127th Wing

Michigan Air National Guard

Selfridge Air National Guard Base, Michigan

ADAL FUEL CELL & CORROSION CONTROL, BLDG 154

Project No. VGLZ162323

Type B3 Final HEF Mod Submittal

Specifications

Volume 3 of 4

December 16, 2022

Joint Venture with

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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 A13.1	(2020) Scheme for the Identification of Piping Systems
ASME B16.1	(2015) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2016) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.21	(2016) 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	(2018) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A135/A135M	(2009; R2014) 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/

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13	(2022) Standard for the Installation of Sprinkler Systems
NFPA 24	(2022) Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 1963	(2019) Standard for Fire Hose Connections

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

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders
UFC 3-600-01	(2016; with Change 6, 2021) Fire Protection Engineering for Facilities
UFC 4-211-01	(2017; with Change 2, 18 May 2020) Aircraft Maintenance Hangars
ANGETL 15-01-03	(2015; 1 May) Fire Protection Design Guidance

UNDERWRITERS LABORATORIES (UL)

UL 199	(2020) UL Standard for Safety Automatic Sprinklers for Fire-Protection Service
UL 312	(2010; Reprint Mar 2018) UL Standard for Safety Check Valves for Fire-Protection Service
UL 405	(2013; Bul. 2020) UL Standard for Safety Fire Department Connection Devices
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.2 SYSTEM DESCRIPTION

Provide wet pipe sprinkler system(s) in all areas of the building. Except as modified herein, the system must meet the requirements of NFPA 13, ANGETL 15-01-03, UFC 4-211-01 and UFC 3-600-01. 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

The hydraulic calculations shall be based on the fire loop supplied by the fire pumps provided as part of the Building 154 package. The pump is rated for 130 psi at 2500 gpm. Contractor shall base their calculations on the actual pump furnished. Hydraulic calculations must be based upon the Hazen-Williams formula with a "C" value noted in NFPA 13 for piping, and 140 for underground piping. Hydraulic calculations must be based on operation of the fire pump. The design area reduction in NFPA 13 for quick response sprinklers is not permitted. Hydraulic calculations shall include a minimum 10 psi safety factor on the system pressure.

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 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.

f. 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 fire protection drawings. Hydraulic calculations must be in accordance with the Area/Density Method of NFPA 13. An allowance for exterior hose streams is not required to be added to the sprinkler system demand since the hydrants are fed from a separate water supply.

1.2.2 Sprinkler Coverage

Sprinklers must be uniformly spaced on branch lines. Provide coverage throughout 100 percent of the building. This includes, but is not limited to, telephone rooms, electrical equipment rooms (regardless of the fire resistance rating of the enclosure), boiler rooms, switchgear rooms, transformer rooms, attached electrical vaults and other electrical and mechanical spaces. 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 contractor's 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 reviewed by the QFPE. The QFPE must affix their review stamp (not PE 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" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. 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

Valves, including gate, check, butterfly, and globe; G

Riser Check Valves; G

Relief Valves; G

Sprinklers ; G

Pipe Hangers and Supports ; G

Sprinkler Alarm Switch; G

Valve Supervisory (Tamper) Switch; G

Fire Department Connection; G

Air Vent; G

Nameplates; G

SD-05 Design Data

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

Submit 3 copies and one PDF version 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:

1. A descriptive index with drawings listed in sequence by number. A legend sheet identifying device symbols, nomenclature, and conventions used in the package.

2. 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.

3. 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.

4. 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.

5. Plan and elevation views which establish that the equipment will fit the allotted spaces with clearance for installation and maintenance.

6. 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.

7. Details of each type of riser assembly, pipe hanger, 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.

8. Details of each type of pipe hanger, and related components.

9. Include fire pump curve with shop drawings and hydraulic calculations.

1.4.1.2 Product Data

Submit 3 copies and one PDF version 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. Include fire pump curve with submittal.

1.4.1.4 Operating and Maintenance (O&M) Instructions

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA as supplemented and modified by this specification section.

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 Nameplates

Major components of equipment must have the manufacturer's name, address, type or style, model or serial number, catalog number, date of installation, installing Contractor's name and address, and the contract number provided on a new name plate permanently affixed to the item or equipment. Nameplates must be etched metal or plastic, permanently attached by screws to control units, panels or adjacent walls.

2.1.3 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.

2.1.4 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. Equipment in Fire Pump Building shall be rated for 250 psi.

2.2 UNDERGROUND PIPING COMPONENTS

2.2.1 Pipe

Enter the building below grade with a continuous section of welded stainless steel fire water service piping from a point 5 ft outside the building walls to a flanged fitting located at least 1 ft above the finished floor within the building. Non-welded fittings are not permitted within this section of piping, such as flanges, mechanical couplings, and push-on fittings. Weld and hydrostatically test the stainless steel pipe at the fabrication shop or manufacturer. Welding in the field is not permitted. Perform the hydrostatic test in accordance with NFPA 24. Cover bolts, nuts, rodding, and couplings located below grade with a bituminous coating and wrapped in a minimum 6 mil polyethylene plastic. Piping more than 5 feet outside the building walls shall be provided under Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

2.2.2 Buried Utility Warning and Identification Tape

Provide detectable aluminum foil plastic-backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 3 inches minimum width, color coded for the utility involved, with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be CAUTION BURIED WATER PIPING BELOW or similar. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material. Bury tape with the printed side up at a depth of 12 inches below the top surface of earth or the top surface of the subgrade under pavements.

2.3 ABOVEGROUND PIPING COMPONENTS

2.3.1 Steel Piping Components

2.3.1.1 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 Schedule 40 only.

2.3.1.2 Fittings

Shop-fabricated or field-fabricated fittings, and fittings that require making a hole in the pipe, are not permitted. 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. Saddle tees are not permitted. Reducing couplings are not permitted except as allowed by NFPA 13.

2.3.1.3 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.

2.3.1.4 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. Installation of cleated (e.g., Uni-Flange) flanges on any piping is prohibited.

2.3.2 Flexible Sprinkler Hose

The use of flexible hose is not permitted.

2.3.3 Pipe Hangers and Supports

Provide galvanized pipe hangers, and supports in accordance with NFPA 13. Provide clevis type hangers for piping 4 inches and greater.

