- t. Minimum Operating Conditions. Designed and constructed ASD's to operate within the following service conditions:

- (1) Ambient Temperature Rating: 0 to 120 degrees F.
- (2) Non-condensing relative humidity rating: less than 95 percent.
- (3) Ambient rating: Not exceed **3,300 feet**.

2.1.1.1 ASD for HVAC Application

ASDs must have the following features:

- a. A local operator control providing the following functions:
 - (1) Remote/Local operator selection with password access.
 - (2) Run/Stop and manual speed commands.
 - (3) All programming functions.
 - (4) Scrolling through all display functions.
- b. A local operator control panel with the following data displayed:
 - (1) ASD status.
 - (2) Frequency.
 - (3) Motor RPM.

- (4) Phase current.
- (5) Scrolling through all display functions.
- (6) Fault diagnostics in descriptive text.
- (7) All programmed parameters.
- c. Standard PI loop controller with input terminal for controlled variable and parameter settings.
- d. User interface terminals for remote control of ASD speed, speed feedback, and an isolated form C SPDT relay, which energizes on a drive fault condition.
- e. An isolated form C SPDT auxiliary relay which energizes on a run command.
- f. An adjustable carrier frequency with 16 KHz minimum upper limit.
- g. A built-in or external line reactor with 3 percent minimum impedance to protect the DC bus capacitors and rectifier section diodes.
- h. Historical logging information and displays:
 - (2) Running log of total power versus time.
 - (3) Total run time.
 - (5) .
- i. The ASD must be capable of automatic control by a remote 4-20 mA signal, by BACnetLONworks network command, or manually by the ASD control panel.
- j. ASDs must include the following operator programmable parameters:
 - (1) Upper and lower limit frequency.
 - (2) Acceleration and deceleration rate.
 - (3) Variable torque volts per Hertz curve.
 - (4) Starting voltage level.
 - (5) Starting frequency level.
 - (6) Display speed scaling.
 - (7) Enable/disable soft stall feature.
 - (8) Motor overload level.
 - (9) Motor stall level.
 - (10) Jump frequency and hysteresis band.
 - (11) PWM carrier frequency.

k. ASD must have the following protective features:

- (1) An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.
- (2) An electronic adjustable soft stall feature, allowing the ASD to lower the frequency to a point where the motor will not exceed the full-load amperage when an overload ASD will automatically return to the requested frequency when load conditions permit.
- (3) A separate electronic stall at 110 percent ASD rated current, and a separate hardware trip at 190 percent current.
- (4) The ability to shut down if inadvertently started into a rotating load without damaging the ASD or the motor.
- (5) The ability to keep a log of a minimum of four previous fault conditions, indicating the fault type and time of occurrence in descriptive text.
- (6) The ability to sustain 110 percent rated current for 60 seconds.
- (7) The ability to shutdown safely or protect against and record the following fault conditions:
 - (a) Over current (and an indication if the over current was during acceleration, deceleration, or running).
 - (b) Over current internal to the drive.
 - (c) Motor overload at start-up.
 - (d) Over voltage from utility power.
 - (e) Motor running overload.
 - (f) Over voltage during deceleration.
 - (g) ASD over heat.
 - (h) Load and ground fault.
 - (h) Abnormal parameters or data in ASD EEPROM.

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, and NEMA ICS 6, with a heater if located outdoors. An HMCP device shall provide the disconnecting means. The operating handle shall protrude through the door, but the disconnect shall not be mounted on the door. The handle shall indicate ON, OFF, and tripped conditions. The handle shall have provisions to accommodate a minimum of three padlocks in the OFF position. Interlocks shall prevent unauthorized opening or closing of the ASD door with the disconnect handle in the ON position. The door handle interlock should have provisions to be defeated by qualified maintenance personnel.

2.3 WIRES AND CABLES

All wires and cables must conform to NEMA 250, NEMA ICS 7, NFPA 70.

2.4 NAMEPLATES

Nameplates external to NEMA enclosures must conform with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manufacturer's standard, permanent nameplates for internal areas of enclosures.

2.5 SOURCE QUALITY CONTROL

2.5.1 ASD Test Plan

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans.

2.5.2 ASD Test Report

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test reports.

PART 3 EXECUTION

3.1 INSTALLATION

Per NEMA ICS 3.1, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer must supervise the installation of all equipment, and wiring.

3.2 GROUNDING

Per NEMA ICS 7.2, ASD must be solidly grounded to the main distribution.

3.3 FIELD QUALITY CONTROL

Specified products must be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Conduct performance verification tests in the presence of Government representative, observing and documenting complete compliance of the system to the specifications. Submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.3.1 ASD Test

A proposed test plan must be submitted to the contracting officer at least 28 calendar days prior to proposed testing for approval. The tests must conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Government reserves the right to witness all tests and review any documentation. Inform the Government at least 14 working days prior to the dates of testing. Perform the ASD test with the assistance of a factory-authorized service representative.

3.3.2 Performance Verification Tests

"Performance Verification Test" plan must provide the step by step procedure required to establish formal verification of the performance of the ASD. Compliance with the specification requirements must be verified by inspections, review of critical data, demonstrations, and tests. The Government reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. Inform the Government 14 calendar days prior to the date the test is to be conducted.

3.3.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test must commence. The system must be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of 0.9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. The contractor is not allowed in the building during the endurance test. The system must respond as designed.

3.4 DEMONSTRATION

3.4.1 Training

Coordinate training requirements with the Contracting Officer. Provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. Provide all training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the contracting officer.

3.4.1.1 Instructions to Government Personnel

Provide the services of competent instructors with minimum two-year field experience with the operation and maintenance of similar ASDs who will give full instruction to designated personnel in operation, maintenance, calibration, configuration, and programming of the complete control system. Orient the training specifically to the system installed. Instructors must be thoroughly familiar with the subject matter they are to teach. The number of training days of instruction furnished must be as specified. A training day is defined as eight hours of instruction, including two 15-minute breaks and excluding lunch time; Monday through Friday. Provide a training manual for each student at each training phase which describes in detail the material included in each training program. Provide one additional copy for archiving. Provide equipment and materials required for classroom training. Provide a list of additional related courses, and offers, noting any courses recommended. List each training course individually by name, including duration, approximate cost per person, and location of course. Unused copies of training manuals must be turned over to the Government at the end of last training session.

3.4.1.2 Operating Personnel Training Program

Provide one 2-hour training session at the site at a time and place mutually agreeable between the Contractor and the Government. Provide session to train 4 operation personnel in the functional operations of the system and the procedures that personnel will follow in system operation.

This training shall include:

- a. System overview
- b. General theory of operation
- c. System operation
- d. Alarm formats
- e. Failure recovery procedures
- f. Troubleshooting

3.4.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training must be conducted on site at a location designated by the Government. Provide a one-day training session to train four engineering personnel in the functional operations of the system. This training must include:

- a. System overview
- b. General theory of operation
- c. System operation
- d. System configuration
- e. Alarm formats
- f. Failure recovery procedures
- g. Troubleshooting and repair
- h. Maintenance and calibration
- i. System programming and configuration

-- End of Section --

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SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM

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.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81 (2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023) National Electrical Code

NFPA 780 (2023) Standard for the Installation of Lightning Protection Systems

U.S. AIR FORCE (USAF)

AFI 32-1065 (2017) Grounding Systems

UNDERWRITERS LABORATORIES (UL)

UL 96 (2016) UL Standard for Safety Lightning Protection Components

UL 467 (2022) UL Standard for Safety Grounding and Bonding Equipment

UL Electrical Construction (2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

1.2.1 Verification of Dimensions

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before making any departures from the design.

1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest UL Listed products of a manufacturer regularly engaged in production of lightning protection system components. Comply with **NFPA 70**, **NFPA 780**, and **UL 96**.

1.2.3 Lightning Protection System Installers Documentation

Provide documentation showing that the installer is certified with a commercial third-party inspection company whose sole work is lightning protection, or is a UL Listed Lightning Protection Installer. In either case, the documentation must show that they have completed and passed the requirements for certification or listing, and have a minimum of 2 years documented experience installing lightning protection systems for DoD projects of similar scope and complexity.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overall lightning protection system; G

Each major component; G

SD-06 Test Reports

Lightning Protection and Grounding System Test Plan; G

Lightning Protection and Grounding System Test; G

SD-07 Certificates

Lightning Protection System Installers Documentation; G

Component UL Listed and Labeled; G

Lightning protection system inspection certificate; G

Roof manufacturer's warranty; G

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" has been substituted for "should" wherever it appears. Interpret references in these standards to "authority having jurisdiction," or words of similar meaning, to mean Contracting Officer.

1.4.1 Installation Drawings

1.4.1.1 Overall System Drawing

Submit installation shop drawing for the overall lightning protection system. Include on the drawings the physical layout of the equipment (plan view and elevations), mounting details, relationship to other parts of the work, and wiring diagrams.

1.4.1.2 Major Components

Submit detail drawings for each major component including manufacturer's

descriptive and technical literature, catalog cuts, and installation instructions.

1.4.2 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled. Listing alone in [UL Electrical Construction](#), which is the UL Electrical Construction Directory, is not acceptable evidence. In lieu of Listed and Labeled, submit written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories.

1.4.3 Lightning Protection and Grounding System Test Plan

Provide a lightning protection and grounding system test plan. Detail both the visual inspection and electrical testing of the system and components in the test plan. Identify (number) the system test points/locations along with a listing or description of the item to be tested and the type of test to be conducted. As a minimum, include a sketch of the facility and surrounding lightning protection system as part of the specific test plan for each structure. Include the requirements specified in paragraph, "Testing of Integral Lightning Protection System" in the test plan.

1.4.4 Lightning Protection System Inspection Certificate

Provide certification from a commercial third-party inspection company whose sole work is lightning protection, stating that the lightning protection system complies with [NFPA 780](#) and [AFI 32-1065](#). Third party inspection company cannot be the system installer or the system designer. Alternatively, provide a UL Lightning Protection Inspection Master Label Certificate for each facility indicating compliance to [NFPA 780](#) and [AFI 32-1065](#). In either case, [AFI 32-1065](#) takes precedence over [NFPA 780](#), whether or not it is more stringent.

Inspection must cover every connection, air terminal, conductor, fastener, accessible grounding point and other components of the lightning protection system to ensure 100% system compliance. This includes witnessing the tests for the resistance measurements for ground rods with test wells, and for continuity measurements for bonds. It also includes verification of proper surge protective devices for power, data and telecommunication systems. Random sampling or partial inspection of a facility is not acceptable.

1.5 SITE CONDITIONS

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before changing the design.

PART 2 PRODUCTS

2.1 MATERIALS

Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist which would cause corrosion of conductors,

provide conductors with protective coatings, such as tin or lead, or oversize conductors. Where a mechanical hazard is involved, increase conductor size to compensate for the hazard or protect conductors. When metallic conduit or tubing is provided, electrically bond conductor to conduit or tubing at the upper and lower ends by clamp type connectors or welds (including exothermic). All lightning protection components, such as bonding plates, air terminals, air terminal supports and braces, chimney bands, clips, connector fittings, and fasteners are to comply with the requirements of **UL 96** classes as applicable.

2.1.1 Main and Bonding Conductors

NFPA 780 and **UL 96** Class I, Class II, or Class II modified materials as applicable.

2.1.2 Copper Only

Provide copper conductors, except where aluminum conductors are required for connection to aluminum equipment.

2.2 COMPONENTS

2.2.1 Air Terminals

Provide solid air terminals with a blunt tip. Tubular air terminals are not permitted. Support air terminals more than **24 inches** in length by suitable brace, supported at not less than one-half the height of the terminal.

2.2.2 Ground Rods

Provide ground rods made of solid copper conforming to conform to **UL 467**. Provide ground rods that are not less than **3/4 inch** in diameter and **10 feet** in length. Do not mix ground rods of copper-clad steel or solid copper on the job.

2.2.3 Grounding Plates

Provide grounding plates made of solid copper conforming to **UL 96**.

2.2.4 Connections and Terminations

Provide connectors for splicing conductors that conform to **UL 96**, class as applicable. Conductor connections can be made by clamps or welds (including exothermic). Provide style and size connectors required for the installation.

2.2.5 Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to **NFPA 780** and **UL 96**.

PART 3 EXECUTION

3.1 INTEGRAL SYSTEM

Provide a lightning protection system that meets the requirements of **NFPA 780**. Lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, grounding electrodes.

Bond secondary conductors with grounded metallic parts within the building. Make interconnections within side-flash distances at or below the level of the grounded metallic parts.

3.1.1.1 Roof-Mounted Components

Coordinate with the roofing manufacturer and provide certification that the [roof manufacturer's warranty](#) is not violated by the installation methods for air terminals and roof conductors.

3.1.1.1.1 Air Terminals

Use adhesive shoes with adhesive approved by the roof manufacturer when installing air terminals on "rubber" (EPDM) type roofs.

3.1.1.1.2 Roof Conductors

Use adhesive shoes with adhesive approved by the roof manufacturer when installing roof conductors on "rubber" (EPDM) type roofs. Use a standing seam base for installation of roof conductors on a standing seam metal roof that does not produce any roof penetrations.

3.1.2 Down Conductors

Protect exposed down conductors from physical damage as required by [NFPA 780](#). Use Schedule 80 PVC to protect down conductors. Paint the Schedule 80 PVC to match the surrounding surface with paint that is approved for use on PVC.

3.1.3 Ground Connections

Attach each down conductor to ground rods by welding (including exothermic), brazing, or compression. All connections to ground rods below ground level must be by exothermic weld connection or with a high compression connection using a hydraulic or electric compression tool to provide the correct circumferential pressure. Accessible connections above ground level and in test wells can be accomplished by mechanical clamping.

3.1.4 Grounding Electrodes

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not less [10 feet](#). Set ground rods not less than [3 feet](#) nor more than [8 feet](#), from the structure foundation, and at least beyond the drip line for the facility. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in [IEEE 81](#). Maximum allowed resistance of a driven ground rod is 25 ohms, under normally dry conditions. Contact the Contracting Officer for direction on how to proceed when two of any three ground rods, driven not less than [10 feet](#) into the ground, a minimum of [10 feet](#) apart, and equally spaced around the perimeter, give a combined value exceeding 50 ohms immediately after having driven.

3.2 APPLICATIONS

3.2.1 Nonmetallic Exterior Walls with Metallic Roof

Bond metal roof sections together which are insulated from each other so that they are electrically continuous, having a surface contact of at least

3 square inches.

3.3 INTERFACE WITH OTHER STRUCTURES

3.3.1 Fences

Bond metal fence and gate systems to the lightning protection system whenever the fence or gate is within 6 feet of any part of the lightning protection system in accordance with ANSI C2.

3.4 RESTORATION

Where sod has been removed, place sod as soon as possible after completing the backfilling. Restore, to original condition, the areas disturbed by trenching, storing of dirt, cable laying, and other work. Overfill to accommodate for settling. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration. Maintain disturbed surfaces and replacements until final acceptance.

3.5 FIELD QUALITY CONTROL

3.5.1 Lightning Protection and Grounding System Test

Test the lightning protection and grounding system to ensure continuity is not in excess of 1 ohm and that resistance to ground is not in excess of 25 ohms. Provide documentation for the measured values at each test point. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Include in the written report: locations of test points, measured values for continuity and ground resistances, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

-- End of Section --

SECTION 27 10 00

BUILDING TELECOMMUNICATIONS CABLING SYSTEM

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.

ASTM INTERNATIONAL (ASTM)

ASTM D709 (2017) Standard Specification for
Laminated Thermosetting Materials

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E (2005) Cabinets, Racks, Panels, and
Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100 (2000; Archived) The Authoritative
Dictionary of IEEE Standards Terms

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-83-596 (2021) Indoor Optical Cable

ICEA S-90-661 (2021) Category 3 and 5E Individually
Unshielded Twisted Pairs, Indoor Cables
(With or Without an Overall Shield) for
Use in General Purpose and LAN
Communications Wiring Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA/BICSI 568 (2006) Standard for Installing Building
Telecommunications Cabling

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 66 (2019) Performance Standard for Category 6
and Category 7 100 Ohm Shielded and
Unshielded Twisted Pairs

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-21 (1988a; R 2012) FOTP-21 - Mating
Durability of Fiber Optic Interconnecting
Devices

TIA-526-14	(2015c) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-568.0	(2020e) Generic Telecommunications Cabling for Customer Premises
TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-568.2	(2018d) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568.3	(2022e) Optical Fiber Cabling Components Standard
TIA-569	(2019e; Add 1 2022) Telecommunications Pathways and Spaces
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-1152	(2016; R 2021) Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
TIA/EIA-598	(2014D; Add 2 2018) Optical Fiber Cable Color Coding
TIA/EIA-604-10	(2002a) FOCIS 10 Fiber Optic Connector Intermateability Standard - Type LC

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68	Connection of Terminal Equipment to the Telephone Network (47 CFR 68)

UNDERWRITERS LABORATORIES (UL)

UL 444	(2017; Reprint Jun 2021) UL Standard for Safety Communications Cables
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 969	(2017; Reprint Mar 2018) UL Standard for Safety Marking and Labeling Systems
UL 1286	(2022) UL Standard for Safety Office Furnishings
UL 1863	(2004; Reprint Oct 2019) UL Standard for Safety Communication Circuit Accessories

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568.1, TIA-568.2, TIA-568.3, TIA-569, TIA-606 and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect (MC).)

1.3.2 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect (IC).)

1.3.3 Floor Distributor (FD)

A distributor used to connect horizontal cable and cabling subsystems or equipment. (International expression for horizontal cross-connect (HC).)

1.3.4 Telecommunications Room (TR)

An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.

1.3.5 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including wireless) including the entrance point at the building wall and continuing to the equipment room.

1.3.6 Equipment Room (ER) (Telecommunications)

An environmentally controlled centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.7 Open Cable

Cabling that is not run in a raceway as defined by NFPA 70. This refers to cabling that is "open" to the space in which the cable has been installed and is therefore exposed to the environmental conditions associated with that space.

1.3.8 Open Office

A floor space division provided by furniture, moveable partitions, or other means instead of by building walls.

1.3.9 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The building telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport telephone and data (including LAN) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor or campus distributor at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding and interbuilding interconnecting cabling, pathway, and terminal hardware. The intrabuilding backbone provides connectivity from the floor distributors to the building distributors or to the campus distributor and from the building distributors to the campus distributor as required. The backbone system shall be wired in a star topology with the campus distributor at the center or hub of the star. Provide telecommunications pathway systems referenced herein as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. The telecommunications contractor must coordinate with the NMCI/COSC/NGEN contractor concerning access to and configuration of telecommunications spaces. The telecommunications contractor may be required to coordinate work effort within the telecommunications spaces with the NMCI/COSC/NGEN contractor.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Drawings; G

Telecommunications Space Drawings; G

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Telecommunications Cabling (backbone and horizontal); G

Patch Panels; G

Telecommunications Outlet/Connector Assemblies; G

Connector Blocks; G

Spare Parts; G

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Include performance and characteristic curves. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Telecommunications Cabling Testing; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Manufacturer Qualifications; G

Test Plan; G

SD-09 Manufacturer's Field Reports

Factory Reel Tests; G

SD-10 Operation and Maintenance Data

Telecommunications Cabling and Pathway System Data Package 5; G

SD-11 Closeout Submittals

Record Documentation; G

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

In exception to Section 01 33 00 SUBMITTAL PROCEDURES, submitted plan drawings shall be a minimum of 11 by 17 inches in size using a minimum scale of 1/8 inch per foot. 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. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Drawings

Provide drawings in accordance with TIA-606. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict

final telecommunications installed wiring system infrastructure in accordance with TIA-606. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the EF telecommunications and ER telecommunications, CD's, and FD's to the telecommunications work area outlets. The following drawings shall be provided as a minimum:

- a. T1 - Layout of complete building per floor - Building Area/Serving Zone Boundaries, Backbone Systems, and Horizontal Pathways. Layout of complete building per floor. The drawing indicates location of building areas, serving zones, vertical backbone diagrams, telecommunications rooms, access points, pathways, grounding system, and other systems that need to be viewed from the complete building perspective.
- b. T2 - Serving Zones/Building Area Drawings - Drop Locations and Cable Identification (ID'S). Shows a building area or serving zone. These drawings show drop locations, telecommunications rooms, access points and detail call outs for common equipment rooms and other congested areas.
- c. T4 - Typical Detail Drawings - Faceplate Labeling, Firestopping, Americans with Disabilities Act (ADA), Safety, Department of Transportation (DOT). Detailed drawings of symbols and typicals such as faceplate labeling, faceplate types, faceplate population installation procedures, detail racking, and raceways.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years of similar scope and size. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor.