2.3.4 Valves

Provide valves of types approved for fire service. Valves must open by counterclockwise rotation.

2.3.4.1 Control Valve

Manually operated sprinkler control/gate valve must be outside stem and yoke (OS&Y) type or butterfly type as indicated on the drawings and must be listed.

2.3.4.2 Check Valves

Check valves must comply with UL 312. Check valves 4 inches and larger must be of the swing type, have a clear waterway and meet the requirements of MSS SP-71, for Type 3 or 4. Inspection plate must be provided on valves larger than 6 inches.

2.3.5 Riser Check Valves

Provide riser check valve, standard trim piping, pressure gauges, testing valves, and main drain, and other components as required for a fully operational system.

2.4 ALARM INITIATING AND SUPERVISORY DEVICES

2.4.1 Sprinkler Alarm Switch

Switches shall be vane type flow switch(es). Connection of switch must be by the fire alarm installer. Vane type alarm actuating devices must have mechanical diaphragm controlled retard device adjustable from 10 to 60 seconds and must instantly recycle.Flow switches for elevator power shunt must not have a retard feature.

2.4.2 Valve Supervisory (Tamper) Switch

Switch must be integral to the control valve or suitable for mounting to the type of control valve to be supervised open. The switch must be tamper resistant and contain SPDT (Form C) contacts arranged to transfer upon removal of the housing cover or closure of the valve of more than two rotations of the valve stem.

2.5 FIRE DEPARTMENT CONNECTION

Fire department connection must be freestanding or flush type with cast-brass body, matching wall escutcheon lettered "Auto Spkr" with a chromium-plated finish. The connection must have individual self-closing clappers, caps with drip drains and chains. Female inlets must have 2 1/2-inch diameter American National Fire Hose Connection Screw Threads (NH) per NFPA 1963. Comply with UL 405.

2.6 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. Minimum sprinkler k-factors shall be in accordance with drawings. Concealed or recessed pendent sprinklers shall be provided in all areas with ceilings. All sprinklers shall be quick response type except where otherwise indicated on the drawings.

2.6.1 Pendent Sprinkler

Pendent sprinkler must be quick-response type. Pendent sprinklers must have a polished chrome finish. Assembly must include an integral escutcheon.

2.6.2 Upright Sprinkler

Upright sprinkler must be brass.

2.6.3 Sidewall Sprinkler

Sidewall sprinkler must be the quick-response type. Sidewall sprinkler must have a polished-chrome finish.

2.6.4 Concealed Sprinkler

Concealed sprinkler must be chrome-plated quick-response type. Coverplate must be white.

2.7 ACCESSORIES

2.7.1 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.

2.7.2 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.

2.7.3 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.

2.7.4 Sprinkler Guard

Listed guard must be a steel wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards shall be listed for use with the specific sprinkler (manufacturer and model) to be protected. Guards must be provided on sprinklers located in all mechanical, electrical, and storage rooms as well as any sprinklers within 7 feet of the floor.

2.7.5 Relief Valve

Relief valves must be listed and installed at the riser in accordance with NFPA 13.

2.7.6 Air Vent

Air vents must be UL Listed and of the automatic type with redundant float design that eliminates piping to a drain. Provide automatic air vents at high points in the system to vent at least 95 percent of the volumetric capacity of the system. Design the sprinkler system to reduce the quantity of automatic air vents such as connecting branchlines or providing a cross-main at the peak. Provide a minimum clear height of 8 inches for air vent. Install the vent at an accessible high point on the fire sprinkler system remote from the system riser where gas can be vented and at a location that the pressure gauge provided for visual monitoring can be viewed from directly below.

2.7.7 Identification Sign

Valve identification sign must be minimum 6 inches wide by 2 inches high with enamel baked finish on minimum 18 gage steel or 0.024-inch aluminum with red letters on a white background or white letters on red background. Wording of sign must include, but not be limited to "main drain", "auxiliary drain", "inspector's test", "alarm test", "alarm line", and similar wording as required to identify operational components. Where there is more than one sprinkler system, signage must include specific details as to the respective system.

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, NFPA 24 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.

d. Provide a minimum clearance of 3 feet access to and in front of all equipment and 6-in. behind the equipment (e.g., control valves, check valves, floor control valve assemblies, waterflow switches, etc.).

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 UNDERGROUND PIPING INSTALLATION

Underground piping shall comply with NFPA 24.

3.4 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.

3.4.1 Protection of Piping Against Earthquake Damage

Seismic restraint is not required.

3.4.2 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.

3.4.3 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.

3.4.4 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 (+/- 2 inches).

e. 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.

3.4.5 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.

3.4.6 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. 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.

3.4.7 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.

3.4.8 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 in accordance with Section 07 84 00 FIRESTOPPING.

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.

3.4.9 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.

3.4.10 Inspector's Test Connection

Unless otherwise indicated, the test connection must consist of 1-inch pipe connected at the riser as a combination test and drain valve; a test valve located approximately 7 feet above the floor; a smooth bore brass outlet equivalent to the smallest orifice sprinkler used in the system; and a painted metal identification sign affixed to the valve with the words "Inspector's Test". All test connection piping must be inside of the building and penetrate the exterior wall at the location of the discharge orifice only. The discharge orifice must be located outside the building wall no more than 2 feet above finished grade, directed so as not to cause damage to adjacent construction or landscaping during full flow discharge, or to the sanitary sewer. Discharge to the exterior must not interfere with exiting from the facility. Water discharge or runoff must not cross the path of egress from the building. Do not discharge to the roof. Discharge to floor drains, janitor sinks or similar fixtures is not permitted.

Provide concrete splash blocks at all drain and inspector's test connection discharge locations if not discharging to a concrete surface. Splash blocks must be large enough to mitigate erosion and not become dislodged during a full flow of the drain. Ensure all discharged water drains away from the facility and does not cause property damage. Test connections are not permitted in the hangar bays.

3.4.11 Drains

a. Route clear water drains to building exterior and discharge no higher than 2 feet above grade. Provide independent atmospheric and pressurized drainage systems, or provide a means of hydraulic isolation (e.g., check valve between cup drain and main drain). Provide a concrete splash block at drain outlet. Discharge to the exterior must not interfere with exiting from the facility. Water discharge or runoff must not cross the path of egress from the building.

b. Auxiliary drains must be provided as required by NFPA 13. Auxiliary drains are permitted to discharge to a floor drain if the drain is sized to accommodate full flow (min 40 gpm). Discharge to service sinks or similar plumbing fixtures is not permitted.

3.4.12 Installation of Fire Department Connection

Connection must be mounted on the exterior wall approximately 3 feet above finished grade. The piping between the connection and the check valve must be provided with an automatic drip in accordance with NFPA 13 and piped to drain to the outside or a floor drain within the same room.

3.4.13 Identification Signs

Signs must be affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate or as required by NFPA 13. Main drain test results must be etched into main drain identification sign. Hydraulic design data must be etched into the nameplates and permanently affixed to each sprinkler riser as specified in NFPA 13. Provide labeling on the surfaces of all feed and cross mains to show the pipe function (e.g., "Sprinkler System", "Fire Department Connection") and normal valve position (e.g. "Normally Open", "Normally Closed"). For pipe sizes 4-inch and larger provide white painted stenciled letters and arrows, a minimum of 2 inches in height and visible from at least two sides when viewed from the floor. For pipe sizes less than 4-inch, provide white painted stenciled letters and arrows, a minimum of 0.75-inch in height and visible from the floor.

3.5 ELECTRICAL

Except as modified herein, electric equipment and wiring must be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Alarm signal wiring connected to the building fire alarm control system must be by the fire alarm installer.

3.6 PAINTING

Color code mark piping as specified in Section 09 90 00 PAINTS AND COATINGS and section 3.4.13. After all field painting is complete, provide labeling on the surfaces of the piping to show the water flow direction and pipe function (e.g. "To Fire Dept. Connection", "To Test Header"). Provide white painted stenciled letters and arrows, a minimum 2 inches in height and visible from at least three sides when viewed from the floor. Labeling must be in accordance with MIL-STD-101. Mark all exposed interior piping with plastic wrap around-type pipe labels conforming to ASME A13.1. Indicate the type of fluid carried and direction of flow. Labels that stick-on (adhesive backed) or are held on with straps/adhesive tape are not permitted. Labels are not required on any fire suppression system branchlines regardless of size, or mains and cross-mains less than a nominal 2-1/2 inches. Labels are not required on piping routed below the floor line in trenches or pits.

3.7 FIELD QUALITY CONTROL

3.7.1 Test Procedures

Submit detailed test procedures, prepared and signed by the NICET Level 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.

3.7.2 Pre-Government Testing

3.7.2.1 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 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 for each riser, manifold, and fire department connection.

b. NFPA 13 Underground Material and Test Certificate

3.7.2.2 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) and 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. Government final testing will not be performed until after the connections to the building fire alarm 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.

3.7.3 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.

3.7.4 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. Marked-up red line drawings of the system as actually installed.

Government Final Tests will be witnessed by the Designated Fire Protection Engineer and Contracting Officer. At this time, all required tests noted in the paragraph "Minimum System Tests" must be repeated at their discretion.

3.8 MINIMUM SYSTEM TESTS

The system, including the underground water mains, and the aboveground piping 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 and NFPA 24.

3.8.1 Underground Piping

3.8.1.1 Flushing

Underground piping must be flushed at a minimum of 10 fps in accordance with NFPA 24.

3.8.1.2 Hydrostatic Test

New underground piping must be hydrostatically tested in accordance with NFPA 24.

3.8.2 Aboveground Piping

3.8.2.1 Hydrostatic Test

Aboveground piping must be hydrostatically tested in accordance with NFPA 13. There must be no drop in gauge pressure or visible leakage when the system is subjected to the hydrostatic test. The test pressure must be read from a gauge located at the low elevation point of the system or portion being tested.

3.8.3 Main Drain Flow Test

Following flushing of the underground piping, a main drain test must be made to verify the adequacy of the water supply. Static and residual pressures must be recorded on the certificate specified in paragraph SUBMITTALS.

3.9 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.

3.10 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.

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SECTION 21 30 00

FIRE PUMPS

PART 1 GENERAL

1.1 SUMMARY

Except as modified in this Section or on the drawings, install fire pumps in conformance with UFC 3-600-01, NFPA 20, NFPA 70, and NFPA 72. In the event of a conflict between specific provisions of this specification and applicable NFPA standards, this specification governs. Devices and equipment for fire protection service must be UL Fire Prot Dir listed or FM APP GUIDE approved. Interpret all reference to the authority having jurisdiction to mean the Contracting Officer.

1.2 SEQUENCING

The fire pumps and pressure maintenance pump shall automatically operate in accordance with the guidance stated in NFPA 20. Actual setpoints shall be based on the fire pumps to be furnished under this specification. Start the fire pump automatically upon a drop in system pressure in accordance with NFPA 20. When starting the fire pump, do not exceed ten seconds before the pump is operating at the design pressure. The secondary pump is only intended to run if the primary pump fails. Only one fire pump should be running at a time.

1.2.1 Primary Fire Pump

Primary fire pump shall automatically operate when the pressure drops 10 psi or manually when the starter is operated. Pump shall automatically shut down after reaching the stop pressure and the expiration of a minimum 15-minute run timer unless manually shutdown.

1.2.2 Pressure Maintenance Pump

Pressure maintenance pump shall operate/start when the system pressure drops 10 psi below the jockey pump stop point. Pump shall automatically stop when the system pressure reaches (pump churn + the static pressure) 168 psi and after the pump has operated for the minimum pump run time specified herein. The contractor shall verify start and stop pressures based on actual pump rating.

1.3 FIRE PUMP INSTALLATION RELATED SUBMITTALS

The Fire Protection Specialist shall prepare a list of the submittals, from the Contract Submittal Register, that relate to the successful installation of the fire pump(s), no later than 7 days after the approval of the Fire Protection Specialist and the Manufacturer's Representative. The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the Fire Protection Specialist when submitted to the Government.