1.6.2.2 Key Personnel

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Supervisors and installers assigned to the installation of this system or

any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel.

In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of 3 years experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum **Manufacturer Qualifications**

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with **TIA-568.1**, **TIA-568.2** and **TIA-568.3**.

1.6.3 **Test Plan**

Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the components and accessories for each cable type specified, 60 days prior to the proposed test date. Include procedures for certification, validation, and testing.

1.6.4 Regulatory Requirements

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. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5 Standard Products

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 this section.

1.6.5.1 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.

1.6.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 DELIVERY AND STORAGE

Provide protection from weather, moisture, extreme heat and cold, dirt, dust, and other contaminants for telecommunications cabling and equipment placed in storage.

1.8 ENVIRONMENTAL REQUIREMENTS

Connecting hardware shall be rated for operation under ambient conditions of 32 to 140 degrees F and in the range of 0 to 95 percent relative humidity, noncondensing.

1.9 WARRANTY

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.

1.10 MAINTENANCE

1.10.1 Operation and Maintenance Manuals

Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance of products provided as a part of the [telecommunications cabling and pathway system](#), Data Package 5. Submit operations and maintenance data in accordance with Section [01 78 23](#) OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data Package 5, include the requirements of paragraphs TELECOMMUNICATIONS DRAWINGS, [TELECOMMUNICATIONS SPACE DRAWINGS](#), and RECORD DOCUMENTATION. Ensure that these drawings and documents depict the as-built configuration.

1.10.2 Record Documentation

Provide T5 drawings including documentation on cables and termination hardware in accordance with [TIA-606](#). T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts and cover plate assignments, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided in hard copy format Provide the following T5 drawing documentation as a minimum:

- a. Cables - A record of installed cable shall be provided in accordance with [TIA-606](#). The cable records shall include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with [TIA-606](#). Include manufacture date of cable with submittal.
- b. Termination Hardware - A record of installed patch panels, cross-connect points, distribution frames, terminating block arrangements and type, and outlets shall be provided in accordance with [TIA-606](#). Documentation shall include the required data fields as a minimum in accordance with [TIA-606](#).

1.10.3 Spare Parts

In addition to the requirements of Section [01 78 23](#) OPERATION AND MAINTENANCE DATA, provide a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking.

PART 2 PRODUCTS

2.1 COMPONENTS

Components shall be UL or third party certified. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. 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. Provide a complete

system of telecommunications cabling and pathway components using star topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets/racks. Cabling and interconnecting hardware and components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70 and conform to the requirements specified herein.

2.2 TELECOMMUNICATIONS PATHWAY

Provide telecommunications pathways in accordance with TIA-569 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide system furniture pathways in accordance with UL 1286.

2.3 TELECOMMUNICATIONS CABLING

Cabling shall be UL listed for the application and shall comply with TIA-568.0, TIA-568.1, TIA-568.2, TIA-568.3 and NFPA 70. Provide a labeling system for cabling as required by TIA-606 and UL 969. Ship cable on reels or in boxes bearing manufacture date for for unshielded twisted pair (UTP) in accordance with ICEA S-90-661 for all cable used on this project. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.3.1 Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70 and performance characteristics in accordance with TIA-568.1.

2.3.1.1 Horizontal Copper

Provide horizontal copper cable, UTP, 100 ohm in accordance with TIA-568.2, UL 444, ANSI/NEMA WC 66, ICEA S-90-661. Provide four each individually twisted pair, minimum size 24 AWG conductors, Category 6, with a blue thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) and length marking at regular intervals in accordance with ICEA S-90-661. Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG) communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. Cables installed in conduit within and under slabs shall be UL listed and labeled for wet locations in accordance with NFPA 70.

2.3.1.2 Horizontal Optical Fiber

Provide optical fiber horizontal cable in accordance with ICEA S-83-596 and TIA-568.3. Cable shall be tight buffered, multimode, 50/125-um diameter laser optimized, OM3. Cable shall be imprinted with manufacturer, flammability rating and fiber count at regular intervals not to exceed 40 inches.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. Cables installed in conduit within and under slabs be UL listed and labeled for wet locations in accordance with NFPA 70. The cable jacket shall be of single jacket construction with color coding of cordage jacket, fiber, unit, and group in accordance with TIA/EIA-598.

2.4 TELECOMMUNICATIONS SPACES

Provide connecting hardware and termination equipment in the telecommunications entrance facility and telecommunication equipment room to facilitate installation as shown on design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with TIA-606.

2.4.1 Connector Blocks

Provide insulation displacement connector (IDC) Type 110 for Category 6 systems. Provide blocks for the number of horizontal and backbone cables terminated on the block plus 25 percent spare.

2.4.2 Cable Guides

Provide cable guides specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on existing equipment racks. Cable guides of ring or bracket type devices mounted on rack panels for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, or nuts and lockwashers.

2.4.3 Patch Panels

Provide ports for the number of horizontal and backbone cables terminated on the panel plus 25 percent spare. Provide pre-connectorized optical fiber and copper patch cords for patch panels. Provide patch cords, as complete assemblies, with matching connectors as specified. Provide fiber optic patch cables with crossover orientation in accordance with TIA-568.3. Patch cords shall meet minimum performance requirements specified in TIA-568.1, TIA-568.2 and TIA-568.3 for cables, cable length and hardware specified.

2.4.3.1 Modular to 110 Block Patch Panel

Provide in accordance with TIA-568.1 and TIA-568.2. Panels shall be third party verified and shall comply with EIA/TIA Category 6 requirements. Panel shall be constructed of 0.09 inches minimum aluminum and shall be rack mounted and compatible with an existing equipment rack. Panel shall provide 48 non-keyed, 8-pin modular ports, wired to T568B. Patch panels shall terminate the building cabling on Type 110 IDCs and shall utilize a printed circuit board interface. The rear of each panel shall have incoming cable strain-relief and routing guides. Panels shall have each port factory numbered and be equipped with laminated plastic nameplates above each port.

2.4.3.2 Fiber Optic Patch Panel

Provide panel for maintenance and cross-connecting of optical fiber cables. Panel shall be constructed of 18 gauge steel minimum and shall be rack mounted and compatible with existing equipment rack. Each panel shall provide 12 adapters as duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, alignment sleeves. Provide dust cover for unused adapters. The rear of each panel shall have a cable management tray a minimum of 8 inches deep with removable cover, incoming cable strain-relief and routing guides. Panels shall have each adapter factory numbered and be equipped with laminated plastic nameplates above

each adapter.

2.4.4 Optical Fiber Distribution Panel

Wall mounted optical fiber distribution panel (OFDP) shall be constructed in accordance with [ECIA EIA/ECA 310-E](#) utilizing 18 gauge steel minimum. Panel shall be divided into two sections, distribution and user. Distribution section shall have strain relief, routing guides, splice tray and shall be lockable, user section shall have a cover for patch cord protection. Each panel shall provide 12 multimode pigtails and adapters. Provide adapters as duplex LC with zirconia ceramic alignment sleeves. Provide dust covers for adapters. Provide patch cords as specified in the paragraph PATCH PANELS.

2.5 TELECOMMUNICATIONS OUTLET/CONNECTOR ASSEMBLIES

2.5.1 Outlet/Connector Copper

Outlet/connectors shall comply with [FCC Part 68](#), [TIA-568.1](#), and [TIA-568.2](#). UTP outlet/connectors shall be [UL 1863](#) listed, non-keyed, 8-pin modular, constructed of high impact rated thermoplastic housing and shall be third party verified and shall comply with [TIA-568.2](#) Category 6 requirements. Outlet/connectors provided for UTP cabling shall meet or exceed the requirements for the cable provided. Outlet/connectors shall be terminated using a Type 110 IDC PC board connector, color-coded for both T568A and T568B wiring. Each outlet/connector shall be wired T568A or T568B. UTP outlet/connectors shall comply with [TIA-568.2](#) for [200](#) mating cycles.

2.5.2 Optical Fiber Adapters(Couplers)

Provide optical fiber adapters suitable for duplex LC in accordance with [TIA/EIA-604-10](#) with zirconia ceramic alignment sleeves, as indicated. Provide dust cover for adapters. Optical fiber adapters shall comply with [TIA-455-21](#) for 500 mating cycles.

2.5.3 Optical Fiber Connectors

Provide in accordance with [TIA-455-21](#). Optical fiber connectors shall be duplex LC in accordance with [TIA/EIA-604-10](#) with zirconia ceramic alignment sleeves, ferrule, epoxyless compatible with 50/125 multimode fiber. The connectors shall provide a maximum attenuation of 0.3 dB at 850 nm with less than a 0.2 dB change after 500 mating cycles.

2.6 GROUNDING AND BONDING PRODUCTS

Provide in accordance with [UL 467](#), [TIA-607](#), and [NFPA 70](#). Components shall be identified as required by [TIA-606](#). Provide ground rods, bonding conductors, and grounding busbars as specified in Section [26 20 00](#) INTERIOR DISTRIBUTION SYSTEM.

2.7 FIRESTOPPING MATERIAL

Provide as specified in Section [07 84 00](#) FIRESTOPPING.

2.8 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.

2.9 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, **0.125 inches** 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 **one by 2.5 inches**. Lettering shall be a minimum of **0.25 inches** high normal block style.

2.10 TESTS, INSPECTIONS, AND VERIFICATIONS

2.10.1 Factory Reel Tests

Provide documentation of the testing and verification actions taken by manufacturer to confirm compliance with **TIA-568.1**, **TIA-568.2**, **TIA-568.3**, and **TIA-526-14** for multimode optical fiber cables.

PART 3 EXECUTION

3.1 INSTALLATION

Install telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware in accordance with **NECA/BICSI 568**, **TIA-568.1**, **TIA-568.2**, **TIA-568.3**, **TIA-569**, **NFPA 70**, and UL standards as applicable. Provide cabling in a star topology network. Pathways and outlet boxes shall be installed as specified in Section **26 20 00 INTERIOR DISTRIBUTION SYSTEM**. Install telecommunications cabling with copper media in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling. Cabling shall be run with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

3.1.1 Cabling

Install UTP, and optical fiber telecommunications cabling system as detailed in **TIA-568.1**, **TIA-568.2**, **TIA-568.3**. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables. Provide a device to monitor cable pull tensions. Do not exceed **25 pounds** pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. For UTP cable, bend radii shall not be less than four times the cable diameter. Cables shall be terminated; no cable shall contain unterminated elements. Cables shall not be spliced. Label cabling in accordance with paragraph LABELING in this section.

3.1.1.1 Backbone Cable

- a. Copper Backbone Cable. Install intrabuilding backbone copper cable, in indicated pathways, between the campus distributor, located in the telecommunications entrance facility or room, the building distributors and the floor distributors located in telecommunications rooms and telecommunications equipment rooms as indicated on drawings.
- b. Optical fiber Backbone Cable. Install intrabuilding backbone optical fiber in indicated pathways. Do not exceed manufacturer's recommended bending radii and pull tension. Prepare cable for pulling by cutting outer jacket **10 inches** leaving strength members exposed for approximately **10 inches**. Twist strength members together and attach to pulling eye. Vertical cable support intervals shall be in accordance with manufacturer's recommendations.

3.1.1.2 Horizontal Cabling

Install horizontal cabling as indicated on drawings. Do not untwist Category 6 UTP cables more than **one half inch** from the point of termination to maintain cable geometry. Provide slack cable in the form of a figure eight (not a service loop) on each end of the cable, **10 feet** in the telecommunications room, and **12 inches** in the work area outlet.

3.1.2 Pathway Installations

Provide in accordance with **TIA-569** and **NFPA 70**. Provide building pathway as specified in Section **26 20 00** INTERIOR DISTRIBUTION SYSTEM.

3.1.3 Service Entrance Conduit, Overhead

Provide service entrance overhead as specified in Section **26 20 00** INTERIOR DISTRIBUTION SYSTEMS.

3.1.4 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section **07 84 00** FIRESTOPPING.

3.1.5 Grounding and Bonding

Provide in accordance with **TIA-607**, **NFPA 70** and as specified in Section **26 20 00** INTERIOR DISTRIBUTION SYSTEM.

3.2 LABELING

3.2.1 Labels

Provide labeling in accordance with **TIA-606**. Handwritten labeling is unacceptable. Stenciled lettering for voice and data circuits shall be provided using thermal ink transfer process.

3.2.2 Cable

Cables shall be labeled using color labels on both ends with identifiers in accordance with **TIA-606**.

3.2.3 Termination Hardware

Workstation outlets and patch panel connections shall be labeled using color coded labels with identifiers in accordance with TIA-606.

3.3 FIELD APPLIED PAINTING

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 09 90 00 PAINTS AND COATINGS.

3.3.1 Painting Backboards

If backboards are required to be painted, then the manufactured fire retardant backboard must be painted with fire retardant paint, so as not to increase flame spread and smoke density and must be appropriately labeled. Label and fire rating stamp must be unpainted.

3.4 FIELD FABRICATED 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.

3.5 TESTING

3.5.1 Telecommunications Cabling Testing

Perform telecommunications cabling inspection, verification, and performance tests in accordance with TIA-568.1, TIA-568.2, TIA-568.3. Test equipment shall conform to TIA-1152. Perform optical fiber field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure.

3.5.1.1 Inspection

Visually inspect UTP and optical fiber jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for T568A or T568B pin assignments, and inspect cabling connections to confirm compliance with TIA-568.1, TIA-568.2, TIA-568.3, . Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.

3.5.1.2 Verification Tests

UTP backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but prior to being cross-connected.

For multimode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with TIA-568.3 and TIA-526-14 using Method B, OTDR for multimode optical fiber. Perform verification acceptance tests.

3.5.1.3 Performance Tests

Perform testing for each outlet and MUTOA as follows:

- a. Perform Category 6 link tests in accordance with TIA-568.1 and TIA-568.2. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.
- b. Optical fiber Links. Perform optical fiber end-to-end link tests in accordance with TIA-568.3.

3.5.1.4 Final Verification Tests

Perform verification tests for UTP and optical fiber systems after the complete telecommunications cabling and workstation outlet/connectors are installed.

- a. Data Tests. These tests assume the Information Technology Staff has a network installed and are available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

-- End of Section --

SECTION 28 31 76

INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE

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.

FM GLOBAL (FM)

FM APP GUIDE (updated on-line) Approval Guide
<http://www.approvalguide.com/>

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1 (2002; R 2008) Guide on the Surges
Environment in Low-Voltage (1000 V and
Less) AC Power Circuits

IEEE C62.41.2 (2002) Recommended Practice on
Characterization of Surges in Low-Voltage
(1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 4 (2018) Standard for Integrated Fire
Protection and Life Safety System Testing

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA
20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

NFPA 72 (2022) National Fire Alarm and Signaling
Code

NFPA 90A (2021) Standard for the Installation of
Air Conditioning and Ventilating Systems

NFPA 170 (2021) Standard for Fire Safety and
Emergency Symbols

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-601-02 (2021) Fire Protection Systems Inspection,
Testing, and Maintenance

UFC 4-010-06 (2016; with Change 1, 2017) Cybersecurity
of Facility-Related Control Systems

UNDERWRITERS LABORATORIES (UL)

UL 268A (2008; Reprint Oct 2014) Smoke Detectors
for Duct Application

UL 497A	(2001; Bul. 2019) UL Standard for Safety Secondary Protectors for Communications Circuits
UL 497B	(2004; Reprint Feb 2022) UL Standard for Safety Protectors for Data Communications and Fire Alarm Circuits
UL 864	(2014; Reprint May 2020) UL Standard for Safety Control Units and Accessories for Fire Alarm Systems
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021) UL Standard for Safety Surge Protective Devices
UL 2034	(2017; Reprint Sep 2018) UL Standard for Safety Single and Multiple Station Carbon Monoxide Alarms
UL 2075	(2013; Bul. 2019) UL Standard for Safety Gas and Vapor Detectors and Sensors
UL 2572	(2016; Bul. 2018) UL Standard for Safety Mass Notification Systems
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.2 RELATED SECTIONS

Section 21 13 13 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION

1.3 SUMMARY

1.3.1 Scope

- a. This work includes designing and modifying the existing fire alarm and mass notification (MNS) system as described herein and on the contract drawings. Include system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, initiating devices, notification appliances, supervising station fire alarm transmitters/mass notification transceiver, and other accessories and miscellaneous items required for a complete operational system even though each item is not specifically mentioned or described. Provide system complete and ready for operation. Existing interior fire alarm system was manufactured by Siemens Desigo. Design and installation must comply with UFC 4-010-06 and AFGM 2019-320-02.
- b. Provide equipment, materials, installation, workmanship, inspection, and testing in strict accordance with NFPA 72, except as modified herein.
- c. The fire alarm and mass notification system must be independent of the building security, building management, and energy/utility monitoring systems other than for control functions.

1.3.2 Qualified Fire Protection Engineer (QFPE)

Services of the QFPE must include:

- a. Reviewing SD-02, SD-03, and SD-05 submittal packages for completeness and compliance with the provisions of this specification. Construction (shop) drawings and calculations must be prepared by, or prepared under the immediate supervision of, the QFPE. The QFPE must affix their professional engineering stamp with signature to the shop drawings, calculations, and material data sheets, indicating approval prior to submitting the shop drawings to the DFPE.
- b. Providing a letter documenting that the SD-02, SD-03, and SD-05 submittal package has been reviewed and noting any outstanding comments.
- c. Performing in-progress construction surveillance prior to installation of ceilings (rough-in inspection).
- d. Witnessing pre-Government and final Government functional performance testing and performing a final installation review.
- e. Signing applicable certificates under SD-07.

1.4 DEFINITIONS

Wherever mentioned in this specification or on the drawings, the equipment, devices, and functions must be defined as follows:

1.4.1 Interface Device

An addressable device that interconnects hard wired systems or devices to an analog/addressable system.

1.4.2 Fire Alarm and Mass Notification Control Unit (FMCU)

A master control unit having the features of a fire alarm control unit (FACU) and an autonomous control unit (ACU) where these units are interconnected to function as a combined fire alarm/mass notification system. The FACU and ACU functions may be contained in a single cabinet or in independent, interconnected, and co-located cabinets.

1.4.3 Remote Fire Alarm and Mass Notification Control Unit

A control unit, physically remote from the fire alarm and mass notification control unit, that receives inputs from automatic and manual fire alarm devices; may supply power to detection devices and interface devices; may provide transfer of power to the notification appliances; may provide transfer of condition to relays or devices connected to the control unit; and reports to and receives signals from the fire alarm and mass notification control unit.

1.4.4 Terminal Cabinet

A steel cabinet with locking, hinge-mounted door where terminal strips are securely mounted inside the cabinet.

1.4.5 Control Module and Relay Module

Terms utilized to describe emergency control function interface devices as defined by NFPA 72.

1.4.6 Designated Fire Protection Engineer (DFPE)

The DoD fire protection engineer that oversees that Area of Responsibility for that project. This is sometimes referred to as the "cognizant" fire protection engineer. Interpret reference to "authority having jurisdiction" and/or AHJ in referenced standards to mean the Designated Fire Protection Engineer (DFPE). The DFPE may be responsible for review of the contractor submittals having a "G" designation, and for witnessing final inspection and testing.

1.4.7 Qualified Fire Protection Engineer (QFPE)

A QFPE is an individual who is a licensed professional engineer (P.E.), who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and has relevant fire protection engineering experience.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.

Shop drawings (SD-02), product data (SD-03) and calculations (SD-05) must be prepared by the fire alarm designer and combined and submitted as one complete package. The QFPE must review the SD-02/SD-03/SD-05 submittal package for completeness and compliance with the Contract provisions prior to submission to the Government. The QFPE must provide a Letter of Confirmation that they have reviewed the submittal package for compliance with the contract provisions. This letter must include their registered professional engineer stamp and signature. Partial submittals and submittals not reviewed by the QFPE will be returned by the Government disapproved without review.

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualified Fire Protection Engineer (QFPE); G

Fire alarm system designer; G

Supervisor; G

Technician; G

Installer; G

Test Technician; G

Fire Alarm System Site-Specific Software Acknowledgement; G

SD-02 Shop Drawings

Nameplates; G
Wiring Diagrams; G
System Layout; G
Initiating devices; G
Battery Power; G
Voltage Drop Calculations; G

SD-03 Product Data

Duct Smoke Detectors; G
Carbon monoxide detector; G
Addressable Interface Devices; G
Addressable Control Modules; G
Surge Protective Devices; G
Alarm Wiring; G
Back Boxes and Conduit; G
Environmental Enclosures or Guards; G

SD-06 Test Reports

Test Procedures; G

SD-07 Certificates

Verification of Compliant Installation; G
Request for Government Final Test; G

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G
Instruction of Government Employees; G

SD-11 Closeout Submittals

As-Built Drawings
Spare Parts

1.6 SYSTEM OPERATION

Fire alarm system/mass notification system operation is existing to remain.

1.6.1 Alarm Initiating Devices

- a. Connect alarm initiating devices to initiating device circuits (IDC) Class "B", or to signaling line circuits (SLC) Class "B" and installed in accordance with NFPA 72.

1.6.2 Functions and Operating Features

The system must function to operate as existing and as indicated below.

- a. Activation of a carbon monoxide alarm initiating device must automatically initiate the following functions:
 - (1) Visual indication of the device operated on the FMCU and remote annunciator.
 - (2) Transmission of a carbon monoxide alarm signal to the designated receiving station on existing FMCU.
 - (3) Activation of all strobes and the audible carbon monoxide message throughout the building.
 - (4) Recording of the event electronically in the history log of the FMCU.

1.7 TECHNICAL DATA AND SITE-SPECIFIC SOFTWARE

Technical data and site-specific software (meaning technical data that relates to computer software) that are specifically identified in this project, and may be required in other specifications, must be delivered, strictly in accordance with the CONTRACT CLAUSES. The fire alarm system manufacturer must submit written confirmation of this contract provision as "Fire Alarm System Site-Specific Software Acknowledgement". Identify data delivered by reference to the specification paragraph against which it is furnished. Data to be submitted must include complete system, equipment, and software descriptions. Descriptions must show how the equipment will operate as a system to meet the performance requirements of this contract. The site-specific software data package must also include the following:

- a. Items identified in NFPA 72, titled "Site-Specific Software".
- b. Identification of programmable portions of the system equipment and capabilities.
- c. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.
- d. Provision of operational software data on all modes of programmable portions for fire alarm and mass notification.
- e. Description of Fire Alarm and Mass Notification Control Unit equipment operation.
- f. Description of auxiliary and remote equipment operations.
- g. Library of application software.
- h. Operation and maintenance manuals.

1.8 EXISTING EQUIPMENT

- a. Equipment and devices must be compatible and operable with the existing fire alarm/mass notification system and must not impair reliability or operational functions of existing supervising station fire alarm system.
- b. Equipment and devices must be compatible and operable with the existing building fire alarm/mass notification system. Equipment must not impair reliability or operational functions of the existing system. The existing building system control unit is.
- c. Equipment and devices must be compatible and operable with the existing installation-wide mass notification system and must not impair reliability or operational functions of the existing system.

1.9 QUALITY ASSURANCE

1.9.1 Submittal Documents

1.9.1.1 Preconstruction Submittals

Within 36 days of contract award but not less than 14 days prior to commencing any work on site, the Contractor must submit the following for review and approval. SD-02, SD-03 and SD-05 submittals received prior to the review and approval of the qualifications of the fire alarm subcontractor and QFPE must be returned disapproved without review. All resultant delays must be the sole responsibility of the Contractor.

1.9.1.2 Shop Drawings

Shop drawings must not be smaller than the Contract Drawings. Drawings must comply with the requirements of NFPA 72 and NFPA 170. Minimum scale for floor plans must be 1/8"=1'.

1.9.1.3 Nameplates

Nameplate illustrations and data to obtain approval by the Contracting Officer before installation.

1.9.1.4 Wiring Diagrams

Two copies of point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams must show connections from field devices to the FMCU initiating circuits, switches, relays and terminals, including pathway diagrams between the control unit and shared communications equipment within the protected premises. Point-to-point wiring diagrams must be job specific and must not indicate connections or circuits not being utilized. Provide complete riser diagrams indicating the wiring sequence of all devices and their connections to the control equipment. Include a color-code schedule for the wiring.

1.9.1.5 System Layout

Two copies of plan view drawing showing device locations, terminal cabinet

locations, junction boxes, other related equipment, conduit routing, conduit sizes, wire counts, conduit fill calculations, wire color-coding, circuit identification in each conduit, and circuit layouts for all floors. Indicate the addresses of all devices, modules, relays, and similar.

Provide a complete description of the system operation in matrix format similar to the "Typical Input/Output Matrix" included in the Annex of NFPA 72.

1.9.1.6 Initiating Devices

Calculations and supporting data on each circuit to indicate that there is at least 25 percent spare capacity for initiating devices. Annotate data for each circuit on the drawings.

1.9.1.7 Battery Power

Calculations and supporting data as required in paragraph Battery Power Calculations for alarm, alert, and supervisory power requirements. Calculations including ampere-hour requirements for each system component and each control unit component, and the battery recharging period, must be included on the drawings.

1.9.1.8 Voltage Drop Calculations

Voltage drop calculations for each notification circuit indicating that sufficient voltage is available for proper operation of the system and all components, at a minimum rated voltage of the system operating on batteries. Include the calculations on the system layout drawings.

1.9.1.9 Product Data

Two copies of annotated descriptive data to show the specific model, type, and size of each item. Catalog cuts must also indicate the NRTL listing. The data must be highlighted to show model, size, and options that are intended for consideration. Data must be adequate to demonstrate compliance with all contract requirements. Product data for all equipment must be combined into a single submittal.

Provide an equipment list identifying the type, quantity, make, and model number of each piece of equipment to be provided under this submittal. The equipment list must include the type, quantity, make and model of spare equipment. Types and quantities of equipment submitted must coincide with the types and quantities of equipment used in the battery calculations and those shown on the shop drawings.

1.9.1.10 Operation and Maintenance (O&M) Instructions

Six copies of the Operation and Maintenance Instructions. The O&M Instructions must be prepared in a single volume or in multiple volumes, with each volume indexed, and may be submitted as a Technical Data Package. Manuals must be approved prior to training. The Interior Fire Alarm And Mass Notification System Operation and Maintenance Instructions must include the following:

- a Operating manual outlining step-by-step procedures required for system startup, operation, and shutdown. The manual must include the manufacturer's name, model number, service manual, parts list, and

preliminary equipment list complete with description of equipment and their basic operating features.

- b. Maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals must include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed.
- c. Complete procedures for system revision and expansion, detailing both equipment and software requirements.
- d. Software submitted for this project on CD/DVD media utilized.
- e. Printouts of configuration settings for all devices.
- f. Routine maintenance checklist. The routine maintenance checklist must be arranged in a columnar format. The first column must list all installed devices, the second column must state the maintenance activity or state no maintenance required, the third column must state the frequency of the maintenance activity, and the fourth column provided for additional comments or reference. All data (devices, testing frequencies, and similar) must comply with [UFC 3-601-02](#).
- g. A final Equipment List must be submitted with the Operating and Maintenance (O&M) manual.

1.9.1.11 As-Built Drawings

The drawings must show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final Government test of the system. At least one set of the as-built (marked-up) drawings must be provided at the time of, or prior to the final Government test.

1.9.2 Qualifications

1.9.2.1 Fire Alarm System Designer

The fire alarm system designer must be certified as a Level III (minimum) Technician by National Institute for Certification in Engineering Technologies (NICET) in the Fire Alarm Systems subfield of Fire Protection Engineering Technology or meet the qualifications for a QFPE.

1.9.2.2 Supervisor

A NICET Level III or IV fire alarm technician must supervise the installation of the fire alarm/mass notification system. The fire alarm technicians supervising the installation of equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.9.2.3 Technician

Fire alarm technicians with a minimum of four years of experience must be utilized to install and terminate fire alarm/mass notification devices, cabinets and control units. The fire alarm technicians installing the equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.9.2.4 Installer

NICET Level II technician to assist in the installation of fire alarm/mass notification devices. A licensed electrician must be allowed to install wire, cable, conduit and backboxes for the fire alarm system/mass notification system. The fire alarm installer must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.9.2.5 Test Technician

Fire alarm technicians with a minimum of eight years of experience and NICET Level III or IV utilized in testing and certification of the installation of the fire alarm/mass notification devices, cabinets and control units. The fire alarm technicians testing the equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment installed as part of this project.

1.9.2.6 Manufacturer

Components must be of current design and must be in regular and recurrent production at the time of installation. Provide design, materials, and devices for a protected premises fire alarm system, complete, conforming to NFPA 72, except as specified herein.

1.9.3 Regulatory Requirements

Equipment and material must be listed or approved. Listed or approved, as used in this section, means listed, labeled or approved by a Nationally Recognized Testing Laboratory (NRTL) such as UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of any item of equipment described must not be construed as waiving this requirement. All listings or approvals by testing laboratories must be from an existing ANSI or UL published standard. The recommended practices stated in the manufacturer's literature or documentation must be considered as mandatory requirements.

1.10 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity, and temperature variation, dirt and dust, and other contaminants.

1.11 MAINTENANCE

1.11.1 Spare Parts

Furnish the following spare parts in the manufacturers original unopened containers:

- a. One of each type of detector installed.
- b. One of each type of detector base and head installed.
- c. One of each type of addressable monitor module installed.
- d. One of each type of addressable control module installed.
- e. One low voltage, surge protective device.

1.11.2 Special Tools

Software, connecting cables and proprietary equipment, necessary for the maintenance, testing, and reprogramming of the equipment must be furnished to the Contracting Officer, prior to the instruction of Government employees.

PART 2 PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENT

All fire alarm and mass notification equipment must be listed for use under the applicable reference standards. Interfacing of [UL 864](#) or similar approved industry listing with Mass Notification equipment listed to [UL 2572](#) must be done in a laboratory listed configuration, if the software programming features cannot provide a listed interface control.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Standard Products

Provide materials, equipment, and devices that have been tested by a nationally recognized testing laboratory and listed for fire protection service when so required by [NFPA 72](#) or this specification. Select material from one manufacturer, where possible, and not a combination of manufacturers, for any particular classification of materials. Material and equipment must be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid opening.

2.3 SMOKE DETECTORS

2.3.1 Duct Smoke Detectors

Duct-mounted addressable photoelectric smoke detectors must consist of a smoke detector, as specified in paragraph Spot Type Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry must be mounted in a metallic or plastic enclosure exterior to the duct. It is not permitted to cut the duct insulation to install the duct detector directly on the duct. Detectors must be listed for operation over the complete range of air velocities, temperature and humidity expected at the detector when the air-handling system is operating. Detectors must be powered from the FMCU.

- a. Sampling tubes must run the full width of the duct. The duct detector package must conform to the requirements of [NFPA 90A](#), [UL 268A](#), and must be listed for use in air-handling systems. The control functions, operation, reset, and bypass must be controlled from the FMCU.
- b. Lights to indicate the operation and alarm condition must be visible and accessible with the unit installed and the cover in place. Remote indicators must be provided where required by [NFPA 72](#). Remote indicators as well as the affected fan units must be properly identified in etched plastic placards.
- c. Detectors must provide for control of auxiliary contacts that provide control, interlock, and shutdown functions specified in Section

23 09 00 to INSTRUMENTATION AND CONTROL FOR HVAC. Auxiliary contacts provide for this function must be located within 3 feet of the controlled circuit or appliance. The auxiliary contacts must be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

2.4 CARBON MONOXIDE DETECTOR

Analog/addressable carbon monoxide (CO) detectors must be listed to UL 2075 and set to respond to the sensitivity limits of UL 2034. Carbon monoxide detectors must be listed for use with fire alarm control units. Detectors must be surface mounted in the vertical orientation and supported independently of wiring connections. Detectors must be self-restoring. For FMCU with no listed compatible addressable CO detectors, provide listed 4-wire detectors. Do not provide CO detectors with local alarms. Detector must be provided with an LED status indicator.

- a. Where 4-wire CO detectors are necessary, each 4-wire CO detector must be individually monitored via addressable interface modules for alarm and off normal/trouble conditions (including loss of power to the individual detector). Power circuits for 4-wire CO detectors must be dedicated to powering the CO detectors only. Battery powered and 120 VAC powered detectors are prohibited.
- b. Wiring connections must be made by means of screw terminals and detectors must be equipped with trouble relays. Detectors must be able to mount a single-gang electrical box.
- c. A trouble condition at an individual CO detector must not affect any other CO detectors. CO detectors must be powered by the FMCU.
- d. Detectors must be provided with a means to test CO gas entry into the CO sensing cell.

2.5 ADDRESSABLE INTERFACE DEVICES

The initiating device being monitored must be configured as a Class "B" initiating device circuits. The module must be listed as compatible with the control unit. The module must provide address setting means compatible with the control unit's SLC supervision and store an internal identifying code. Monitor module must contain an integral LED that flashes each time the monitor module is polled and is visible through the device cover plate. Modules must be listed for the environmental conditions in which they will be installed.

2.6 ADDRESSABLE CONTROL MODULES

The control module must be capable of operating as a relay (dry contact form C) for interfacing the control unit with other systems. The module must be listed as compatible with the control unit. The indicating device or the external load being controlled must be configured as Class B notification appliance circuits. The system must be capable of supervising, audible, visual and dry contact circuits. The control module must have both an input and output address. The supervision must detect a short on the supervised circuit and must prevent power from being applied to the circuit. The control module must provide address setting means compatible with the control unit's SLC supervision and store an internal identifying code. The control module must contain an integral LED that flashes each time the control module is polled and is visible through the

device cover plate. Control Modules must be listed for the environmental conditions in which they will be installed.

2.7 SECONDARY POWER SUPPLY

Provide for system operation in the event of primary power source failure. Transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power must be automatic and must not cause transmission of a false alarm.

2.7.1 Batteries

Batteries are existing to remain.

2.7.1.1 Capacity

Battery size must be the greater of the following two capacities. When determining the required capacity under alarm condition, visual notification appliances must include both textual and non-textual type appliances.

- a. Sufficient capacity to operate the fire alarm system under supervisory and trouble conditions, including audible trouble signal devices for 48 hours and audible and visual signal devices under alarm conditions for an additional 15 minutes.
- b. Sufficient capacity to operate the mass notification for 60 minutes after loss of AC power.

2.7.1.2 Battery Power Calculations

- a. Verify that battery capacity exceeds supervisory and alarm power requirements for the criteria noted in the paragraph "Capacity" above.
 - (1) Substantiate the battery calculations for alarm and supervisory power requirements. Include ampere-hour requirements for each system component and each control unit component, and compliance with [UL 864](#).
 - (2) Provide complete battery calculations for both the alarm and supervisory power requirements. Submit ampere-hour requirements for each system component with the calculations.
 - (3) Provide voltage drop calculations to indicate that sufficient voltage is available for proper operation of the system and all components. Calculations must be performed using the minimum rated voltage of each component.
- b. For battery calculations assume a starting voltage of 24 VDC for starting the calculations to size the batteries. Calculate the required Amp-Hours for the specified standby time, and then calculate the required Amp-Hours for the specified alarm time. Using 20.4 VDC as starting voltage, perform a voltage drop calculation for circuits containing device and/or appliances remote from the power sources.

2.8 SURGE PROTECTIVE DEVICES

[Surge protective devices](#) must be provided to suppress all voltage transients which might damage fire alarm control unit components. Systems

having circuits located outdoors, communications equipment must be protected against surges induced on any signaling line circuit. Cables and conductors, that serve as communications links, must have surge protection circuits installed at each end. The surge protective device must wire in series to the power supply of the protected equipment with screw terminations. Line voltage surge arrestor must be installed directly adjacent to the power panel where the FMCU breaker is located.

- a. Surge protective devices for nominal 120 VAC must be [UL 1449](#) listed with a maximum 500 volt suppression level and have a maximum response time of 5 nanoseconds. The surge protective device must also meet [IEEE C62.41.1](#) and [IEEE C62.41.2](#) category B tests for surge capacity. The surge protective device must feature multi-stage construction and be provided with a long-life indicator lamp (either light emitting diode or neon) which extinguishes upon failure of protected components. Any unit fusing must be externally accessible.
- b. Surge protective devices for nominal 24 VAC, fire alarm telephone dialer, or ethernet connection must be [UL 497B](#) listed, meet [IEEE C62.41.1](#) and have a maximum response time of 1-nanosecond. The surge protective device must feature multi-stage construction and be self-resetting. The surge protective device must be a base and plug style. The base assembly must have screw terminals for fire [alarm wiring](#). The base assembly must accept "plug-in" surge protective module.
- c. All surge protective devices (SPD) must be the standard product of a single manufacturer and be equal or better than the following:
 - (1) For 120 VAC nominal line voltage: [UL 1449](#) and [UL 1283](#) listed, series connected 120 VAC, 20A rated, surge protective device in a NEMA 4x enclosure. Minimum 50,000 amp surge current rating with EMI/RFI filtering and a dry contact circuit for remote monitoring of surge protection status.
 - (2) For 24-volt nominal line voltage: [UL 497B](#) listed, series connected low voltage, 24-volt, 5A rated, loop circuit protector, base and replaceable module.
 - (3) For alarm telephone dialers: [UL 497A](#) listed, series connected, 130-volt, 150 mA rated with self-resetting fuse, dialer circuit protector with modular plug and play.
 - (4) For IP-DACS: [UL 497B](#) listed, series connected, 6.4-volt, 1.5A rated with 20 kA/pair surge current, data network protector with modular plug and play.

2.9 WIRING

Provide wiring materials under this section as specified in Section [26 20 00](#) INTERIOR DISTRIBUTION SYSTEM with the additions and modifications specified herein.

2.9.1 Alarm Wiring

IDC and SLC wiring must be solid copper cable in accordance with the manufacturers requirements. Copper signaling line circuits and initiating device circuit field wiring must be No. 14 AWG size conductors at a minimum. Wire size must be sufficient to prevent voltage drop problems.

Circuits operating at 24 VDC must not operate at less than the listed voltages for the detectors and/or appliances. Power wiring, operating at 120 VAC minimum, must be a minimum No. 12 AWG solid copper having similar insulation. Acceptable power-limited cables are FPL, FPLR or FPLP as appropriate with red colored covering. Nonpower-limited cables must comply with NFPA 70.

2.10 ENVIRONMENTAL ENCLOSURES OR GUARDS

Environmental enclosures must be provided to permit fire alarm/mass notification components to be used in areas that exceed the environmental limits of the listing. The enclosure must be listed for the device or appliance as either a manufactured part number or as a listed compatible accessory for the component is currently listed. Guards required to deter mechanical damage must be either a listed manufactured part or a listed accessory for the category of the initiating device or notification appliance.