1.4 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 WATER WORKS ASSOCIATION (AWWA)

AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2020) Scheme for the Identification of Piping Systems
ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard

ASTM INTERNATIONAL (ASTM)

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	(2020) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A449	(2014) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2018) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A795/A795M	(2013) Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized)

	Welded and Seamless Steel Pipe for Fire Protection Use
ASTM B88	(2016) Standard Specification for Seamless Copper Water Tube
ASTM D3308	(2012; R 2017) Standard Specification for P TFE Resin Skived Tape
ASTM F436	(2011) Hardened Steel Washers

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13	(2022) Standard for the Installation of Sprinkler Systems
NFPA 1963	(2019) Standard for Fire Hose Connections
NFPA 20	(2020) Standard for the Installation of Stationary Pumps for Fire Protection
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

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders
UFC 3-600-01	(2016; with Change 6, 2021) Fire Protection Engineering for Facilities

UNDERWRITERS LABORATORIES (UL)

UL 448	(2017) UL Standard for Safety Centrifugal Stationary Pumps for Fire-Protection Service
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.

Submit the following:

SD-01 Preconstruction Submittals

Fire Pump Installation Related Submittals

SD-02 Shop Drawings

Installation Drawings; G

3 copies

As-Built Drawings; G

Pump Room; G

SD-03 Product Data

Catalog Data; G

Spare Parts

Preliminary Tests

At least 14 days prior to the proposed date and time to begin Preliminary Tests

Field Tests; G

At least 2 weeks before starting field tests

Manufacturer's Representative; G

Field Training; G

Final Acceptance Test

SD-05 Design Data

Surge Arrestor Calculations; G

SD-06 Test Reports

Preliminary Tests

3 copies of the completed Preliminary Tests Reports, no later that 7 days after the completion of the Preliminary Tests.

Final Acceptance Test

SD-07 Certificates

Fire Protection Specialist

No later than 14 days after the Notice to Proceed and prior to the submittal of the fire pump installation drawings

Qualifications of Welders

Qualifications of Installer

Preliminary Test Certification

Final Test Certification

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions; G

At least 14 days prior to conducting field training

Flow Meter

Submit Data Package 2 for flow meter and controllers in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.6 EXTRA MATERIALS

Submit Spare Parts data for each different item of equipment and material specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

1.7 QUALITY ASSURANCE

1.7.1 Fire Protection Specialist

Work specified in this section shall be performed under the supervision of and certified by a Qualified Fire Protection Engineer (QFPE). QFPE shall be the same individual submitted under Section 21 13 13 WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION. Submit the name and documentation of certification of the proposed Fire Protection Specialists. The Fire Protection Specialist shall be an individual who is a registered professional engineer who has passed the fire protection engineering written examination administered by the National Council of Examiners and Surveys (NCEES) and has relevant fire protection engineering experience.

1.7.2 Qualifications of Welders

Submit certificates of each welder's qualifications prior to site welding; certifications shall not be more than one year old.

1.7.3 Qualifications of Installer

Prior to installation, submit data for approval showing that the Contractor has successfully installed fire pumps and associated equipment of the same type and design as specified herein, or that he has a firm contractual agreement with a subcontractor having such required experience. The data shall include the names and locations of at least two installations where the Contractor, or the subcontractor referred to above, has installed such systems. Indicate the type and design of each system and certify that each system has performed satisfactorily in the manner intended for a period of not less than 18 months.

1.7.4 Preliminary Test Certification

When preliminary tests have been completed and corrections made, submit a signed and dated certificate with a request for a formal inspection and tests.

1.7.5 Final Test Certification

Concurrent with the Final Acceptance Test Report, submit certification by the Fire Protection Specialist that the fire pump installation is in accordance with the contract requirements, including signed approval of the Preliminary and Final Acceptance Test Reports. Submit data for approval showing the name and certification of all involved individuals with such qualifications at or prior to submittal of drawings.

1.7.6 Manufacturer's Representative

Work specified in this section shall be performed under the supervision of and certified by a representative of the fire pump manufacturer. Submit the name and documentation of certification of the proposed Manufacturer's Representative, concurrent with submittal of the Fire Protection Specialist Qualifications. The Manufacturer's Representative shall be regularly engaged in the installation of the type and complexity of fire pump(s) specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.8 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. Additionally, all pipes shall be either capped or plugged until installed.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

a. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

b. Submit manufacturer's catalog data included with the Fire Pump Installation Drawings for each separate piece of equipment proposed for use in the system. Catalog data shall indicate the name of the manufacturer of each item of equipment, with data annotated to indicate model to be provided. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided. Catalog data for material and equipment shall include, but not be limited to, the following:

   (1) Fire pumps, drivers and controllers including manufacturer's certified shop test characteristic curve for each pump. Shop test curve may be submitted after approval of catalog data but shall be submitted prior to the final tests.

   (2) Pressure maintenance pump and controller.

(3) Piping components.

(4) Valves, including gate, check, globe and relief valves.

(5) Gauges.

(6) Hose valve manifold test header and hose valves.

(7) Flow meter.

(8) Restrictive orifice union.

(9) Associated devices and equipment.

c. All equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, contract number and accepted date; capacity or size; system in which installed and system which it controls and catalog number. Pumps and motors shall have standard nameplates securely affixed in a conspicuous place and easy to read. Fire pump shall have nameplates and markings in accordance with UL 448. Electric motor nameplates shall provide the minimum information required by NFPA 70, Section 430-7.

2.2 FIRE PUMP

Fire pump shall be electric motor driven. Each pump capacity shall be rated at 2500 gpm with a rated net pressure of 130 psi. Pump churn pressure shall not exceed 154 psi. Fire pump shall furnish not less than 150 percent of rated flow capacity at not less than 65 percent of rated net pressure. Pump shall be centrifugal horizontal split case fire pump. Horizontal pump shall be equipped with automatic air release devices. The maximum rated pump speed shall be 1785 rpm when driving the pump at rated capacity. Pump shall be automatic start and automatic stop. Pump shall conform to the requirements of UL 448. Rate valves, piping, fittings, and related equipment for 250 psi.

2.3 REQUIREMENTS FOR FIRE PROTECTION SERVICE

2.3.1 General Requirements

Materials and Equipment shall have been tested by Underwriters Laboratories, Inc. and listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM APP GUIDE.