PART 3 EXECUTION

3.1 VERIFYING ACTUAL FIELD CONDITIONS

Before commencing work, examine all adjoining work on which the contractor's work is in any way dependent for perfect workmanship according to the intent of this specification section, and report to the Contracting Officer's Representative any condition which prevents performance of first class work. No "waiver of responsibility" for incomplete, inadequate or defective adjoining work will be considered unless notice has been filed before submittal of a proposal.

3.2 INSTALLATION

3.2.1 Smoke Detectors

Locate detectors as required by NFPA 72 and their listing as indicated on the drawings on a 4-inch mounting box. Smoke detectors are permitted to be on the wall no lower than 12 inches from the ceiling with no minimum distance from the ceiling. Install smoke detectors no closer than 3 feet from air handling supply diffusers. Detectors installed in acoustical ceiling tiles must be centered in the tiles plus or minus 2 inches.

3.2.2 Carbon Monoxide Detectors

Locate detectors as required by NFPA 72 and their listings as indicated on the drawings on a 4-inch mounting box. Carbon monoxide detectors must be installed separate from smoke detectors.

3.3 SYSTEM FIELD WIRING

3.3.1 Wiring within Cabinets, Enclosures, and Boxes

Provide wiring installed in a neat and workmanlike manner and installed parallel with or at right angles to the sides and back of any box, enclosure, or cabinet. Conductors that are terminated, spliced, or otherwise interrupted in any enclosure, cabinet, mounting, or junction box must be connected to screw-type terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. The use of wire nuts or similar devices is prohibited. Wiring to conform with NFPA 70.

Indicate the following in the wiring diagrams:

- a. Point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams must show connections from field devices to the FMCU and remote fire alarm/mass notification control units, initiating circuits, switches, relays and terminals.
- b. Complete riser diagrams indicating the wiring sequence of devices and their connections to the control equipment. Include a color code schedule for the wiring. Include floor plans showing the locations of devices and equipment.

3.3.2 Alarm Wiring

- a. Voltages must not be mixed in any junction box, housing or device, except those containing power supplies and control relays.
- b. Utilize shielded wiring where recommended by the manufacturer. For shielded wiring, ground the shield at only one point, in or adjacent to the FMCU.
- c. Pigtail or T-tap connections to signal line circuits, initiating device circuits, supervisory alarm circuits, and notification appliance circuits are prohibited.
- d. Color coding is required for circuits and must be maintained throughout the circuit. Conductors used for the same functions must be similarly color coded. Conform wiring to NFPA 70.
- e. Pull all conductors splice free. The use of wire nuts, crimped connectors, or twisting of conductors is prohibited. Where splices are unavoidable, the location of the junction box or pull box where they occur must be identified on the as-built drawings. The number and location of splices must be subject to approval by the Designated Fire Protection Engineer (DFPE).

3.3.3 Back Boxes and Conduit

In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide all wiring in rigid metal conduit or intermediate metal conduit unless specifically indicated otherwise. Minimum conduit size must be 3/4-inch in diameter. Do not use electrical non-metallic tubing (ENT) or flexible non-metallic tubing and associated fittings.

- a. Galvanized rigid steel (GRS) conduit must be utilized where exposed to weather, where subject to physical damage, and where exposed on exterior of buildings. Intermediate metal conduit (IMC) may be used in lieu of GRS as allowed by NFPA 70.
- b. Electrical metallic tubing (EMT) is permitted above suspended ceilings or exposed where not subject to physical damage. Do not use EMT underground, encased in concrete, mortar, or grout, in hazardous locations, where exposed to physical damage, outdoors or in fire pump rooms. Use die-cast compression connectors.
- c. For rigid metallic conduit (RMC), only threaded type fitting are

permitted for wet or damp locations.

- d. Flexible metal conduit is permitted for initiating device circuits **6 feet** in length or less. Flexible metal conduit is prohibited for notification appliance circuits and signaling line circuits. Use liquid tight flexible metal conduit in damp and wet locations.
- e. Schedule 40 (minimum) polyvinyl chloride (PVC) is permitted where conduit is routed underground or underground below floor slabs. Convert non-metallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before turning up through floor slab.
- f. Exterior wall penetrations must be weathertight. Conduit must be sealed to prevent the infiltration of moisture.

3.3.4 Conductor Terminations

Labeling of conductors at terminal blocks in terminal cabinets, FMCU and the LOC must be provided at each conductor connection. Each conductor or cable must have a shrink-wrap label to provide a unique and specific designation. Each terminal cabinet, FMCU, and remote FMCU must contain a laminated drawing that indicates each conductor, its label, circuit, and terminal. The laminated drawing must be neat, using 12 point lettering minimum size, and mounted within each cabinet, control unit, or unit so that it does not interfere with the wiring or terminals. Maintain existing color code scheme where connecting to existing equipment.

3.4 FIRESTOPPING

Provide firestopping for holes at conduit penetrations through floor slabs, fire-rated walls, partitions with fire-rated doors, corridor walls, and vertical service shafts.

3.5 PAINTING

- a. In unfinished areas (including areas above drop ceilings), paint all exposed electrical conduit (serving fire alarm equipment), fire alarm conduit, surface metal raceway, junction boxes and covers red. In lieu of painting conduit, the contractor may utilize red conduit with a factory applied finish.
- b. In finished areas, paint exposed electrical conduit (serving fire alarm equipment), fire alarm conduit, surface metal raceways, junction boxes, and electrical boxes to match adjacent finishes. The inside cover of the junction box must be identified as "Fire Alarm" and the conduit must have painted red bands **3/4-inch** wide at **10-foot** centers and at each side of a floor, wall, or ceiling penetration.
- c. Painting must comply with Section **09 90 00** PAINTS AND COATINGS.

3.6 FIELD QUALITY CONTROL

3.6.1 Test Procedures

Submit detailed test procedures, prepared and signed by the NICET Level III or IV Fire Alarm Technician, and the representative of the installing company, and reviewed by the QFPE 60 days prior to performing system tests. Detailed test procedures must list all components of the installed

system such as initiating devices and circuits, notification appliances and circuits, signaling line devices and circuits, control devices/equipment, batteries, transmitting and receiving equipment, power sources/supply, annunciators, special hazard equipment, emergency communication equipment, interface equipment, and surge protective devices. Test procedures must include sequence of testing, time estimate for each test, and sample test data forms. The test data forms must be in a check-off format (pass/fail with space to add applicable test data; similar to the forms in NFPA 72 and NFPA 4.) The test procedures and accompanying test data forms must be used for the pre-Government testing and the Government testing. The test data forms must record the test results and must:

- a. Identify the NFPA Class of all Initiating Device Circuits (IDC), and Notification Appliance Circuits (NAC), Voice Notification System Circuits (NAC Audio), and Signaling Line Circuits (SLC).
- b. Identify each test required by NFPA 72 Test Methods and required test herein to be performed on each component, and describe how these tests must be performed.
- c. Identify each component and circuit as to type, location within the facility, and unique identity within the installed system. Provide necessary floor plan sheets showing each component location, test location, and alphanumeric identity.
- d. Identify all test equipment and personnel required to perform each test (including equipment necessary for smoke detector testing. The use of magnets is not permitted.
- e. Provide space to identify the date and time of each test. Provide space to identify the names and signatures of the individuals conducting and witnessing each test.

3.6.2 Pre-Government Testing

3.6.2.1 Verification of Compliant Installation

Conduct inspections and tests to ensure that devices and circuits are functioning properly. Tests must meet the requirements of paragraph entitled "Minimum System Tests" as required by NFPA 72. The contractor and an authorized representative from each supplier of equipment must be in attendance at the pre-Government testing to make necessary adjustments. After inspection and testing is complete, provide a signed Verification of Compliant Installation letter by the QFPE that the installation is complete, compliant with the specification and fully operable. The letter must include the names and titles of the witnesses to the pre-Government tests. Provide all completion documentation as required by NFPA 72 including all referenced annex sections and the test reports noted below.

- a. NFPA 72 Record of Completion.
- b. NFPA 72 Record of Inspection and Testing.
- c. Fire Alarm and Emergency Communication System Inspection and Testing Form.
- d. Documentation that all tests identified in the paragraph "Minimum

System Tests" are complete.

3.6.2.2 Request for Government Final Test

When the verification of compliant installation has been completed, submit a formal request for Government final test to the Designated Fire Protection Engineer (DFPE) Contracting Officer's Representative (COR). Government final testing will not be scheduled until the DFPE has received copies of the request for Government final testing and Verification of Compliant Installation letter with all required reports. Government final testing will not be performed until after the connections to the installation-wide fire reporting system and the installation-wide mass notification system have been completed and tested to confirm communications are fully functional. Submit request for test at least 15 calendar days prior to the requested test date.

3.6.3 Correction of Deficiencies

If equipment was found to be defective or non-compliant with contract requirements, perform corrective actions and repeat the tests. Tests must be conducted and repeated if necessary until the system has been demonstrated to comply with all contract requirements.

3.6.4 Government Final Tests

The tests must be performed in accordance with the approved test procedures in the presence of the DFPE. Furnish instruments and personnel required for the tests. The following must be provided at the job site for Government Final Testing:

- a. The manufacturer's technical representative.
- b. The contractor's Qualified Fire Protection Engineer (QFPE).
- c. Marked-up red line drawings of the system as actually installed.
- d. Loop resistance test results.
- e. Complete program printout including input/output addresses.
- f. Copy of pre-Government Test Certificate, test procedures and completed test data forms.

Government Final Tests will be witnessed by the Designated Fire Protection Engineer, Contracting Officer's Representative (COR), and Qualified Fire Protection Engineer (QFPE). At this time, any and all required tests noted in the paragraph "Minimum System Tests" must be repeated at their discretion.

3.7 MINIMUM SYSTEM TESTS

3.7.1 System Tests

Test the system in accordance with the procedures outlined in NFPA 72. The required tests are as follows:

- a. Loop Resistance Tests: Measure and record the resistance of each circuit with each pair of conductors in the circuit short-circuited at the farthest point from the circuit origin. The tests must be

witnessed by the Contracting Officer and test results recorded for use at the final Government test.

- b. Verify the absence of unwanted voltages between circuit conductors and ground. The tests must be accomplished at the pre-Government test with results available at the final system test.
- c. Verify that the control unit is in the normal condition as detailed in the manufacturer's O&M manual.
- d. Test each initiating device and notification appliance and circuit for proper operation and response at the control unit. Smoke detectors must be tested in accordance with manufacturer's recommended calibrated test method. Use of magnets is prohibited. Testing of duct smoke detectors must comply with the requirements of NFPA 72 except disconnect at least 20 percent of devices. If there is a failure at these devices, then supervision must be tested at each device.
- e. Carbon Monoxide Detector Tests: Carbon monoxide detectors must be tested in accordance with NFPA 72 and the manufacturer's recommended calibrated test method.
- f. Test the system for specified functions in accordance with the contract drawings and specifications and the manufacturer's O&M manual.
- g. Test both primary power and secondary power. Verify, by test, the secondary power system is capable of operating the system for the time period and in the manner specified.
- h. Determine that the system is operable under trouble conditions as specified.
- i. Visually inspect wiring.
- j. Test the battery charger and batteries.
- k. Verify that software control and data files have been entered or programmed into the FMCU. Hard copy records of the software must be provided to the Contracting Officer.
- l. Verify that red-line drawings are accurate.
- m. Measure the current in circuits to ensure there is the calculated spare capacity for the circuits.
- n. Measure voltage readings for circuits to ensure that voltage drop is not excessive.
- o. Disconnect the verification feature for smoke detectors during tests to minimize the amount of smoke needed to activate the sensor. Testing of smoke detectors must be conducted using real smoke or the use of canned smoke which is permitted.
- p. Measure the voltage drop at the most remote appliance (based on wire length) on each notification appliance circuit.
- q. Verify the documentation cabinet is installed and contains all as-built shop drawings, product data sheets, design calculations, site-specific software data package, and all documentation required by

paragraph titled "Test Reports".

3.8 SYSTEM ACCEPTANCE

Following acceptance of the system, as-built drawings and O&M manuals must be delivered to the Contracting Officer for review and acceptance. The drawings must show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final Government test of the system. At least one set of as-built (marked-up) drawings must be provided at the time of, or prior to the Final Government Test.

- a. The drawings must be prepared electronically and sized no less than the contract drawings. Furnish one set of CDs or DVDs containing software back-up and CAD based drawings in latest version of AutoCAD, DXF and portable document formats of as-built drawings and schematics.
- b. Include complete wiring diagrams showing connections between devices and equipment, both factory and field wired.
- c. Include a riser diagram and drawings showing the as-built location of devices and equipment.
- d. Provide [Operation and Maintenance \(O&M\) Instructions](#).

3.9 INSTRUCTION OF GOVERNMENT EMPLOYEES

3.9.1 Instructor

Provide the services of an instructor, who has received specific training from the manufacturer for the training of other persons regarding the operation, inspection, testing, and maintenance of the system provided. The instructor must train the Government employees designated by the Contracting Officer, in the care, adjustment, maintenance, and operation of the fire alarm system. The instructor must be thoroughly familiar with all parts of this installation. The instructor must be trained in operating theory as well as in practical O&M work. Submit the instructors information and qualifications including the training history.

3.9.2 Required Instruction Time

Provide 8 hours of instruction after final acceptance of the system. The instruction must be given during regular working hours on such dates and times selected by the Contracting Officer. The instruction may be divided into two or more periods at the discretion of the Contracting Officer. The training must allow for rescheduling for unforeseen maintenance and/or fire department responses.

3.9.3 Technical Training Manual

Provide, in manual format, lesson plans, operating instructions, maintenance procedures, and training data for the training courses. The operations training must familiarize designated government personnel with proper operation of the installed system. The maintenance training course must provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system.

3.10 EXTRA MATERIALS

3.10.1 Repair Service/Replacement Parts

Repair services and replacement parts for the system must be available for a period of 10 years after the date of final acceptance of this work by the Contracting Officer. During the warranty period, the service technician must be on-site within 24 hours after notification. All repairs must be completed within 24 hours of arrival on-site.

During the warranty period, the installing fire alarm contractor is responsible for conducting all required testing and maintenance in accordance with the requirements and recommended practices of NFPA 72 and the system manufacturer. Installing fire alarm contractor is NOT responsible for any damage resulting from abuse, misuse, or neglect of equipment by the end user.

3.10.2 Spare Parts

Spare parts furnished must be directly interchangeable with the corresponding components of the installed system. Spare parts must be suitably packaged and identified by nameplate, tagging, or stamping. Spare parts must be delivered to the Contracting Officer at the time of the Government testing and must be accompanied by an inventory list.

3.10.3 Document Storage Cabinet

Upon completion of the project, but prior to project close-out, place in the document storage cabinet copies of the following record documentation:

- a. As-built shop drawings
- b. Product data sheets
- c. Design calculations
- d. Site-specific software data package
- e. All documentation required by SD-06.

-- End of Section --

SECTION 31 00 00

EARTHWORK

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 ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO T 180 (2017) Standard Method of Test for
Moisture-Density Relations of Soils Using
a 4.54-kg (10-lb) Rammer and a 457-mm
(18-in.) Drop

ASTM INTERNATIONAL (ASTM)

ASTM C117 (2017) Standard Test Method for Materials
Finer than 75-um (No. 200) Sieve in
Mineral Aggregates by Washing

ASTM C136/C136M (2019) Standard Test Method for Sieve
Analysis of Fine and Coarse Aggregates

ASTM D698 (2012; E 2014; E 2015) Laboratory
Compaction Characteristics of Soil Using
Standard Effort (12,400 ft-lbf/cu. ft.
(600 kN-m/cu. m.))

ASTM D1140 (2017) Standard Test Methods for
Determining the Amount of Material Finer
than 75-µm (No. 200) Sieve in Soils by
Washing

ASTM D1556/D1556M (2015; E 2016) Standard Test Method for
Density and Unit Weight of Soil in Place
by Sand-Cone Method

ASTM D1557 (2012; E 2015) Standard Test Methods for
Laboratory Compaction Characteristics of
Soil Using Modified Effort (56,000
ft-lbf/ft³) (2700 kN-m/m³)

ASTM D2216 (2019) Standard Test Methods for
Laboratory Determination of Water
(Moisture) Content of Soil and Rock by Mass

ASTM D2487 (2017; E 2020) Standard Practice for
Classification of Soils for Engineering
Purposes (Unified Soil Classification
System)

ASTM D2974	(2020; E 2020) Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM D4253	(2016; E 2019) Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4254	(2016) Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4829	(2021) Standard Test Method for Expansion Index of Soils

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

1.2 DEFINITIONS

1.2.1 Structural Fill

Soil material placed to support buildings, walls, pads, and other similar facilities.

1.2.2 Embankment Fill

Soil material placed to construct embankment.

1.2.3 Porous Fill

Free-draining material placed for subsurface drainage, as a capillary break, or another specific purpose.

1.2.4 Topsoil

Surface layer of primarily organic soil capable of supporting vegetation growth.

1.2.5 Utility Bedding Material

Fill placed to directly support pipes, conduits, cables, and appurtenant structures. Bedding may also be used to provide a cushion between utilities and bedrock, obstacles, obstructions and other unyielding materials.

1.2.6 Flowable Fill

Fill placed in a plastic or liquid form that flows to near its final placement location with limited assistance and subsequently cures or solidifies to provide a stable or impermeable barrier.

1.2.7 Satisfactory Materials

Satisfactory materials for fill, backfill, and/or any in-situ soils to remain in place comprise any materials classified by [ASTM D2487](#) as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, and CL. Maximum particle size to be no greater than one-half of the allowable lift thickness in any dimension.

1.2.8 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; roots and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

1.2.9 Cohesionless Materials

Cohesionless materials include materials classified in [ASTM D2487](#) as GW, GP, SW, and SP. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Perform testing, required for classifying materials, in accordance with [ASTM D4318](#), [ASTM C117](#), [ASTM C136/C136M](#) and [ASTM D1140](#).

1.2.10 Cohesive Materials

Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesive only when the fines are plastic. Perform testing, required for classifying materials, in accordance with [ASTM D4318](#), [ASTM C117](#), [ASTM C136/C136M](#) and [ASTM D1140](#).

1.2.11 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 3 inch in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.12 Unstable Material

Unstable materials are too weak to adequately support the utility pipe, conduit, equipment, or appurtenant structure. Satisfactory material may become unstable due to ineffective drainage, dewatering, becoming frozen, excessive loading.

1.2.13 Expansive Soils

Expansive soils are defined as soils that have an expansion index greater than 20 when tested in accordance with [ASTM D4829](#).

1.2.14 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted

pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.15 Capillary Water Barrier

A layer of clean, poorly graded crushed rock, stone, or natural sand or gravel having a high porosity which is placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below a slab.

1.2.16 Degree of Compaction (Proctor)

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the maximum density in accordance with AASHTO T 180-21 paragraph 1.5, Note 1.

1.2.17 Degree of Compaction (Relative Density)

Degree of compaction required for soils with less than 5 percent passing the No. 200 sieve, is expressed as a relative percentage of the maximum index density/dry unit weight and minimum index density/dry unit weight, obtained by the test procedures in accordance with ASTM D4253 and ASTM D4254, respectively, abbreviated as a percent of laboratory relative density.

1.2.18 Borrow

Soil brought to the project site from an external location for the purposes of project construction.

1.2.19 Subgrade

Earth materials directly below foundations and directly below granular base materials in building slab and pavement areas including shoulders.

1.3 SUBSURFACE DATA

Subsurface soil boring logs are shown in project plans. These data represent available subsurface information; however, variations may exist between boring locations.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:SD-01 Preconstruction SubmittalsDewatering Work Plan; G Preconstruction Meeting; G

SD-06 Test Reports

Material Test Report

Pipe Inspection Report

Geotechnical Evaluation Report

1.5 QUALITY CONTROL

1.5.1 Geotechnical Engineer

Provide a Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer is responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer is responsible for preparing and updating the Excavation and Trenching Plan and Dewatering Work Plan as construction progresses to reflect changing conditions and submit an updated plan if necessary. Submit a monthly [Geotechnical Evaluation report](#), informing the Contractor and Contracting Officer of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Contractor is responsible for arranging meetings with the Geotechnical Engineer and Contracting Officer throughout the contract duration.