2.3.2 Alarms

Provide audible and visual alarms as required by NFPA 20 on the controller. Provide remote supervision as required by NFPA 20, in accordance with NFPA 72. Provide remote alarm devices located as indicated. Alarm signal shall be activated upon the following conditions: electric motor controller has operated into a pump running condition, loss of electrical power to electric motor starter, ATS monitoring, and phase reversal on line side of motor starter. Exterior alarm devices shall be weatherproof type. Provide alarm silencing switch and red signal lamp, with signal lamp arranged to come on when switch is placed in OFF position.

2.4 UNDERGROUND PIPING COMPONENTS

Underground piping shall comply 21 13 13 WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION.

2.5 ABOVEGROUND PIPING COMPONENTS

2.5.1 Pipe Sizes 2.5 inches and Larger

2.5.1.1 Pipe

Piping shall be ASTM A53/A53M or ASTM A795/A795M, Weight Class STD (Standard), Schedule 40, Type E or Type S, Grade A; black steel pipe. Steel pipe shall be joined by means of flanges welded to the pipe or mechanical grooved joints only. Piping shall not be jointed by welding or weld fittings. Suction piping shall be galvanized on the inside in accordance with NFPA 20.

2.5.1.2 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 250 psi service and shall be the product of the same manufacturer. Fitting and coupling houses shall be malleable iron conforming to ASTM A47/A47M, Grade 32510; ductile iron conforming to ASTM A536, Grade 65-45-12. Gasket shall be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A183 and shall be cadmium plated or zinc electroplated. Saddle tees are not permitted.

2.5.1.3 Flanges

Flanges shall be ASME B16.5, Class 150 flanges. Flanges shall be provided at valves, connections to equipment, and where indicated.

2.5.1.4 Gaskets

Gaskets shall be AWWA C111/A21.11, cloth inserted red rubber gaskets.

2.5.1.5 Bolts

Bolts shall be ASTM A449, Type 1 or 2. Bolts shall extend no less than three full threads beyond the nut with bolts tightened to the required torque.

2.5.1.6 Nuts

Nuts shall be ASTM A194/A194M, Grade 7, or ASTM A193/A193M, Grade 5, or ASTM A563, Grade C3.

2.5.1.7 Washers

Washers shall meet the requirements of ASTM F436. Flat circular washers shall be provided under all bolt heads and nuts.

2.5.2 Piping Sizes 2 inches and Smaller

2.5.2.1 Steel Pipe

Steel piping shall be ASTM A795/A795M, Weight Class STD (Standard), Schedule 40, Type E or Type S, Grade A, or ASTM A53/A53M, Weight Class XS

(Extra Strong), zinc-coated steel pipe with threaded end connections. Fittings shall be malleable iron conforming to ASME B16.3, Class 150, zinc-coated threaded fittings. Unions shall conform to ASME B16.39, Class 150, zinc-coated unions.

2.5.3 Pipe Hangers and Supports

Pipe hangers and support shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE and shall be the adjustable type. Finish of rods, nuts, washers, hangers, and supports shall be zinc-plated after fabrication. Pipe stands shall comply with NFPA 13.

2.5.4 Valves

Valves shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE for fire protection service. Valves shall have flange or threaded end connections.

2.5.4.1 Gate Valves and Control Valves

Gate valves and control valves shall be outside screw and yoke (O.S.&Y.) type which open by counterclockwise rotation. Butterfly-type control valves shall be permitted where indicated on plans and listed.

2.5.4.2 Tamper Switch

All normally open control valves, including but not limited to, the suction control valves, the discharge control valves, shall be equipped with valve tamper switches for monitoring by the fire alarm system.

2.5.4.3 Check Valve

Check valve shall be clear open, swing type check valve with flange or threaded inspection plate.

2.5.4.4 Circulating Relief Valve

An adjustable circulating relief valve shall be provided for each fire pump in accordance with NFPA 20.

2.5.5 Pipe Sleeves

A pipe sleeve shall be provided at each location where piping passes entirely through walls, ceilings, roofs, and floors, including pipe entering buildings from the exterior. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, and floors. Provide one inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of the sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. In fire resistance rated walls and floors, a fire seal shall be provided between the pipe and the sleeve in accordance with Section 07 84 00 FIRESTOPPING.

a. Sleeves in Masonry and Concrete Walls, Ceilings, Roofs, and Floors: Provide hot-dip galvanized steel, ductile-iron, or cast-iron pipe sleeves. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves provided that cavities in the core-drilled hole be completely grouted smooth.

b. Sleeves in Other Than Masonry and Concrete Walls, Ceilings, Roofs, and Floors: Provide galvanized steel sheet pipe not less than 0.90 psf.

2.5.6 Escutcheon Plates

Provide one-piece or split-hinge metal plates for piping entering floors, walls, and ceilings in exposed areas. Provide polished stainless steel or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on plates in unfinished spaces. Plates shall be secured in place.

2.6 Pressure Gauges

Pressure gauges shall be certified, oil-filled type gauges. Pressure gauges shall have a dial not less than 3.50-in and not more than 4.5-in in diameter.

2.6.1 Suction Gauges

The suction gauge shall be a compound pressure and vacuum gauge. The gauge shall have a pressure range at least two times the rated maximum suction pressure. The face of the dial shall read in inches of mercury and psi.

2.6.2 Discharge Gauges

The dial shall indicate pressure to at least twice the rated working pressure of the pump. The face of the dial for each discharge pressure gauge shall read in psi.

2.7 ELECTRIC MOTOR DRIVER

Motors, controllers, contactors, and disconnects shall be provided with their respective pieces of equipment, as specified herein and shall have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Controllers and contactors shall have 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, the cost of providing additional electrical service and related work shall be included under this section. Motor shall conform to NEMA MG 1 Design B type. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1. Motor horsepower shall be of sufficient size so that the nameplate horsepower rating will not be exceeded throughout the entire published pump characteristic curve. The motor and fire pump controller shall be fully compatible.