1.5.2 Qualified Technician

Provide a Qualified Technician to inspect, monitor, sample, and performing field testing. The technician qualifications need to be one of the following: a current National Institute for Certification in Engineering Technologies (NICET) Level II minimum certification in Construction Materials Testing Soils; a Geologist-in-Training with minimum one-year experience; an Engineer-in-Training with minimum one-year experience; a Registered Geologist; or a Professional Engineer.

1.5.3 Lab Validation

Perform testing by a Corps validated commercial testing laboratory or Contractor established testing laboratory meeting the requirements of Section [01 45 00.00 40](#) (or similar number) entitled QUALITY CONTROL and approved by the Contracting Officer. Submit testing laboratory validation for the testing to be performed. Do not permit work requiring testing until testing facilities have been inspected, Corps validated and approved by the Contracting Officer.

1.5.4 Preconstruction Meeting

Conduct a preconstruction meeting at the jobsite at least five business days prior to the start of earthwork operations on the project. The [preconstruction meeting](#) is to be arranged by the Contractor and is to follow the written agenda submitted prior to the meeting. The purpose of this meeting is to review the requirements of this specification and the associated plans. The following individuals must be in attendance at this

meeting: Contractor's Project Manager and Project Superintendent, earthwork subcontractor's Project Manager and Site Foreman, Contractor's Geotechnical Engineer and Testing Agency, Government Geotechnical Engineer and Civil Engineer, and Government Construction Manager and Engineering Technician.

The minutes of this meeting are to be recorded by the Contractor and published via email within 48 hours to all attendees. The minutes must be re-published within 48 hours via email pending any subsequent comments from the attendees.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Structural Fill

Materials classified as GW, GP, GM, GC, GW-GM, GW-GC, GP-GM, GP-GC, GC-GM, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC in accordance with [ASTM D2487](#). Select material type appropriate for the intended purpose.

2.1.2 Porous Fill

Materials containing less than 5 percent passing the No. 200 sieve. Provide the gradation as appropriate for the intended purpose.

2.1.3 Topsoil

Material suitable for topsoil obtained from excavations is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than [one inch](#) diameter, brush, weeds, toxic substances, and other material detrimental to plant growth.

2.1.4 Utility Bedding Material

2.1.4.1 Class I

Angular, [0.25 to 1.5 inch](#), graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

2.1.4.2 Class II

Coarse sands and gravels with maximum particle size of [1.5 inch](#), including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in [ASTM D2487](#).

2.1.4.3 Sand

Clean, coarse-grained sand classified as SW or SP by [ASTM D2487](#) for bedding and backfill.

2.1.4.4 Gravel and Crushed Stone

Clean, coarsely graded natural gravel, crushed stone or a combination thereof having a classification of GW [or](#) GP in accordance with [ASTM D2487](#) for bedding and backfill. Do not exceed maximum particle size of [3 inches](#).

2.2 BURIED WARNING AND IDENTIFICATION MARKERS

Provide polyethylene plastic, metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes	
Red	Electric
Yellow	Gas, Oil; Dangerous Materials
Orange	Telephone and Other Communications
Blue	Water Systems
Green	Sewer Systems
White	Steam Systems
Gray	Compressed Air

2.2.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.2.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.2.3 Detection Wire for Non-Metallic Piping

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

2.3 MATERIAL FOR RIP-RAP

2.3.1 Bedding Material

Provide bedding material consisting of sand, gravel, or crushed rock, well

graded, with a maximum particle size of 2 inches. Compose material of tough, durable particles. Allow fines passing the No. 200 standard sieve with a plasticity index less than 6.

2.3.2 Grout

Provide durable grout composed of cement, water, an air-entraining admixture, and sand mixed in proportions of one-part Portland cement to two parts of sand, sufficient water to produce a workable mixture, and an amount of admixture which will entrain sufficient air, as determined by the Contracting Officer. Mix grout in a concrete mixer. Allow a sufficient mixing time to produce a mixture having a consistency permitting gravity flow into the interstices of the riprap with limited spading and brooming.

PART 3 EXECUTION

3.1 PROTECTION

Perform all work specified in accordance with applicable requirements of the Corps of Engineers publication EM 385-1-1 Safety and Health Requirements Manual. Provide a Geotechnical Engineer to monitor construction activities and to prepare necessary work plans and reports; see paragraph QUALITY CONTROL.

Use equipment of type and size appropriate for the site conditions (soil character and moisture content). Maintenance of exposed subgrades and fills is the responsibility of the Contractor. The Contractor is required to prevent damage by ineffective drainage, dewatering, and heavy loads and equipment by implementing precautionary measures. Repair or replace any defects or damage.

3.1.1 Underground Utilities

Location of the existing utilities indicated is approximate. Physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Contractor is responsible for protecting utilities from damage during construction.

3.1.2 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.2.1 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity. Remove unstable material from working platforms for equipment operation and soil support for subsequent construction features and provide new material as specified herein. It is the responsibility of the Contractor to assess the site conditions to employ necessary measures to permit construction to proceed.

3.1.2.2 Dewatering

Control groundwater flowing toward or into excavations 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 are not allowed within **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. Perform control measures 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, maintain the water level continuously, at least **2 feet** below the working level. Submit a **Dewatering Work Plan** outlining procedures for accomplishing dewatering work. Operate dewatering system continuously until construction work below existing water levels is complete.

3.1.3 Protection of Graded Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.2 SURFACE PREPARATION

3.2.1 Clearing and Grubbing

Remove trees, stumps, logs, shrubs, brush and vegetation and other items that would interfere with construction operations. Remove stumps entirely. Grub out matted roots and roots over **3 inches** in diameter to at least **18 inches** below existing surface.

3.2.2 Stripping

Strip site where indicated on the plans. Strip existing surface materials to a depth of **4 inches** below the existing ground surface in all areas. Strip in all areas within the planned limits of disturbance. All stripped materials not suitable for reuse as topsoil will be wasted in specified disposal area. Screen all stripped soils to remove roots and organic materials prior disposal.

Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Protect topsoil and keep in segregated piles until needed.

3.2.3 Stockpiling Operations

Place and grade stockpiles of satisfactory as specified. Keep stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal by rubber-tired equipment, the ground surface at stockpile locations; separately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material. Do not create stockpiles that could 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. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.3 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Excavate soil

disturbed or weakened by Contractor's operations, and soils softened or made unstable for subsequent construction due to exposure to weather. Use material removed from excavations meeting the specified requirements in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes to minimize surplus material and to minimize additional material to brought on site. Do not excavate below indicated depths except to remove unstable material as determined by the Geotechnical Engineer and confirmed by the Contracting Officer. Remove and replace excavations below the grades shown with appropriate materials as directed by the Contracting Officer.

If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock or as hard/unyielding material, uncover such material, and notify the Contracting Officer. Do not proceed with the excavation of this material until the Contracting Officer has classified the materials as common excavation or rock excavation. Failure on the part of the Contractor to uncover such material, notify the Contracting Officer, and allow sufficient time for classification and delineation 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.

3.3.1 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown. Do not excavate below grades shown. Backfill excessive excavation as directed by the Contracting Officer, with satisfactory, compacted, material or with suitable stone or cobble to grades shown. Dispose excavated material as shown or as directed. Do not allow material to be deposited within **4 feet** from edge of a ditch. Maintain excavations free from detrimental quantities of leaves, brush, sticks, trash, and other debris until final acceptance of the work.

3.3.2 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended by the manufacturer. Provide vertical trench walls where no manufacturer installation instructions are available. Do not exceed the trench width of **24 inches** below the top pipe plus pipe outside diameter (O.D.) for pipes of less than **24 inches** inside diameter, and do not exceed **36 inches** plus pipe outside diameter for pipe sizes larger than **24 inches** inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Government.

3.3.2.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of **3 inch** or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.3.2.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench, notify the Contracting Officer. Following approval, remove such material 4 inch below the required grade and replaced with suitable materials as provided in paragraph FILLING AND COMPACTION.

3.3.2.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with suitable material as provided in paragraph FILLING AND COMPACTION. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost to the Government.

3.3.2.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation or support members.

3.3.3 Underground Utilities

Perform work adjacent to utilities as indicated. Excavation made with power-driven equipment is not permitted within 2 feet of known utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

3.3.4 Structural Excavation

Following general excavation and rough grading activities, excavate the entire utility paid foundation in its entirety. Do not excavate to final grade until just before concrete is to be placed. Roughen level surfaces. Cut sloped surfaces as indicated into rough steps or benches to provide a satisfactory bond for compacting materials. For new pavement areas including exterior concrete pads, over-excavate to a minimum of 12 inches below bottom of new pavement/pad base course, scarify, moisture-condition, and compact to at least 95 percent.

Make excavations to the lines, grades, and elevations shown, or as directed. Provide trenches and foundation pits of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or other hard foundation material of loose debris and cut to a firm, level, stepped, or serrated surface. Remove loose disintegrated rock and thin strata.

Concrete placement is not allowed until footing subgrades have been inspected and approved by the Contracting Officer.

3.4 SUBGRADE PREPARATION

3.4.1 General Requirements

Shape subgrade to line, grade, and cross section as indicated. Remove unsatisfactory and unstable material in surfaces to receive fill or in excavated areas, and replaced with structural fill. Do not place material on surfaces that are muddy, frozen, contain frost, or otherwise containing unstable material. Scarify the surface to a depth of 4 inches prior to placing fill. Step or bench sloped surfaces steeper than 1 vertical to 4 horizontal prior to scarifying. Place 4 inches of loose fill and blend with scarified material. When subgrade is part fill and part excavation or natural ground, scarify to a depth of 8 inches.

3.4.2 Subgrade for Structures, Spread Footings, and Concrete Slabs

Do not excavate below depth shown for structures, spread footings, and concrete slabs. If over excavation occurs, notify the Contracting Officer and remove, replace, and compact as directed. compact disturbed material to 95 percent of ASTM D1557. After final rolling, the surface of the subgrade for buildings and pavements must not show deviations greater than 0.05 foot when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area.

3.4.3 Subgrade for Pavements

Compact top 12 inches of subgrade for pavements to at least 95 percent of ASTM D1557. After final rolling, the surface of the subgrade for buildings and pavements must not show deviations greater than 0.05 foot when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area.

3.5 FILLING AND COMPACTION

Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs for SUBGRADE PREPARATION. Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to plus or minus 2 percent of optimum moisture. Fill and backfill to contours, elevations, and dimensions indicated. Compact and test each lift before placing overlaying lift.

3.5.1 Trench Backfill

Backfill trenches to the grade shown.

3.5.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with satisfactory material or initial backfill material.

3.5.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with satisfactory material placed in layers not exceeding 6 inches loose thickness.

3.5.1.3 Bedding and Initial Backfill

Place initial backfill material and compact it with approved tampers to a height of at least **one foot** above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except where shown or when specified otherwise in the individual piping section, provide bedding for buried piping in accordance with PART 2 paragraph UTILITY BEDDING MATERIAL. Compact backfill to top of pipe to 85 percent of **ASTM D1557**. Provide plastic piping with bedding to spring line of pipe.

3.5.1.4 Final Backfill

Do not begin backfill 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. Bring backfill to indicated finish grade. Where pipe is coated or wrapped for protection against corrosion, the backfill material up to an elevation **2 feet** above sewer lines and **one foot** above other utility lines need to be free from stones larger than **one inch** in any dimension. Heavy equipment for spreading and compacting backfill are not to be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; compact remaining area in layers not more than **4 inches** in compacted thickness with power-driven hand tampers suitable for the material being compacted. Place backfill carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Do not place backfill against foundation walls prior to 7 days after completion of the walls. As far as practicable, bring backfill up evenly on each side of the wall and sloped to drain away from the wall.

Fill the remainder of the trench, except for special materials for buildings and pavements with satisfactory material. Place backfill material and compact as follows:

3.5.1.4.1 Buildings and Pavements

Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction. Compact as specified for Structural Fill.

3.5.1.5 Heat Distribution System

Free initial backfill material of stones larger than **1/4 inch** in any dimension.

3.5.1.6 Electrical Distribution System

Provide a minimum cover of **24 inches** from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.5.1.7 Displacement of Features

After other required tests have been performed and the trench backfill compacted to inspect the pipe to determine whether unexpected or damaging displacement has occurred. Conduct walk-through inspection of pipe sizes larger than **48 inches**. Inspect pipes smaller than **48 inches** using remote methods using closed circuit television, sonar, or hybrid that can provide

a 360-degree inspection of the pipe. Prepare and submit a [pipe inspection report](#) consisting of digital video or photos. 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, replace or repair the defects as directed at no additional cost to the Government.

3.5.1.8 Buried Tape And Detection Wire

3.5.1.8.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape [12 inches](#) below finished grade; under pavements and slabs, bury tape [6 inches](#) below top of subgrade.

3.5.1.8.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed [12 inches](#) above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of [3 feet](#) of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over its entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, terminate the wire in the valve pit at the pump station end of the pipe.

3.5.2 Structural Fill Placement

Place fill and backfill beneath and adjacent to structures in successive horizontal layers of loose material not more than [8 inches](#) in depth, or in loose layers not more than [4 inches](#) in depth when using hand-operated compaction equipment. Do not place over wet or frozen materials. Compact to at least 90 percent of laboratory maximum density for cohesive materials or 95 percent of laboratory maximum density for cohesionless materials, except as otherwise specified. Perform compaction in such a manner as to prevent wedging action or eccentric loading upon or other damage to the structure. Moisture condition fill and backfill material to a moisture content that will readily facilitate obtaining the specified compaction within range of plus 2 or minus 2 percent of optimum moisture content at the time of compaction.

3.5.3 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, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.5.4 Porous Fill Placement

Provide under floor and area-way slabs on a compacted subgrade. Place in a single lift and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.5.5 Compaction

3.5.5.1 General Site

Compact underneath areas designated for vegetation and areas outside the 5 foot line of the paved area or structure to 90 percent of ASTM D1557.

3.5.5.2 Adjacent Areas

Compact areas within 5 feet of structures to 95 percent of ASTM D1557.

3.6 FINISHING/FINISH OPERATIONS

3.6.1 Grading Around Structures

Construct areas within 5 feet outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.6.2 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Contractor's operations, grade as directed.

3.6.3 Topsoil and Seed

On areas to receive topsoil, prepare the compacted subgrade soil to a 2 inches depth for bonding of topsoil with subsoil. Spread topsoil evenly to a thickness of 4 inch and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Keep topsoil separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 2 inches in diameter, and other materials that would interfere with planting and maintenance operations. Remove from the site any surplus of topsoil from excavations and gradings. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from offsite areas.

3.7 DISPOSITION OF SURPLUS MATERIAL

Remove from Government property all surplus or other soil material not required or not suitable for filling or backfilling, along with brush, refuse, stumps, roots, and timber. Properly disposed of in accordance with all applicable laws and regulations.

3.8 TESTING

Perform testing as indicated in Table 1. Submit Material Test Reports within 7 days of tests being completed.

Material Type	Location of Material	Test Method	Test Frequency
Satisfactory soils or Structural fill	Site	Density - ASTM D1556/D1556M .	One test per 500 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines. Double testing frequency for areas compacted by hand-operated machines.
Barrow Materials	Stockpiles	Moisture Content - ASTM D2216	Two tests per day for each type of fill and backfill. Sample taken immediately prior to compaction after moisture conditioning.

Material Type	Location of Material	Test Method	Test Frequency
Barrow Materials	Site	Moisture Density Relationship - ASTM D698	One representative test per 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. Sample to be taken from stockpile or location of placement.
Satisfactory soils or Structural fill	Site	Relative Density - ASTM D4253 and ASTM D4254	One test per 1,000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines. Double testing frequency for areas compacted by hand-operated machines.

Material Type	Location of Material	Test Method	Test Frequency
Barrow Materials	Stockpiles	Gradation - ASTM C136/C136M	One representative test per 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. Sample to be taken from stockpile or location of placement.
Barrow Materials	Stockpiles	Atterberg Limits - ASTM D4318	One representative test per 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. Sample to be taken from stockpile or location of placement.
Barrow Materials	Stockpiles	Organic Content Test - ASTM D2974, Method C	One representative test per 200 lineal feet of embankment.

-- End of Section --

SECTION 32 16 19

CONCRETE CURBS, GUTTERS AND SIDEWALKS

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 ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 182 (2005; R 2017) Standard Specification for
Burlap Cloth Made from Jute or Kenaf and
Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM A615/A615M (2020) Standard Specification for Deformed
and Plain Carbon-Steel Bars for Concrete
Reinforcement

ASTM A1064/A1064M (2017) Standard Specification for
Carbon-Steel Wire and Welded Wire
Reinforcement, Plain and Deformed, for
Concrete

ASTM C31/C31M (2021a) Standard Practice for Making and
Curing Concrete Test Specimens in the Field

ASTM C94/C94M (2021b) Standard Specification for
Ready-Mixed Concrete

ASTM C143/C143M (2020) Standard Test Method for Slump of
Hydraulic-Cement Concrete

ASTM C171 (2020) Standard Specification for Sheet
Materials for Curing Concrete

ASTM C172/C172M (2017) Standard Practice for Sampling
Freshly Mixed Concrete

ASTM C173/C173M (2016) Standard Test Method for Air
Content of Freshly Mixed Concrete by the
Volumetric Method

ASTM C231/C231M (2017a) Standard Test Method for Air
Content of Freshly Mixed Concrete by the
Pressure Method

ASTM C309 (2019) Standard Specification for Liquid
Membrane-Forming Compounds for Curing
Concrete

ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D1751	(2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D5893/D5893M	(2016) Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1	(2017) Standard And Commentary Accessible and Usable Buildings and Facilities

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Concrete

Biodegradable Form Release Agent

SD-06 Test Reports

Field Quality Control

1.3 EQUIPMENT, TOOLS, AND MACHINES

1.3.1 General Requirements

Plant, equipment, machines, and tools used in the work will be subject to approval and must be maintained in a satisfactory working condition at all times. Use equipment capable of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Discontinue using equipment that produces unsatisfactory results. Allow the Contracting Officer access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.3.2 Slip Form Equipment

Slip form paver or curb forming machines, will be approved based on trial

use on the job and must 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.

1.4 ENVIRONMENTAL REQUIREMENTS

1.4.1 Placing During Cold Weather

Do not place concrete when the air temperature reaches 40 degrees F and is falling, or is already below that point. Placement may begin when the air temperature reaches 35 degrees F and is rising, or is already above 40 degrees F. Make provisions 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 35 degrees F, placement and protection must be approved in writing. Approval will be contingent upon full conformance with the following provisions. Prepare and protect the underlying material so that it is entirely free of frost when the concrete is deposited. Heat mixing water and aggregates as necessary to result in the temperature of the in-place concrete being between 50 and 85 degrees F. Methods and equipment for heating must be approved. Use only aggregates that are free of ice, snow, and frozen lumps before entering the mixer. Provide covering or other means as needed to maintain the concrete at a temperature of at least 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period.

1.4.2 Placing During Warm Weather

The temperature of the concrete as placed must not exceed 85 degrees F except where an approved retarder is used. Cool the mixing water and aggregates as necessary to maintain a satisfactory placing temperature. The placing temperature must not exceed 95 degrees F at any time.

PART 2 PRODUCTS

2.1 CONCRETE

Provide concrete conforming to the applicable requirements of ASTM C94/C94M except as otherwise specified. Concrete must have a minimum compressive strength of 3500 psi at 28 days. Size of aggregate must not exceed 1-1/2 inches. Submit copies of certified delivery tickets for all concrete used in the construction.