2.8 FIRE PUMP CONTROLLER

Controller shall be the automatic type and UL listed UL Fire Prot Dir or FM approved FM APP GUIDE for fire pump service. Pump shall be arranged for automatic start and stop, and manual push-button stop. Automatic stopping shall be accomplished only after all starting causes have returned to normal and after a minimum pump run time has elapsed. Controllers shall be completely terminally wired, ready for field connections, and mounted in a NEMA Type 2 drip-proof enclosure arranged so that controller current carrying parts will not be less than 12 inches above the floor. Controller shall be provided with voltage surge arresters installed in accordance with

NFPA 20. Controller shall be equipped with a bourdon tube pressure switch or a solid state pressure switch with independent high and low adjustments, automatic starting relay actuated from normally closed contacts, visual alarm lamps and supervisory power light. Controller shall be equipped with a thermostat switch with adjustable setting to monitor the pump room temperature and to provide an alarm when temperatures falls below 40 degrees F. The controller shall be factory-equipped with a heater operated by thermostat to prevent moisture in the cabinet.

2.8.1 Controller for Electric Motor Driven Fire Pump

Controller shall be electronic soft start starting type. Controller and transfer switch shall have a short circuit rating of 100,000 amps r.m.s. symmetrical at 200-600 volts a.c.. An automatic transfer switch (ATS) shall be provided for each fire pump. The ATS shall comply with NFPA 20 and shall be specifically listed for fire pump service. The ATS shall transfer source of power to the alternate source upon loss of normal power. Controller shall monitor pump running, loss of a phase or line power, phase reversal, low reservoir and pump room temperature. Alarms shall be individually displayed in front of panel by lighting of visual lamps. Each lamp shall be labeled with rigid etched plastic labels. Controller shall be equipped with terminals for remote monitoring of pump running, pump power supply trouble (loss of power or phase and phase reversal), controller connected to alternate power source, alternate power source isolating switch or circuit breaker is open or tripped, and controller or system trouble, and for remote start. Limited service fire pump controllers are not permitted. Controller shall be equipped with a 7-day electric pressure recorder with 24-hour spring wound back-up. The pressure recorder shall provide a readout of the system pressure from 0 to 300 psi, time, and date. Controller shall require the pumps to run for ten minutes for pumps with driver motors under 200 horsepower and for 15 minutes for pumps with motors 200 horsepower and greater, prior to automatic shutdown. The controller shall be equipped with an externally operable isolating switch which manually operates the motor circuit. Means shall be provided in the controller for measuring current for all motor circuit conductors.

2.9 PRESSURE SENSING LINE

A completely separate pressure sensing line shall be provided for each fire pump and for the jockey pump. The sensing line shall be arranged in accordance with Figure A.4.31(a) of NFPA 20. The sensing line shall be 1/2 inch rigid copper pipe Types K, L or M complying with ASTM B88. The sensing line shall be equipped with two bronze check valves with a nominal 0.1 in hole drilled in each clapper. Check valves shall be mounted in the horizontal position, not less than 5 feet apart on the sensing line. Two test connections shall be provided for each sensing line. Test connections shall consist of two brass 1/2 inch globe valves and 1/4 inch gauge connection tee arranged in accordance with NFPA 20. One of the test connections shall be equipped with a 0 to 300 psi water oil-filled gauge. Sensing line shall be connected to the pump discharge piping between the discharge piping control valve and the check valve.

2.10 PRESSURE MAINTENANCE (JOCKEY) PUMP

2.10.1 General

Pressure maintenance pump shall be electric motor driven, in-line vertical shaft, centrifugal type with a rated discharge of 25 gpm at 165 psig. Pump shall draft from the suction supply side of the suction pipe gate valve of the fire pump and shall discharge into the system at the downstream side of the pump discharge gate valve. An approved indicating isolation valve shall be provided in the maintenance pump discharge and suction piping. Oil-filled water pressure gauge and approved check valve in the maintenance pump discharge piping shall be provided. Check valve shall be swing type with removable inspection plate.

2.10.2 Pressure Maintenance Pump Controller

Pressure maintenance pump controller shall be arranged for automatic and manual starting and stopping and equipped with a "manual-off-automatic" switch. The controller shall be completely prewired, ready for field connections, and wall-mounted in a NEMA Type 2 drip-proof enclosure. The controller shall be equipped with a bourdon tube pressure switch or a solid state pressure switch with independent high and low adjustments for automatic starting and stopping. A sensing line shall be provided connected to the pressure maintenance pump discharge piping between the control valve and the check valve. The sensing line shall conform to paragraph, PRESSURE SENSING LINE. The sensing line shall be completely separate from the fire pump sensing lines. An adjustable run timer shall be provided to prevent frequent starting and stopping of the pump motor. The minimum run time shall be in accordance with the manufacturer's recommendations.

2.11 PUMP BASE PLATE AND PAD

Provide a common base plate for each horizontal-shaft fire pump for mounting pump and driver unit. Construct the base plate of cast iron with raised lip tapped for drainage or welded steel shapes with suitable drainage. Provide each base plate for the horizontal fire pumps with a 1 inchgalvanized steel drain line piped to the nearest floor drain. For vertical shaft pumps, pump head shall be provided with a cast-iron base plate and shall serve as the sole plate for mounting the discharge head assembly. Mount pump units and bases on a raised 6 inches reinforced concrete pad that is an integral part of the reinforced concrete floor.

2.12 HOSE VALVE MANIFOLD TEST HEADER

Hose valve test header shall be connected by ASME B16.5, Class 150 flange inlet connection. Hose valves shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE bronze hose gate valves with 2.5 inches American National Fire Hose Connection Screw Standard Threads (NH) in accordance with NFPA 1963. The number of valves shall be in accordance with NFPA 20. Each hose valve shall be equipped with a cap and chain, and located no more than 3 feet and no less than 2 feet above grade.

2.13 FLOW METER

Meter shall be UL listed UL Fire Prot Dir or FM approved FM APP GUIDE as flow meters for fire pump installation with direct flow readout device. Flow meter shall be capable of metering any waterflow quantities between 50 percent and 150 percent of the rated flow of the pumps. Arrange piping to permit flow meter to discharge through the test header and also back to the tank. The meter throttle valve shall be a butterfly valve. The meter control valves shall be a butterlfy valve. Provide automatic air release if flow meter piping between pump discharge and pump suction forms an inverted "U". Meter shall be of the venturi type.

2.14 SURGE ARRESTOR

Provide listed or approved surge arrestors for fire protection systems with a minimum rated working pressure of 275 psi. Provide floor stands for surge arrestors. Provide manufacturer's calculations to determine minimum surge arrestor capacities but no less than 100 gal capacity for each fire pump. Include surge arrestor calculations performed by the manafacturer in the design calculations.