2.1.1 Air Content

Use concrete mixtures that have an 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

Use concrete with a slump of 3 inches plus or minus 1 inch for hand placed concrete or 1 inch plus or minus 1/2 inch for slipformed concrete as determined in accordance with ASTM C143/C143M.

2.1.3 Reinforcement Steel

Use reinforcement bars conforming to ASTM A615/A615M. Use wire mesh reinforcement conforming to ASTM A1064/A1064M.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Use impervious sheet materials conforming to [ASTM C171](#), type optional, except that polyethylene film, if used, must be white opaque.

2.2.2 Burlap

Use burlap conforming to [AASHTO M 182](#).

2.2.3 White Pigmented Membrane-Forming Curing Compound

Use white pigmented membrane-forming curing compound conforming to [ASTM C309](#), Type 2.

2.3 CONCRETE PROTECTION MATERIALS

Use concrete protection materials consisting of 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.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter

Use hard-pressed fiberboard contraction joint filler for curb and gutter.

2.4.2 Expansion Joint Filler, Premolded

Unless otherwise indicated, use [1/2 inch](#) thick premolded expansion joint filler conforming to [ASTM D1751](#) or [ASTM D1752](#).

2.5 JOINT SEALANTS

Use cold-applied joint sealant conforming to [ASTM C920](#) or [ASTM D5893/D5893M](#).

2.6 FORM WORK

Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Use wood or steel forms that are straight and of sufficient strength to resist springing during depositing and consolidating concrete.

2.6.1 Wood Forms

Use forms that are surfaced plank, [2 inches](#) nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Use forms with a nominal length of [10 feet](#). Radius bends may be formed with [3/4 inch](#) boards, laminated to the required thickness.

2.6.2 Steel Forms

Use channel-formed sections with a flat top surface and welded braces at

each end and at not less than two intermediate points. Use forms with interlocking and self-aligning ends. Provide flexible forms for radius forming, corner forms, form spreaders, and fillers as needed. Use forms with a nominal length of 10 feet and that have a minimum of 3 welded stake pockets per form. Use stake pins consisting of solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.3 Sidewalk Forms

Use sidewalk forms that are of a height equal to the full depth of the finished sidewalk.

2.6.4 Curb and Gutter Forms

Use curb and gutter outside forms that have a height equal to the full depth of the curb or gutter. Use rigid forms for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 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 1-1/2 inch benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

Construct subgrade to the specified grade and cross section prior to concrete placement.

3.1.1 Sidewalk Subgrade

Place and compact the subgrade in accordance with Section 31 00 00 EARTHWORK. Test the subgrade 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

Place and compact the subgrade in accordance with Section 31 00 00 EARTHWORK. Test the subgrade for grade and cross section by means of a template extending the full width of the curb and gutter. Use subgrade materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade

Maintain subgrade in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade must be in a moist condition when concrete is placed. Prepare and protect subgrade so that it is free from frost when the concrete is deposited.

3.2 FORM SETTING

Set forms to the indicated alignment, grade and dimensions. Hold forms rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 4 feet. Use additional stakes and braces at corners, deep sections, and radius bends, as required. Use clamps, spreaders, and

braces where required to ensure rigidity in the forms. Remove forms in a manner that will not injure the concrete. Do not use bars or heavy tools against the concrete when removing the forms. Promptly and satisfactorily repair concrete found to be defective after form removal. Clean forms and coat with form oil or [biodegradable form release agent](#) 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

Set forms for sidewalks with the upper edge true to line and grade with an allowable tolerance of [1/8 inch](#) in any [10 foot](#) long section. After forms are set, grade and alignment must be checked with a [10 foot](#) straightedge. Sidewalks must have a transverse slope as indicated. Do not remove side forms less than 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters

Remove forms used along the front of the curb not less than 2 hours nor more than 6 hours after the concrete has been placed. Do not remove forms used along the back of curb until the face and top of the curb have been finished, as specified for concrete finishing. Do not remove gutter forms while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks

Place concrete in the forms in one layer. When consolidated and finished, the sidewalks must be of the thickness indicated. Use a strike-off guided by side forms after concrete has been placed in the forms to bring the surface to proper section to be compacted. Consolidate concrete by tamping and spading or with an approved vibrator. Finish the surface to grade with a strike off.

3.3.2 Concrete Finishing

After straightedging, when most of the water sheen has disappeared, and just before the concrete hardens, finish the surface with a wood or magnesium float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. Produce a scored surface 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

Finish all slab edges, including those at formed joints, with an edger having a radius of [1/8 inch](#). Edge transverse joints before brooming. Eliminate the flat surface left by the surface face of the edger with brooming. Clean and solidly fill corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing with a properly proportioned mortar mixture and then finish.

3.3.4 Surface and Thickness Tolerances

Finished surfaces must not vary more than [5/16 inch](#) from the testing edge of a [10-foot](#) straightedge. Permissible deficiency in section thickness will be up to [1/4 inch](#).

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter

Place concrete to the required section in a single lift. Consolidate concrete using approved mechanical vibrators. Curve shaped gutters must be finished with a standard curb "mule".

3.4.2 Curb and Gutter Finishing

Approved slipformed curb and gutter machines may be used in lieu of hand placement.

3.4.3 Concrete Finishing

Float and finish exposed surfaces with a smooth wood float until true to grade and section and uniform in texture. Brush floated surfaces with a fine-hair brush using longitudinal strokes. Round the edges of the gutter and top of the curb with an edging tool to a radius of $\frac{1}{2}$ inch. Immediately after removing the front curb form, rub the face of the curb with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. Brush the front curb surface, while still wet, in the same manner as the gutter and curb top. Finish the top surface of gutter to grade with a wood float.

3.4.4 Joint Finishing

Finish curb edges at formed joints as indicated.

3.4.5 Surface and Thickness Tolerances

Finished surfaces must not vary more than $\frac{1}{4}$ inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to $\frac{1}{4}$ inch.

3.5 SIDEWALK JOINTS

Construct sidewalk joints to divide the surface into rectangular areas. Space transverse contraction joints at a distance equal to the sidewalk width or 5 feet on centers, whichever is less, and continuous across the slab. Construct longitudinal contraction joints along the centerline of all sidewalks 10 feet or more in width. Construct transverse expansion joints at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, install transverse expansion joints as indicated. Form expansion joints around structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated. Expansion joints are not required between sidewalks and curb that abut the sidewalk longitudinally.

3.5.1 Sidewalk Contraction Joints

Form contraction joints 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. Unless otherwise approved or indicated, either use a jointer to cut the groove or saw a groove in the hardened concrete with a power-driven saw. Construct sawed joints by sawing a groove in the concrete with a $\frac{1}{8}$ inch blade. Provide an ample supply of saw blades on

the jobsite before concrete placement is started. Provide at least one standby sawing unit in good working order at the jobsite at all times during the sawing operations.

3.5.2 Sidewalk Expansion Joints

Form expansion joints using $\frac{1}{2}$ inch joint filler strips. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of preformed filler material conforming to ASTM D1752 or building paper. Hold joint filler in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, round joint edges using an edging tool having a radius of $\frac{1}{8}$ inch. Remove any concrete over the joint filler. At the end of the curing period, clean the top of expansion joints and fill with cold-applied joint sealant. Use joint sealant that is gray or stone in color. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Apply joint sealing material only when the concrete at the joint is surface dry and atmospheric and concrete temperatures are above 50 degrees F. Immediately remove any excess material on exposed surfaces of the concrete and clean the concrete surfaces.

3.5.3 Reinforcement Steel Placement

Accurately and securely fasten reinforcement steel in place with suitable supports and ties before the concrete is placed.

3.6 CURB AND GUTTER JOINTS

Construct curb and gutter joints at right angles to the line of curb and gutter.

3.6.1 Contraction Joints

Construct contraction joints directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 5 feet nor greater than 15 feet in length.

- a. Construct contraction joints (except for slip forming) by means of $\frac{1}{8}$ inch thick separators and of a section conforming to the cross section of the curb and gutter. Remove separators as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.
- b. When slip forming is used, cut the contraction joints in the top portion of the gutter/curb hardened concrete in a continuous cut across the curb and gutter, using a power-driven saw. Cut the contraction joint to a depth of at least one-fourth of the gutter/curb depth using a $\frac{1}{8}$ inch saw blade.

3.6.2 Expansion Joints

Form expansion joints by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Construct expansion joints in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement using the same type and thickness of joints as joints in the pavement. Where curb and gutter

do not abut portland cement concrete pavement, provide expansion joints at least **1/2 inch** in width at intervals not less than **30 feet** nor greater than **120 feet**. Seal expansion joints immediately following curing of the concrete or as soon thereafter as weather conditions permit. Seal expansion joints and the top **1 inch** depth of curb and gutter contraction-joints with joint sealant. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Concrete at the joint must be surface dry and atmospheric and concrete temperatures must be above **50 degrees F** at the time of application of joint sealing material. Immediately remove excess material on exposed surfaces of the concrete and clean concrete surfaces.

3.7 CURING AND PROTECTION

3.7.1 General Requirements

Protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. All equipment needed for adequate curing and protection of the concrete must be on hand and ready for use before actual concrete placement begins. Protect concrete as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method

Cover the entire exposed surface with two or more layers of burlap. Overlap mats at least **6 inches**. Thoroughly wet the mat with water prior to placing on concrete surface and keep the mat continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method

Wet the entire exposed surface with a fine spray of water and then cover with impervious sheeting material. Lay sheets directly on the concrete surface with the light-colored side up and overlapped **12 inches** when a continuous sheet is not used. Use sheeting that is not less than **18-inches** wider than the concrete surface to be cured. Secure sheeting using heavy wood planks or a bank of moist earth placed along edges and laps in the sheets. Satisfactorily repair or replace sheets that are torn or otherwise damaged during curing. Sheeting must remain on the concrete surface to be cured for not less than 7 days.

3.7.1.3 Membrane Curing Method

Apply a uniform coating of white-pigmented membrane-curing compound to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Coat formed surfaces immediately after the forms are removed and in no case longer than 1 hour after the removal of forms. Do not allow concrete surface to dry before application of the membrane. If drying has occurred, moisten the surface of the concrete with a fine spray of water and apply the curing compound as soon as the free water disappears. Apply curing compound in two coats by hand-operated pressure sprayers at a coverage of approximately **200 square feet/gallon** for the total of both coats. Apply the second coat in a direction approximately at right angles to the direction of application of the first coat. The compound must form a uniform, continuous, coherent

film that will not check, crack, or peel and must be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied by the method and at the coverage specified above. Respray areas where the curing compound is damaged by subsequent construction operations within the curing period. Take precautions necessary to ensure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. Tightly seal the top of the joint opening and the joint groove at exposed edges before the concrete in the region of the joint is resprayed with curing compound. Use a method used for sealing the joint groove that prevents loss of moisture from the joint during the entire specified curing period. Provide approved standby facilities for curing concrete pavement at a location accessible to the jobsite 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. Adequately protect concrete surfaces to which membrane-curing compounds have been applied during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from other possible damage to the continuity of the membrane.

3.7.2 Backfilling

After curing, remove debris and backfill, grade, and compact the area adjoining the concrete to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Protect completed concrete from damage until accepted. Repair damaged concrete and clean concrete discolored during construction. Remove and reconstruct concrete that is damaged for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Dispose of removed material as directed.

3.7.4 Protective Coating

Apply a protective coating of linseed oil mixture to the exposed-to-view concrete surface after the curing period, if concrete will be exposed to de-icing chemicals within 6 weeks after placement. Moist cure concrete to receive a protective coating.

3.7.4.1 Application

Complete curing and backfilling operation prior to applying two coats of protective coating. Concrete must be surface dry and clean before each application. Spray apply at a rate of not more than 50 square yards/gallon for first application and not more than 70 square yards/gallon for second application, except that the number of applications and coverage for each application for commercially prepared mixture must be in accordance with the manufacturer's instructions. Protect coated surfaces from vehicular and pedestrian traffic until dry.

3.7.4.2 Precautions

Do not heat protective coating by direct application of flame or electrical heaters and protect the coating from exposure to open flame,

sparks, and fire adjacent to open containers or applicators. Do not apply material at ambient or material temperatures lower than 50 degrees F.

3.8 FIELD QUALITY CONTROL

Submit copies of all test reports within 24 hours of completion of the test.

3.8.1 General Requirements

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, take the action and submit reports as required below, and additional tests to ensure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing

Take concrete samples in accordance with ASTM C172/C172M not less than once a day nor less than once for every 250 cubic yards of concrete placed. Mold cylinders in accordance with ASTM C31/C31M for strength testing by an approved laboratory. Each strength test result must be the average of 2 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 500 psi.

3.8.2.2 Air Content

Determine air content in accordance with ASTM C173/C173M or ASTM C231/C231M. Use ASTM C231/C231M with concretes and mortars made with relatively dense natural aggregates. Make two tests for air content on randomly selected batches of each class of concrete placed during each shift. Make additional tests when excessive variation in concrete workability is reported by the placing foreman or the Government inspector. Notify the placing foreman if results are out of tolerance. The placing foreman must 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

Perform two slump tests on randomly selected batches of each class of concrete for every 250 cubic yards, or fraction thereof, of concrete placed during each shift. Perform additional tests when excessive variation in the workability of the concrete is noted or when excessive crumbling or slumping is noted along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation

Determine the anticipated thickness of the concrete 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, construct the subgrade true to

grade prior to concrete placement. The thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation

Provide finished surfaces for each category of the completed work that are 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 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, reduce high areas 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 must not exceed 5 percent of the area of any integral slab, and the depth of grinding must not exceed 1/4 inch. Remove and replace pavement areas requiring grade or surface smoothness corrections in excess of the limits specified.

3.9.3 Appearance

Exposed surfaces of the finished work will be inspected by the Contracting Officer and deficiencies in appearance will be identified. Remove and replace areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work.

3.10 DETECTABLE WARNING SYSTEM

Install Detectable Warning Systems required by Contract plans in accordance with ICC A117.1, Section 705, and by manufacturers' installation instructions.

-- End of Section --

SECTION 32 31 13

CHAIN LINK FENCES AND GATES

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.

ASTM INTERNATIONAL (ASTM)

ASTM A392	(2011; R 2022a) Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
ASTM A491	(2011; R 2022) Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A824	(2001; R 2022) Standard Specification for Metallic-Coated Steel Marcellled Tension Wire for Use With Chain Link Fence
ASTM C94/C94M	(2023) Standard Specification for Ready-Mixed Concrete
ASTM F567	(2023) Standard Practice for Installation of Chain Link Fence
ASTM F626	(2014; R 2023) Standard Specification for Fence Fittings

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS RR-F-191/1	(Rev F) Fencing, Wire and Post, Metal (Chain-Link Fence Fabric)
FS RR-F-191/2	(Rev E) Fencing, Wire and Post, Metal (Chain-Link Fence Gates)
FS RR-F-191/3	(2023; Rev F) Fencing, Wire and Post, Metal (Chain-Link Fence Posts, Top Rails and Braces)
FS RR-F-191/4	(Rev F) Fencing, Wire and Post, Metal (Chain-Link Fence Accessories)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for

information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fence Assembly; G

Location of Gate, Corner, End, and Pull Posts; G

Gate Assembly; G

Gate Hardware and Accessories; G

Erection/Installation Drawings; G

SD-03 Product Data

Fence Assembly; G

Gate Assembly; G

Gate Hardware and Accessories; G

Zinc Coating; G

Aluminum Alloy Coating; G

Fabric; G

Stretcher Bars; G

Concrete; G

SD-07 Certificates

Certificates of Compliance

SD-08 Manufacturer's Instructions

Fence Assembly

Gate Assembly

Hardware Assembly

Accessories

1.3 QUALITY CONTROL

1.3.1 Certificates of Compliance

Submit [certificates of compliance](#) in accordance with the applicable reference standards and descriptions of this section for the following:

- a. Zinc coating
- b. PVC coating

- c. Aluminum alloy coating
- d. Fabric
- e. Stretcher bars
- f. Gate hardware and accessories
- g. Concrete

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit reports of listing chain-link fencing and accessories regarding weight in ounces for zinc coating.

Submit manufacturer's catalog data for complete fence assembly, gate assembly, hardware assembly and accessories.

2.2 FENCES

2.2.1 Fabric

FS RR-F-191/1; Type II, aluminum-coated steel, 9 gauge, conforming to ASTM A491. Provide selvage knuckled at both selvages. Height of fabric, as indicated.

Provide fabric consisting of wires woven into a 2 inch diamond mesh. Provide one-piece fabric widths for fence heights up to 12 feet.

2.2.1.1 Top and Bottom Selvages

Provide knuckled selvages at top and bottom for fabric with 2 inch mesh and up to 60 inches high, and if over 60 inches high, provide twisted and barbed top selvage and knuckled bottom selvage.

Knuckle top and bottom selvages for 1-3/4 inch and 1 inch mesh fabric.

2.2.2 Posts

2.2.2.1 Metal

2.2.2.1.1 Line Posts

Provide line posts complying with FS RR-F-191/3. Provide Class 2, aluminum pipe, in minimum sizes listed in FS RR-F-191/3 for each class and grade.

2.2.2.1.2 End, Corner and Pull Posts

Provide end, corner, and pull posts in minimum sizes listed in FS RR-F-191/3 for each class and grade. Provide Class 2, aluminum pipe.

2.2.2.2 Post Tops

Provide aluminum tops and designed as a weathertight closure cap. Post top to have finish and coating matching rails and posts. Provide one cap for each post, unless equal protection is provided by a combination post-cap and wire supporting arm. Provide caps with an opening to permit through passage of the top rail.

2.2.3 Braces and Rails

Class 2, aluminum pipe.

2.2.3.1 Top Rail

Provide top rail conforming to minimum sizes specified in [FS RR-F-191/3](#) for each class and grade unless members are to be oversized. Provide expansion couplings [6 inches](#) long at each joint in top rails.

2.2.3.2 Bottom Rail

Provide bottom rail conforming to minimum sizes specified in [FS RR-F-191/3](#) for each class and grade unless members are to be oversized.

2.2.3.3 Post-Brace Assembly

Provide bracing conforming to minimum sizes specified in [FS RR-F-191/3](#) for each class and grade, and [3/8 inch](#) adjustable truss rods and turnbuckles.

2.2.4 Wire Ties

Provide [9-gauge](#) wire for tying fabric to line posts, spaced [12 inches](#) on center. For tying fabric to rails and braces, space wire ties [24 inches](#) on center. For tying fabric to tension wire, space [0.105-inch](#) hog rings [24 inches](#) on center. Manufacturer's standard procedure will be accepted if of equal strength and durability.

[FS RR-F-191/4](#). Provide wire ties constructed of the same material and coating as the fencing fabric.

2.2.5 Sleeves

Provide sleeves for setting into concrete construction of the same material as post sections, sized [1 inch](#) greater than the diameter or dimension of the post. Weld flat plates to each sleeve base to provide anchorage and prevent intrusion of concrete.

2.2.6 Stretcher Bars

Provide bars that have one-piece lengths equal to the full height of the fabric with a minimum cross section of [3/16 by 3/4 inch](#), in accordance with [ASTM F626](#).

2.2.7 Stretcher Bar Bands

Provide bar bands for securing stretcher bars to posts that are steel, wrought iron, or malleable iron spaced not over [15 inches](#) on center. Bands may also be used in conjunction with special fittings for securing rails to posts. Provide bands with projecting edges chamfered or eased.

2.2.8 Tension Wire

Provide metallic coated steel marcelled tension wire, (No. 7-gauge) complying with [ASTM A824](#). Provide aluminum-coated (aluminized) steel wire with coating that weighs not less than [0.4 ounces per square foot](#).

2.2.9 Miscellaneous Hardware

Provide miscellaneous hot-dip galvanized hardware as required.

2.3 GATES

[FS RR-F-191/2](#); Type II, double swing. Shape and size of gate frame, as indicated. Framing and bracing members, round of aluminum alloy. Provide gate frames and braces of minimum sizes listed in [FS RR-F-191/3](#) for each Class and Grade, except that steel pipe frames are a minimum of [1.90 inches](#) o.d., [0.120 inches](#) minimum wall thickness and aluminum pipe frames and intermediate braces are [1.869 inches](#) o.d. minimum, [0.940 lb/ft](#) of length. Provide intermediate members as necessary for gate leaves more than [8 feet](#) wide, to provide rigid construction, free from sag or twist. Provide truss rods or intermediate braces for gate leaves less than [8 feet](#) wide.

2.3.1 Gate Posts

Provide gate posts for supporting each gate leaf in minimum sizes listed in [FS RR-F-191/3](#) for each material class and grade. Gate post material class, grade and finish to match other fence posts.

2.3.2 Gate Fabric

Gate fabric, is as specified for fencing fabric. Attach gate fabric to gate frame in accordance with manufacturer's standards, except that welding is not permitted.

2.3.3 Gate Frame

Provide gate frame assembly that is welded or assembled with special malleable or pressed-steel fittings and rivets to provide rigid connections. Install fabric with stretcher bars at vertical edges; stretcher bars may also be used at top and bottom edges. Attach stretcher bars and fabric to gate frames on all sides at intervals not exceeding [15 inches](#). Attach hardware with rivets or by other means which provides equal security against breakage or removal.

2.3.4 Gate Bracing

Provide diagonal cross-bracing, consisting of [3/8 inch](#) diameter adjustable-length truss rods on welded gate frames, where necessary to obtain frame rigidity without sag or twist. Provide nonwelded gate frames with diagonal bracing.

2.3.5 Gate Hardware and Accessories

Provide gate hardware and accessories that conforms to [ASTM A392](#) and [ASTM F626](#), and as specified. Coating for steel latches, stops, hinges, keepers, and accessories, is galvanized

- a. Provide pressed steel hinges to suit gate size, non-lift-off type,

offset to permit 180-degree opening. Provide hinge with stainless steel pin.

- b. Provide latch that permits accessibility and operation from either side of the gate regardless of the latching arrangement, and with a padlock eye provided as an integral part of the latch. Provide plunger bar type gate latches.
- c. Provide stops and holders of malleable iron for vehicular gates. Provide stops that automatically engage the gate and hold it in the open position until manually released.
- d. Provide accessories constructed of aluminum alloy in conformance with [ASTM F626](#).
- e. Provide double gates with a cane bolt and ground-set keeper, with latch or locking device and padlock eye designed as an integral part.
- f. Provide manufacturer's standard heavy-duty track ball bearing hanger sheaves, overhead framing and supports, guides, stays, bracing, and accessories as required for easy operation of manual sliding gates.

2.4 MATERIALS

2.4.1 [Zinc Coating](#)

Provide zinc-coated ferrous metal components and accessories that are factory coated after fabrication, except as otherwise specified.

For galvanizing field repairs, provide material that is cold-applied zinc-rich coating conforming to [ASTM A780/A780M](#).

2.4.2 [Concrete](#)

Provide concrete conforming to [ASTM C94/C94M](#), and obtaining a minimum 28-day compressive strength of [3,000 psi](#).

2.4.3 [Grout](#)

Provide grout of proportions one part portland cement to three parts clean, well-graded sand and a minimum amount of water to produce a workable mix.

PART 3 EXECUTION

Submit manufacturer's [erection/installation drawings](#) and instructions that detail proper assembly and materials in the design for fence, gate, hardware and accessories.

Provide complete installation conforming to [ASTM F567](#).

3.1 PREPARATION

Ensure final grading and established elevations are complete prior to commencing fence installation.

3.2 INSTALLATION

3.2.1 Fence Installation

Install fence on prepared surfaces to line and grade indicated. Install fence in accordance with fence manufacturer's written installation instructions except as modified herein.

3.2.1.1 Post Spacing

Provide line posts spaced equidistantly apart, not exceeding 10 feet on center. Provide gate posts spaced as necessary for size of gate openings. Do not exceed 500 feet on straight runs between braced posts. Provide corner or pull posts, with bracing in both directions, for changes in direction of 15 degrees or more, or for abrupt changes in grade. Submit drawings showing location of gate, corner, end, and pull posts.

3.2.1.2 Top Tension Wire

Install top tension wires before installing chain-link fabric, and pull wires taut. Place top and bottom tension wires within 8 inches of respective fabric line.

3.2.2 Excavation

Provide excavations for post footings which are drilled holes in virgin or compacted soil, of minimum sizes as indicated. Space footings for line posts 10 feet on center maximum and at closer intervals when indicated, with bottoms of the holes approximately 3 inches below the bottoms of the posts. Set bottom of each post not less than 36 inches below finished grade when in firm, undisturbed soil. Set posts deeper, as required, in soft and problem soils and for heavy, lateral loads. Remove excavated soil from Government property.

When solid rock is encountered near the surface, drill into the rock at least 12 inches for line posts and at least 18 inches for end, pull, corner, and gate posts. Drill holes at least 1 inch greater in diameter than the largest dimension of the placed post. If solid rock is below the soil overburden, drill to the full depth required except that penetration into rock need not exceed the minimum depths specified above.

3.2.3 Setting Posts

Remove loose and foreign materials from holes and moisten the soil prior to placing concrete. Provide tops of footings that are trowel finished and sloped or domed to shed water away from posts. Set hold-open devices, sleeves, and other accessories in concrete.

Keep exposed concrete moist for at least 7 calendar days after placement or cured with a membrane curing material, as approved. Grout all posts set into sleeved holes in concrete with an approved grouting material. Maintain vertical alignment of posts in concrete construction until concrete has set.

3.2.3.1 Earth and Bedrock

Provide concrete bases of dimensions indicated on the manufactures installation drawings. Compact concrete to eliminate voids, and finish to a dome shape.

3.2.3.2 Bracing

Brace gate, corner, end, and pull posts to nearest post with a horizontal brace used as a compression member, placed at least 12 inches below top of fence, and a diagonal tension rod.

3.2.3.3 Tolerances

Provide posts that are straight and plumb within a vertical tolerance of 1/4 inch after the fabric has been stretched. Provide fencing and gates that are true to line with no more than 1/2 inch deviation from the established centerline between line posts. Repair defects as directed.

3.2.4 Concrete Strength

Provide concrete that has attained at least 75 percent of its minimum 28-day compressive strength, but in no case sooner than 7 calendar days after placement, before rails, tension wire, or fabric are installed. Do not stretch fabric and wires or hang gates until the concrete has attained its full design strength.

3.2.5 Brace Assembly

Provide bracing assemblies at end and gate posts and at both sides of corner and pull posts, with the horizontal brace located at midheight of the fabric.

Install brace assemblies so posts are plumb when the diagonal rod is under proper tension. Provide two complete brace assemblies at corner and pull posts where required for stiffness and as indicated.

3.2.6 Tension Wire Installation

Install tension wire by weaving them through the fabric and tying them to each post with not less than 7-gauge galvanized wire or by securing the wire to the fabric with 10-gauge ties or clips spaced 24 inches on center.

3.2.7 Fabric Installation

Provide fabric in single lengths between stretch bars with bottom barbs placed approximately 1-1/2 inches above the ground line. Pull fabric taut and tied to posts, rails, and tension wire with wire ties and bands.

Install fabric on the security side of fence, unless otherwise directed. Ensure fabric remains under tension after the pulling force is released.

3.2.8 Stretcher Bar Installation

Thread stretcher bars through or clamped to fabric 4 inches on center and secured to posts with metal bands spaced 15 inches on center.

3.2.9 Gate Installation

Install gates plumb, level, and secure, with full opening without interference. Install ground set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricated where necessary.

3.2.10 Tie Wires

Provide tie wires that are U-shaped to the pipe diameters to which attached. Twist ends of tie wires not less than two full turns and bent so as not to present a hazard.

3.2.11 Fasteners

Install nuts for tension bands and hardware on the side of the fence opposite the fabric side. Peen ends of bolts to prevent removal of nuts.

3.2.12 Zinc-Coating Repair

Clean and repair galvanized surfaces damaged by welding or abrasion, and cut ends of fabric, or other cut sections with specified galvanizing repair material applied in strict conformance with the manufacturer's printed instructions.

3.2.13 Accessories Installation

3.2.13.1 Post Caps

Install post caps as recommended by the manufacturer.

3.2.14 Grounding

Ground fencing as specified.

Ground all fences crossed by overhead power lines in excess of 600 volts, and all electrical equipment attached to the fence. Ground fences on each side of all gates, at each corner, at the closest approach to each building located within 50 feet of the fence, and where the fence alignment changes more than 15 degrees. Grounding locations can not exceed 650 feet. Bond each gate panel with a flexible bond strap to its gate post. Ground fences crossed by power lines of 600 volts or more at or near the point of crossing and at distances not exceeding 150 feet on each side of crossing. Provide ground conductor consisting of No. 6 AWG solid copper wire. Provide solid copper rod grounding electrodes 3/4 inch by 10 foot long. Drive electrodes into the earth so that the top of the electrode is at least 6 inches below the grade. Where driving is impracticable, bury electrodes a minimum of 12 inches deep and radially from the fence, with top of the electrode not less than 2 feet or more than 8 feet from the fence. Clamp ground conductor to the fence and electrodes with bronze grounding clamps to create electrical continuity between fence posts, fence fabric, and ground rods. Total resistance of the fence to ground cannot exceed 25 ohms.

3.3 CLOSEOUT ACTIVITIES

Remove waste fencing materials and other debris from the work site.

-- End of Section --

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SECTION 32 92 19

SEEDING

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.

ASTM INTERNATIONAL (ASTM)

ASTM D4972 (2018) Standard Test Methods for pH of Soils

U.S. DEPARTMENT OF AGRICULTURE (USDA)

AMS Seed Act (1940; R 1988; R 1998) Federal Seed Act

DOA SSIR 42 (1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

95 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section **31 00 00** EARTHWORK applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section **01 33 00** SUBMITTAL PROCEDURES:

SD-03 Product Data

Wood Cellulose Fiber Mulch

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil Composition Tests (reports and recommendations).

SD-07 Certificates

State Certification and Approval for Seed

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Seed Protection

Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.2 Fertilizer Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer may be furnished in bulk with certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Seed, and Fertilizer Storage

Store in cool, dry locations away from contaminants.

1.5.2.2 Topsoil

Prior to stockpiling topsoil, treat growing vegetation with application of appropriate specified non-selective herbicide. Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.2.3 Handling

Do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions

Do not plant when the ground is muddy, or when air temperature exceeds 90 degrees Fahrenheit.

1.7 TIME LIMITATIONS

1.7.1 Seed

Apply seed within twenty four hours after seed bed preparation.

PART 2 PRODUCTS

2.1 SEED

2.1.1 Classification

Provide State-certified seed of the latest season's crop delivered in original sealed packages, bearing producer's guaranteed analysis for percentages of mixtures, purity, germination, weedseed content, and inert

material. Label in conformance with **AMS Seed Act** and applicable state seed laws. Wet, moldy, or otherwise damaged seed will be rejected. Field mixes will be acceptable when field mix is performed on site in the presence of the Contracting Officer.

2.1.2 Planting Dates

<u>Planting Season</u>	<u>Planting Dates</u>
Season 1	March 1 - August 31
Season 2	September 1 - November 15
Temporary Seeding	March 15- June 15

Coordinate seeding requirements with erosion and sediment control drawings.

2.1.3 Seed Purity

Refer to erosion and sediment control drawings for temporary and permanent seeding requirements.

2.1.4 Seed Mixture by Weight

Proportion seed mixtures by weight. Temporary seeding must later be replaced by Season 1 and Season 2 plantings for a permanent stand of grass. The same requirements of turf establishment for Season 1 and Season 2 apply for temporary seeding.

2.2 TOPSOIL

2.2.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph COMPOSITION. When available topsoil must be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK.

2.2.2 Off-Site Topsoil

Conform to requirements specified in paragraph COMPOSITION. Additional topsoil must be furnished by the Contractor.

2.2.3 Composition

Containing from 5 to 10 percent organic matter as determined by the **topsoil composition tests** of the Organic Carbon, 6A, Chemical Analysis Method described in **DOA SSIR 42**. Maximum particle size, **3/4 inch**, with maximum 3 percent retained on **1/4 inch** screen. The pH must be tested in accordance with **ASTM D4972**. Topsoil must be free of sticks, stones, roots, and other debris and objectionable materials. Other components must conform to the following limits:

Silt	25-50 percent

Clay	10-30 percent
Sand	20-35 percent
pH	5.5 to 7.0
Soluble Salts	600 ppm maximum

2.3 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.3.1 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, and soil stabilized with nitrogen and having the following properties:

2.3.1.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

2.3.1.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.4 FERTILIZER

2.4.1 Granular Fertilizer

Organic or synthetic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

10 percent available nitrogen
10 percent available phosphorus
10 percent available potassium

2.5 MULCH

Mulch must be free from noxious weeds, mold, and other deleterious materials.

2.5.1 Straw

Stalks from oats, wheat, rye, barley, or rice. Furnish in air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Straw must contain no fertile seed.

2.5.2 Hay

Air-dry condition and of proper consistency for placing with commercial

mulch blowing equipment. Hay must be sterile, containing no fertile seed.

2.5.3 Wood Cellulose Fiber Mulch

Use recovered materials of either paper-based (100 percent post-consumer content) or wood-based (100 percent total recovered content) hydraulic mulch. Processed to contain no growth or germination-inhibiting factors and dyed an appropriate color to facilitate visual metering of materials application. Composition on air-dry weight basis: 9 to 15 percent moisture, pH range from 5.5 to 8.2. Use with hydraulic application of grass seed and fertilizer.

2.6 WATER

Source of water must be approved by Contracting Officer and of suitable quality for irrigation, containing no elements toxic to plant life.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 EXTENT OF WORK

Provide soil preparation prior to planting (including soil conditioners as required), fertilizing, seeding, and surface topdressing of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.1.1 Topsoil

Provide 4 inches of off-site topsoil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer, pH adjusters or soil conditioners into soil a minimum depth of 4 inches by disking, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 3/4 inch in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas from damage by vehicular or pedestrian traffic.

3.1.1.2 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

3.1.1.3 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.

3.2 SEEDING

3.2.1 Seed Application Seasons and Conditions

Immediately before seeding, restore soil to proper grade. Do not seed when ground is muddy or in an unsatisfactory condition for seeding. If special conditions exist that may warrant a variance in the above seeding dates or conditions, submit a written request to the Contracting Officer stating the special conditions and proposed variance. Apply seed within twenty

four hours after seedbed preparation. Sow seed by approved sowing equipment. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing.

3.2.2 Seed Application Method

Seeding method must be broadcasted and drop seeding.

3.2.2.1 Broadcast and Drop Seeding

Seed must be uniformly broadcast at the rate of **pounds per 1000 square feet**. Use broadcast or drop seeders. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing. Cover seed uniformly to a maximum depth of **1/4 inch** in clay soils and **1/2 inch** in sandy soils by means of spike-tooth harrow, cultipacker, raking or other approved devices.

3.2.3 Mulching

3.2.3.1 Hay or Straw Mulch

Hay or straw mulch must be spread uniformly at the rate of **2 tons per acre**. Mulch must be spread by hand, blower-type mulch spreader, or other approved method. Mulching must be started on the windward side of relatively flat areas or on the upper part of steep slopes, and continued uniformly until the area is covered. The mulch must not be bunched or clumped. Sunlight must not be completely excluded from penetrating to the ground surface. All areas installed with seed must be mulched on the same day as the seeding. Mulch must be anchored immediately following spreading.

3.2.3.2 Mechanical Anchor

Mechanical anchor must be a V-type-wheel land packer; a scalloped-disk land packer designed to force mulch into the soil surface; or other suitable equipment.

3.2.3.3 Asphalt Adhesive Coated Mulch

Hay or straw mulch may be spread simultaneously with asphalt adhesive applied at a rate between **10 to 13 gallons per 1000 square feet**, using power mulch equipment which must be equipped with suitable asphalt pump and nozzle. The adhesive-coated mulch must be applied evenly over the surface. Sunlight must not be completely excluded from penetrating to the ground surface.

3.2.4 Rolling

Immediately after seeding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding **90 pounds** for each foot of roller width. If seeding is performed with cultipacker-type seeder or by hydroseeding, rolling may be eliminated.

3.2.5 Erosion Control Material

Install in accordance with manufacturer's instructions, where indicated or as directed by the Contracting Officer.

3.2.6 Watering

Start watering areas seeded as required by temperature and wind conditions. Apply water at a rate sufficient to insure thorough wetting of soil to a depth of 2 inches without run off. During the germination process, seed is to be kept actively growing and not allowed to dry out.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations at the Contractor's expense. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean other paving when work in adjacent areas is complete.

-- End of Section --

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SECTION 33 30 00

SANITARY SEWERAGE

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.

ASTM INTERNATIONAL (ASTM)

ASTM C94/C94M	(2023) Standard Specification for Ready-Mixed Concrete
ASTM C270	(2019a; E 2019) Standard Specification for Mortar for Unit Masonry
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F949	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-6	(1998) Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Contractor's License; G

SD-02 Shop Drawings

Installation Drawings; G

SD-03 Product Data

Gravity Pipe

SD-06 Test Reports

Hydrostatic Sewer Test; G

Low-Pressure Air Tests; G

SD-07 Certificates

Pre-Installation Inspection Request; G

Post-Installation Inspection; G

1.3 QUALITY CONTROL

1.3.1 Installer Qualifications

Install specified materials by a licensed underground utility Contractor licensed for such work in the state where the work is to be performed. Verify installing [Contractor's License](#) is current and state certified or state registered.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Check upon arrival; identify and segregate as to types, functions, and sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.

1.4.1.1 Piping

Inspect materials delivered to site for damage; store with minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping and jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

1.4.2 Handling

Handle pipe, fittings, and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition. Take special care not to damage linings of pipe and fittings; if lining is damaged, make satisfactory repairs. Carry, do not drag, pipe to trench. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install the plastic pipe in accordance with the manufacturer's recommendation and discard those materials if the storage period exceeds the recommended shelf life. Discard solvents in

use when the recommended pot life is exceeded.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Sanitary Sewer Gravity Pipeline

Provide 6 inch lines of polyvinyl chloride (PVC) plastic pipe. Provide new and modify existing exterior sanitary gravity sewer piping and appurtenances. Provide each system complete and ready for operation. The exterior sanitary gravity sewer system includes equipment, materials, installation, and workmanship as specified herein more than 5 feet outside of building walls.

2.2 MATERIALS

Provide materials conforming to the respective specifications and other requirements specified below. Submit manufacturer's product specification, standard drawings or catalog cuts.

2.2.1 Gravity Pipe

2.2.1.1 PVC Gravity Sewer Piping

2.2.1.1.1 PVC Gravity Pipe and Fittings

ASTM D3034, SDR 35, or ASTM F949 with ends suitable for elastomeric gasket joints.

2.2.1.1.2 PVC Gravity Joints and Jointing Material

Provide joints conforming to ASTM D3212. Gaskets are to conform to ASTM F477.

2.2.2 Cement Mortar

Provide cement mortar conforming to ASTM C270, Type M with Type II cement.

2.2.3 Portland Cement Concrete

Provide portland cement concrete conforming to ASTM C94/C94M, compressive strength of 4000 psi at 28 days, except for concrete cradle and encasement or concrete blocks for manholes. Concrete used for cradle and encasement is to have a compressive strength of 2500 psi minimum at 28 days. Protect concrete in place from freezing and moisture loss for 7 days.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Installation Drawings

Submit Installation Drawings showing complete detail, both plan and side view details with proper layout and elevations.

3.2 INSTALLATION

Backfill after inspection by the Contracting Officer. Before, during, and

after installation, protect plastic pipe and fittings from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer.