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 INSPECTION BY FIRE PROTECTION SPECIALIST

The Fire Protection Specialist shall periodically perform a thorough inspection of the fire pump installation, including visual observation of the pump while running, to assure that the installation conforms to the contract requirements. There shall be no excessive vibration, leaks (oil or water), unusual noises, overheating, or other potential problems. Inspection shall include piping and equipment clearance, access, supports, and guards. Any discrepancy shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered. The Fire Protection Specialist shall witness the preliminary and final acceptance tests and, after completion of the inspections and a successful final acceptance test, shall sign test results and certify in writing that the installation the fire pump installation is in accordance with the contract requirements.

3.3 INSTALLATION

Equipment, materials, workmanship, fabrication, assembly, erection, installation, examination, inspection and testing shall be in accordance NFPA 20, except as modified herein. In addition, the fire pump shall be installed in accordance with the written instructions of the manufacturer. Exposed horizontal piping, including drain piping, shall be installed to provide maximum headroom, but no less than 90 in above the finished floor, except where specifically noted on the drawings. Pipe installation shall not encroach upon the Dedicated Equipment Space required by NFPA 70 for switchboards, switchgear, panelboards, and motor control centers. Provide a minimum of 36 in clearance on one side of the fire pump assembly for maintenance and in front of the pump controller or the minimum required by NFPA 70), whichever is greater. A clear width of 36 in must also be provided from the pump room entry to the fire pump assembly and controller. Provide a minimum of 36 in of access to, and in front of all other equipment and 6 in behind equipment (e.g. check valves, control valves, etc.).

3.3.1 Installation Drawings

Submit Fire Pump Installation Drawings consisting of a detailed plan view, detailed elevations and sections of the pump room, equipment and piping, drawn to a scale of not less than 1/2 inch = 1 foot. Working (shop) drawings must meet the drawing requirements in NFPA 13 for Working Drawings. Drawings and calculations must be prepared by, or under the immediate supervision of, the Fire Protection Specialist. The Fire Protection Specialist must affix their professional engineering stamp with signature to the shop drawings, calculations, and material data sheets, indicating approval prior to submitting to the Government. Drawings shall indicate equipment, piping, and associated pump equipment to scale. Indicate all clearance, such as those between piping and equipment; between equipment and walls, ceiling and floors; and for electrical working distance clearance around all electrical equipment. Include a legend identifying all symbols, nomenclatures, and abbreviations. Indicate a complete piping and equipment layout including elevations and/or section views of the following:

a. Fire pumps, controllers, piping, valves, and associated equipment.

b. Sensing line for each pump including the pressure maintenance pump.

c. Pipe hangers and sway bracing.

d. Restraint of underground water main at entry-and exit-points to the building including details of pipe clamps, tie rods, mechanical retainer glands, and thrust blocks.

e. A one-line schematic diagram indicating layout and sizes of all piping, devices, valves and fittings.

f. A complete point-to-point connection drawing of the pump power, control and alarm systems, as well as interior wiring schematics of each controller.

3.3.2 Pump Room Configuration

Provide detail plan view of the pump room including elevations and sections showing the fire pumps, pressure maintenance pump, associated equipment, and piping. Submit working drawings on sheets not smaller than 24 by 36 inches; include data for the proper installation of each system. Show piping schematic of pumps, devices, valves, pipe, and fittings. Provide an isometric drawing of the fire pump and all associated piping. Show point to point electrical wiring diagrams. Show piping layout and sensing piping arrangement. Include:

a. Pumps, drivers, and controllers

b. Hose valve manifold test header

c. Circuit diagrams for pumps

d. Wiring diagrams of each controller

3.3.3 Accessories

Supports, piping offsets, fittings, and any other accessories required shall be furnished as specified to provide a complete installation and to eliminate interference with other construction.

3.4 PIPE AND FITTINGS

Piping shall be inspected, tested and approved before burying, covering, or concealing. Fittings shall be provided for changes in direction of piping and for all connections. Changes in piping sizes shall be made using tapered reducing pipe fittings. Bushings shall not be used. Photograph all piping prior to burying, covering, or concealing.

3.4.1 Cleaning of Piping

Interior and ends of piping shall be clean and free of any water or foreign material. Piping shall be kept clean during installation by means of plugs or other approved methods. When work is not in progress, open ends of the piping shall be securely closed so that no water or foreign matter will enter the pipes or fittings. Piping shall be inspected before placing in position.

3.4.2 Threaded Connections

Jointing compound for pipe threads shall be polytetrafluoroethylene (PTFE) pipe thread tape conforming to ASTM D3308 and shall be applied to male threads only. Exposed ferrous pipe threads shall be provided with one coat of zinc molybdate primer applied to a minimum of dry film thickness of 1 mil.

3.4.3 Pipe Hangers and Supports

Additional hangers and supports shall be provided for concentrated loads in aboveground piping, such as for valves and risers.

3.4.3.1 Vertical Piping

Piping shall be supported at not more than 10 foot intervals.

3.4.3.2 Horizontal Piping

Horizontal piping supports shall be in accordance with NFPA 13.

3.4.4 Drain Piping

Terminate all drain piping and test piping from the fire pump or associated appurtenances to the exterior of the facility so it will not cause damage. Provide concrete pads or splash blocks where discharge location is to other than a concrete slab. Ensure that all discharged water drains away from the facility and does not cause property damage. Drainage piping less than 0.75-in may discharge to a floor drain.

3.4.5 Grooved Mechanical Joint

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, rubber gaskets, couplings, and grooving tools shall be products of the same manufacturer. 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, 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 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.

3.4.6 Pipe Penetrations

Cutting structural members for passage of pipes or for pipe-hanger fastenings will not be permitted. Pipes that must penetrate concrete or masonry walls or concrete floors shall be core-drilled and provided with pipe sleeves. Each sleeve shall be Schedule 40 galvanized steel, ductile iron or cast iron pipe and shall extend through its respective wall or floor and be cut flush with each wall surface. Sleeves shall provide required clearance between the pipe and the sleeve per NFPA 13. The space between the sleeve and the pipe shall be firmly packed with mineral wool insulation. Where pipes penetrate fire rated walls, fire partitions, or floors, pipes shall be fire stopped in accordance with Section 07 84 00 FIRESTOPPING. In penetrations that are not fire-rated or not a floor penetration, the space between the sleeve and the pipe shall be sealed at both ends with plastic waterproof cement that will dry to a firm but pliable mass or with a mechanically adjustable segmented elastomer seal.