3.2.1 Connections to Existing Lines

Obtain approval from the Contracting Officer before making connection to existing line. Conduct work so that there is minimum interruption of service on existing line.

3.2.2 General Requirements for Installation of Pipelines

These general requirements apply except where specific exception is made in the following paragraphs entitled "Special Requirements."

3.2.2.1 Location

Terminate the work covered by this section at a point approximately 5 feet from the building, unless otherwise indicated. Install pressure sewer lines beneath water lines only, with the top of the sewer line being at least 2 feet below bottom of water line. When these separation distances can not be met, contact the Contracting Officer for direction.

3.2.2.1.1 Sanitary Piping Installation Parallel with Water Line

3.2.2.1.1.1 Normal Conditions

Install sanitary piping or manholes at least 10 feet horizontally from a water line whenever possible. Measure the distance from edge-to-edge.

3.2.2.1.1.2 Unusual Conditions

When local conditions prevent a horizontal separation of 10 feet, the sanitary piping or manhole may be laid closer to a water line provided that:

- a. The top (crown) of the sanitary piping is to be at least 18 inches below the bottom (invert) of the water main.
- b. Where this vertical separation cannot be obtained, construct the sanitary piping with AWWA-approved ductile iron water pipe pressure and conduct a hydrostatic sewer test without leakage prior to backfilling.
- c. The sewer manhole is to be of watertight construction and tested in place.

3.2.2.1.2 Installation of Sanitary Piping Crossing a Water Line

3.2.2.1.2.1 Normal Conditions

Lay sanitary sewer piping by crossing under water lines to provide a separation of at least 18 inches between the top of the sanitary piping and the bottom of the water line whenever possible.

3.2.2.1.2.2 Unusual Conditions

When local conditions prevent a vertical separation described above, use the following construction:

- a. Construct sanitary piping passing over or under water lines with AWWA-approved ductile iron water pressure piping and conduct a hydrostatic sewer test without leakage prior to backfilling.
- b. Protect sanitary piping passing over water lines by providing:
 - (1) A vertical separation of at least 18 inches between the bottom of the sanitary piping and the top of the water line.
 - (2) Adequate structural support for the sanitary piping to prevent excessive deflection of the joints and the settling on and breaking of the water line.
 - (3) That the length, minimum 20 feet, of the sanitary piping be centered at the point of the crossing so that joints are equidistant and as far as possible from the water line.

3.2.2.2 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK.

3.2.2.3 Pipe Laying and Jointing

Inspect each pipe and fitting before and after installation; replace those found defective and remove from site. Provide proper facilities for lowering sections of pipe into trenches. Lay nonpressure pipe with the bell ends in the upgrade direction. Adjust spigots in bells to give a uniform space all around. Blocking or wedging between bells and spigots will not be permitted. Replace by one of the proper dimensions, pipe or fittings that do not allow sufficient space for installation of joint material. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Provide batterboards not more than 25 feet apart in trenches for checking and ensuring that pipe invert elevations are as indicated. Laser beam method may be used in lieu of batterboards for the same purpose. Construct branch connections by use of regular fittings or solvent cemented saddles as approved. Provide saddles for PVC pipe conforming to Table 4 of ASTM D3034.

3.2.3 Special Requirements

3.2.3.1 Installation of PVC Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of ASTM D2321 for laying and joining pipe and fittings. Make joints with the gaskets specified for joints with this piping and assemble in accordance with the requirements of ASTM D2321 for assembly of joints. Make joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.2.4 Concrete Work

Cast-in-place concrete is included in Section 03 30 00 CAST-IN-PLACE CONCRETE. Support the pipe on a concrete cradle, or encased in concrete

where indicated or directed.

3.2.5 Miscellaneous Construction and Installation

3.2.5.1 Metal Work

3.2.5.1.1 Workmanship and Finish

Perform metal work so that workmanship and finish will be equal to the best practice in modern structural shops and foundries. Form iron to shape and size with sharp lines and angles. Do shearing and punching so that clean true lines and surfaces are produced. Make castings sound and free from warp, cold shuts, and blow holes that may impair their strength or appearance. Give exposed surfaces a smooth finish with sharp well-defined lines and arises. Provide necessary rabbets, lugs, and brackets wherever necessary for fitting and support.

3.2.5.1.2 Field Painting

After installation, clean cast-iron frames, covers, gratings, and steps not buried in concrete to bare metal, remove mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint. Do not paint surfaces subject to abrasion.

3.2.6 Installations of Wye Branches

Install wye branches in an existing sewer using a method which does not damage the integrity of the existing sewer. Do not cut into piping for connections except when approved by the Contracting Officer. When the connecting pipe cannot be adequately supported on undisturbed earth or tamped backfill, support on a concrete cradle as directed by the Contracting Officer. Provide and install concrete required because of conditions resulting from faulty construction methods or negligence without any additional cost to the Government. Do not damage the existing sewer when installing wye branches in an existing sewer.

3.3 FIELD QUALITY CONTROL

The Contracting Officer will conduct field inspections and witness field tests specified in this section. Be able to produce evidence, when required, that each item of work has been constructed in accordance with the drawings and specifications.

3.3.1 Tests

Perform field tests and provide labor, equipment, and incidentals required for testing.

3.3.1.1 Hydrostatic Sewer Test

When unusual conflicts are encountered between sanitary sewer and waterlines a hydrostatic pressure sewer test will be performed in accordance with the applicable AWWA standard for the piping material or AWWA C600 with a minimum test pressure of 30 psi.

3.3.1.2 Leakage Tests for Nonpressure Lines

Test lines for leakage by either by low-pressure air tests. When necessary to prevent pipeline movement during testing, place additional

backfill around pipe sufficient to prevent movement, but leaving joints uncovered to permit inspection. When leakage or pressure drop exceeds the allowable amount specified, make satisfactory correction and retest pipeline section in the same manner. Correct visible leaks regardless of leakage test results.

3.3.1.2.1 Low-Pressure Air Tests

3.3.1.2.1.1 PVC Pipelines

Test PVC pipe in accordance with UBPPA UNI-B-6. The allowable pressure drop is located in UBPPA UNI-B-6. Make calculations in accordance with the Appendix to UBPPA UNI-B-6.

3.3.2 Inspection

Check each straight run of pipeline for gross deficiencies by holding a light in a manhole; the light must show a practically full circle of light through the pipeline when viewed from the adjoining end of line.

3.3.2.1 Pre-Installation Inspection

Prior to connecting the new service, perform pre-installation inspection after trenching and layout is complete. Submit pre-installation inspection request for field support at least 14 days in advance. The Installation's Utilities Field Support personnel will perform the pre-installation inspection.

3.3.2.2 Post-Installation Inspection

Perform a post-installation inspection after connection has been made and before the connection is buried. Submit post-installation inspection request for field support at least 14 days in advance. The Installation's Utilities Field Support personnel will perform the post-connection inspection.

-- End of Section --

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SECTION 33 40 00

STORMWATER UTILITIES

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 ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO HB-17 (2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M (2003; R 2021) Standard Specification for Gray Iron Castings

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A536 (1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings

ASTM A798/A798M (2017) Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications

ASTM A807/A807M (2019) Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications

ASTM B26/B26M (2018; E 2018) Standard Specification for Aluminum-Alloy Sand Castings

ASTM C231/C231M (2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

ASTM C270 (2019a; E 2019) Standard Specification for Mortar for Unit Masonry

ASTM D1751 (2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

ASTM D1752 (2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled

PVC Expansion Joint Fillers for Concrete
Paving and Structural Construction

ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F679	(2016) Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F794	(2021) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

SD-07 Certificates

Frame and Cover or Gratings; G

SD-08 Manufacturer's Instructions

Placing Pipe; G

SD-11 Closeout Submittals

Post-Installation Inspection Report; G

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Inspect materials delivered to site for damage and unload and store materials with minimal handling. Do not store materials directly on the ground. Keep the inside of pipes and fittings free of dirt and debris. Before, during, and after installation, protect plastic pipe and fittings from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe in accordance with the manufacturer's recommendations and discard if the storage period exceeds the recommended shelf life. Discard solvents in use when the recommended pot life is exceeded.

1.3.2 Handling

Handle materials in a manner that ensures delivery to the trench in sound, undamaged condition. Carry pipe to the trench.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe sizes for culverts and storm drains are indicated on the drawings.

2.1.1 Poly Vinyl Chloride (PVC) Pipe

2.1.1.1 Type PSM PVC Pipe

ASTM D3034, maximum SDR 35.

2.1.1.2 Profile PVC Pipe

ASTM F794, Series 46.

2.1.1.3 Smooth Wall PVC Pipe

ASTM F679.

2.2 PIPE JOINTS

2.2.1 PVC Plastic Pipe

Provide solvent cement or elastomeric gasket type joints in accordance with the specification for the pipe and as recommended by the pipe manufacturer. Use solvent cement conforming to ASTM D2564. Provide gaskets for elastomeric joints conforming to ASTM F477.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Concrete

Unless otherwise specified, provide concrete and reinforced concrete conforming to the requirements for 4,000 psi concrete under Section 03 30 00 CAST-IN-PLACE CONCRETE. Provide air content by volume of

concrete mixture, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 1-1/2 inches. Determine air content in accordance with ASTM C231/C231M. Provide a minimum concrete covering over steel reinforcing of not less than 1 inch thick for covers and not less than 1-1/2 inches thick for walls and flooring. For concrete deposited directly against the ground, provide a covering thickness of at least 3 inches between steel and ground. Provide expansion-joint filler material conforming to ASTM D1751, or ASTM D1752, or provide be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

2.3.2 Mortar

Mortar is not allowed for pipe joints. Provide mortar for pipe connections to drainage structures conforming to ASTM C270, Type M, except that the maximum placement time will be 1 hour. Provide a sufficient quantity of water in the mixture to produce a stiff workable mortar but in no case may the quantity exceed 5 gallons of water per sack of cement. Use water that is clean and free of harmful acids, alkalis, and organic impurities. Use the mortar within 30 minutes after the ingredients are mixed with water.

2.3.3 Precast Reinforced Concrete Manholes

Provide precast reinforced concrete manholes conforming to ASTM C478/C478. Provide joints between precast concrete risers and tops that are full-bedded in cement mortar and smoothed to a uniform surface on both interior and exterior of the structure.

2.3.4 Frame and Cover or Gratings

Submit certification on the ability of frame and cover or gratings to carry the imposed live load indicated on the drawings. Provide frame and cover or gratings made of cast gray iron, ASTM A48/A48M, Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26/B26M, Alloy 356.0-T6. Stamp or cast the word "Storm Sewer" into covers so that it is plainly visible.

2.3.5 Steel Ladder

Provide a steel ladder where the depth of the storm drainage structure exceeds 12 feet. Provide ladders not less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. Provide two stringers that are a minimum 3/8 inch thick and 2-1/2 inches wide. Galvanize ladders and inserts after fabrication in conformance with ASTM A123/A123M.

PART 3 EXECUTION

3.1 EXCAVATION FOR STORM DRAINS AND DRAINAGE STRUCTURES

Excavate trenches, excavate for appurtenances and backfill for culverts and storm drains, in accordance with the applicable portions of Section 31 00 00 EARTHWORK and the requirements specified below.

3.1.1 Trenching

Excavate trenches to the width indicated on the drawings or as specified herein. Trench width should permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Place sheeting

and bracing, where required, within the trench width as specified, without any overexcavation.

3.1.2 Removal of Rock

Replace rock in either ledge or boulder formation with suitable materials to provide a compacted earth cushion. Provide a compacted earth cushion between unremoved rock and the pipe with a thickness of at least 8 inches or 1/2 inch for each foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Maintain the cushion under the bell as well as under the straight portion of the pipe where bell-and-spigot pipe is used. Excavate rock as specified and defined in Section 31 00 00 EARTHWORK.

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, remove such material to the depth required and replace with select granular material to the proper grade. Compact select granular material as specified in paragraph FINAL BACKFILL. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, perform such removal and replacement at no additional cost to the Government.

3.2 BEDDING AND INITIAL BACKFILL

Provide a firm bedding foundation of uniform density throughout the entire length of the pipe.

3.2.1 Concrete Pipe

Use select granular material conforming to Section 31 00 00 EARTHWORK for haunch and bedding material. Compact haunch and outer bedding to at least 90 percent laboratory maximum density and place in layers not exceeding 6 inch loose thickness for compaction by hand-operated compactors and 200 mm 8 inches for other than hand-operated machines. Loosely place middle bedding and do not compact. After the pipe has been properly bedded, place haunch material, at a moisture content that will facilitate compaction, evenly along both sides of the pipe and thoroughly compact each layer with mechanical tampers or rammers to the springline of the pipe. Thoroughly compact the haunch material under the haunches of the pipe. For bell and spigot pipe, form a depression in bedding material for bells so entire barrel of pipe is uniformly supported. Minimize the length, depth, and width of bell depressions to that required for properly making the particular type of joint.

3.2.1.1 Trenches

After the pipe has been properly bedded and haunch material placed to the midpoint (springline) of the pipe, backfill and compact the remainder of the trench by spreading and rolling or compacting by mechanical rammers or tampers in layers not exceeding 6 inches. Test for density as necessary to ensure conformance to the compaction requirements specified below. Leave untreated sheeting in place beneath structures or pavements.

3.2.1.2 Fill Sections

For pipe placed in fill sections, uniformly spread fill material longitudinally on both sides of the pipe in layers not exceeding 6 inches in compacted depth, and compact 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 12 inches above the top of the pipe must extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 12 feet, whichever is less. After the backfill has reached at least 12 inches above the top of the pipe, place and thoroughly compact the remainder of the fill in layers not exceeding 8 inches.

3.2.2 Corrugated Steel and Aluminum Pipe

Provide bedding and structural backfill for corrugated steel and aluminum pipe and pipe arch in accordance with ASTM A798/A798M. It is not required to shape the bedding to the pipe geometry. However, for pipe arches, either shape the bedding to the relatively flat bottom arc or fine grade the foundation to a shallow v-shape. Structural backfill material consists of materials classified by ASTM D2487 as either GW, GM, GP-GM, GW-GM, GC, GP-GC or SW. Provide bedding for corrugated structural plate pipe meeting the requirements of ASTM A807/A807M.

3.2.3 Ductile Iron Pipe

Provide bedding for ductile iron pipe as shown on the drawings.

3.2.4 Plastic Pipe

Provide bedding for PVC pipe meeting the requirements of ASTM D2321. Use Class IB or II material for PVC, PE, SRPE pipe bedding, haunching, and initial backfill. Use Class I, II, or III material for PP pipe bedding, haunching and initial backfill.

3.3 PLACING PIPE

Submit printed copies of the pipe manufacturer's recommended pipe installation procedures prior to installation. Thoroughly examine each section of pipe before being laid; do not use defective or damaged pipe. Protect plastic pipe, from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Lay pipelines to the grades and alignment indicated. Provide proper facilities for lowering sections of pipe into trenches. Do not lay pipe in water or when trench conditions or weather are unsuitable for such work. Divert drainage or dewater trenches during construction as necessary. Deflection of installed flexible pipe must not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (percent)
Plastic (PVC, HDPE, SRPE, and PP)	5

3.3.1 PVC Pipe

Lay pipe proceeding upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.4 DRAINAGE STRUCTURES

3.4.1 Manholes

Construct manholes of precast reinforced concrete. Construct inlets of precast reinforced concrete. Provide manholes and inlets complete with frames and covers or gratings; and with fixed galvanized steel ladders as indicated. The wall along the line where steel ladders are installed must be vertical for its entire length. Adequately anchor ladders to the wall by means of steel inserts spaced not more than 6 feet vertically, and install to provide at least 6 inches of space between the wall and the rungs.

3.5 INSTALLATION OF TRACER WIRE AND WARNING TAPE

Install warning tape above all storm drain pipe in accordance with Section 31 00 00 EARTHWORK.

3.6 FINAL BACKFILL

Backfill trenches with satisfactory material deposited in layers of a maximum of 8 inches loose thickness and compacted to 90 percent of maximum density for cohesive soils and 95 percent of maximum density for cohesionless soils in accordance with Section 31 00 00 EARTHWORK. Testing is the responsibility of the Contractor and will be performed at no additional cost to the Government. Unless otherwise specified, determine field in-place density of final backfill at a frequency of one test per 50 linear feet, or fraction thereof, of each lift of backfill. Submit test results in accordance with Section 31 00 00 EARTHWORK. Do not displace or damage pipe when compacting final backfill by rolling or operating heavy equipment parallel with the pipe. Movement of construction machinery over a culvert or storm drain at any stage of construction will be at the Contractor's risk. Repair or replace any damaged pipe. Protect concrete pipes with a minimum of 3 feet of cover prior to permitting heavy construction equipment to pass over them during construction. Provide the minimum cover for construction loads over corrugated steel pipes as specified in Section 26, Division II of AASHTO HB-17. Provide minimum cover for construction loads over plastic pipes as specified in ASTM D2321.

3.7 FIELD QUALITY CONTROL

3.7.1 Tests

Testing is the responsibility of the Contractor. Perform all testing and retesting at no additional cost to the Government.

3.7.1.1 Deflection Testing

Conduct deflection test no sooner than 30 days after completion of final backfill and compaction testing. Clean or flush all lines prior to testing. Perform a deflection test on entire length of installed flexible pipeline upon completion of work adjacent to and over the pipeline,

including backfilling, placement of fill, grading, paving, placement of concrete, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads must not exceed the limits in paragraph PLACING PIPE above as percent of the average inside diameter of pipe. Use a mandrel to determine if allowable deflection has been exceeded.

3.7.1.1.1 Mandrel

Pass the mandrel through each run of pipe by pulling it by hand. If deflection readings in excess of the allowable deflection of average inside diameter of pipe are obtained, stop and begin test from the opposite direction. The mandrel must meet the pipe manufacturer's recommendations and the following requirements. Provide a mandrel that is rigid, nonadjustable, has a minimum of 9 fins, pulling rings at each end, and is engraved with the nominal pipe size and mandrel outside diameter. The mandrel must be 5 percent less than the certified-actual pipe diameter for plastic pipe, 5 percent less than the certified-actual pipe diameter for corrugated steel and aluminum, 3 percent less than the certified-actual pipe diameter for ductile iron culvert pipe. The Government will verify the outside diameter (OD) of the Contractor provided mandrel through the use of Contractor provided proving rings.

3.7.2 Inspection

3.7.2.1 Post-Installation Inspection

Inspect each segment of pipe for alignment, settlement, joint separations, soil migration through the joint, cracks, buckling, bulging and deflection. An engineer must evaluate all defects to determine if any remediation or repair is required.

3.7.2.1.1 Flexible Pipe

Check each flexible pipe (PVC) for rips, tears, joint separations, soil migration through the joint, cracks, localized buckling, bulges, settlement and alignment.

3.7.2.1.2 Post-Installation Inspection Report

The deflection results and final post installation inspection report must include: pipe location identification, equipment used for inspection, inspector name, deviation from design, grade, deviation from line, deflection and deformation of flexible pipe, inspector notes, condition of joints, condition of pipe wall (e.g. distress, cracking, wall damage dents, bulges, creases, tears, holes, etc.).

3.7.3 Repair of Defects

3.7.3.1 Deflection Testing

When deflection readings are in excess of the allowable deflection of average inside diameter of pipe are obtained, remove pipe which has excessive deflection and replace with new pipe. Retest 30 days after completing backfill, leakage testing and compaction testing.

3.7.3.2 Inspection

Replace pipe or repair defects indicated in the Post-Installation

Inspection Report.

3.7.3.2.1 Flexible Pipe

Replace pipes having cracks or splits.

3.8 PROTECTION

Protect storm drainage piping and adjacent areas from superimposed and external loads during construction.

3.9 WARRANTY PERIOD

Pipe segments found to have defects during the warranty period must be replaced with new pipe and retested.

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