3.5 Surge Arrestor Installation

Provide each arrestor with an indicating isolation valve to separate it from the system. Electrically supervise this valve in the normally open position. Provide a drain after the isolation valve to relieve pressure from the surge arrestor during testing and maintenance. When connecting the surge arrestor to the riser, the use of piping, fittings, and valving smaller than the connecting orifice on the surge arrestor is not permitted.

3.6 ELECTRICAL WORK

Electric motor and controls shall be in accordance with NFPA 20, NFPA 72 and NFPA 70, unless more stringent requirements are specified herein or are indicated on the drawings. Working clearances around controllers shall comply with NFPA 70, Article 110. Electrical wiring and associated equipment shall be provided in accordance with NFPA 20 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide wiring in rigid metal conduit or intermediate metal conduit, except electrical metallic tubing conduit may be provided in dry locations not enclosed in concrete or where not subject to mechanical damage.

3.7 PIPE COLOR CODE MARKING

Color code marking of piping as specified in Section 09 90 00 PAINTS AND COATINGS. After all field painting is compelte, provide labeling on the surfaces of the piping in the pump room to show the water flow direction and pipe function (e.g., "Suction", "Discharge", "To Fire Dept. Connection", "To Test Header").

Provide white painted stenciled letters and arrows, a minimum 2 in in height and visible from at least three sides when viewed from the floor. Labeling must be in accordance with MIL-STD-101.

Mark all exposed interior piping with plastic wrap around-type pipe labels conforming to ASME A13.1. Indicate the type of fluid carried and direction of flow. Labels that stick-on (adhesive backed) or are held on with straps/adhesive tape are not permitted. Labels are not required on any fire suppression system branchlines regardless of size, or mains and cross-mains less than a nominal 2-1/2 in. Labels are not required on piping routed below the floor line in trenches or pits.

3.8 FLUSHING

The fire pump suction and discharge piping shall be flushed in accodance with NFPA 20 Table 14.1.1.1. The new pumps may be used to attain the required flushing volume. No underground piping shall be flushed by using the fire pumps. Flushing operations shall continue until water is clear, but not less than 10 minutes. Submit a signed and dated flushing certificate before requesting field testing.

3.9 FIELD TESTS

Submit system diagrams that show the layout of equipment, piping, and storage units, and typed condensed sequence of operation, wiring and control diagrams, and operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

3.9.1 Hydrostatic Test

Piping shall be hydrostatically tested at 200 psig for a period of 2-hours, or at least 50 psi in excess of the maximum pressure, in accordance with NFPA 20.

3.9.2 Preliminary Tests

Submit proposed procedures for Preliminary Tests prior to the proposed date and time to begin Preliminary Tests. The Fire Protection Specialist shall take all readings and measurements. The fire pump Manufacturer's Representative and a representative of the fire pump controller manufacturer shall witness the complete operational testing of the fire pump and drivers. The fire pump controller manufacturer's representative shall be an experienced technician employed by the respective manufacturers and capable of demonstrating operation of all features of respective components including trouble alarms and operating features. Fire pumps, drivers and equipment shall be thoroughly inspected and tested to insure that the system is correct, complete, and ready for operation. Tests shall ensure that pumps are operating at rated capacity, pressure and speed. Tests shall include manual starting and running to ensure proper operation and to detect leakage or other abnormal conditions, flow testing, automatic start testing, testing of automatic settings, sequence of operation check, test of required accessories; test of pump alarms devices and supervisory signals, test of pump cooling, operational test of relief valves, and test of automatic power transfer. Pumps shall run without abnormal noise, vibration or heating. If any component or system was found to be defective, inoperative, or not in compliance with the contract requirements during the tests and inspection, the corrections shall be made and the entire preliminary test shall be repeated. Submit Preliminary Tests Reports, to include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Report shall be signed by the Fire Protection Specialist and the Manufacturer's Representative.

3.9.3 Final Acceptance Test

The Fire Protection Specialist shall take all readings and measurements. The fire pump Manufacturer's Representative, and the fire pump controller manufacturer's representative shall also witness for the final tests.

Repair any damage caused by hose streams or other aspects of the test. Submit proposed date and time to begin Final Acceptance Test, with the Acceptance Procedures. Notification shall be provided at least 14 days prior to the proposed start of the test. Submit 3 copies of the completed Final Acceptance Test Reports, no later that 7 days after the completion of the tests. All items in the reports shall be signed by the Fire Protection Specialist and the Manufacturer's Representative. Test reports in booklet form (each copy furnished in a properly labeled three ring binder) showing all field tests and measurements taken during the preliminary and final testing, and documentation that proves compliance with the specified performance criteria, upon completion of the installation and final testing of the installed system. Each test report shall indicate the final position of the controls and pressure switches. The test reports shall include the description of the hydrostatic test conducted on the piping and flushing of the suction and discharge piping. A copy of the manufacturer's certified pump curve for each fire pump shall be included in the report. Notification shall include a copy of the Contractor's Material & Test Certificates for Fire Pumps in accordance with NFPA 20. Include the following in the final acceptance test:

3.9.3.1 Flow Tests

Flow tests using the test header, hoses and playpipe nozzles shall be conducted. Flow tests shall be performed at churn (no flow),25, 50, 75, 100, 125 and 150 percent capacity for each pump and at full capacity of the pump installation. Flow readings shall be taken from each nozzle by means of a calibrated pitot tube with gauge or other approved measuring equipment. Rpm, suction pressure and discharge pressure reading shall be taken as part of each flow test. Voltage and ampere readings shall taken on each phase as part of each flow test for electric-motor driven pumps.

3.9.3.2 Starting Tests

Pumps shall be tested for automatic starting and sequential starting. Setting of the pressure switches shall be tested when pumps are operated by pressure drop. Tests may be performed by operating the test connection on the pressure sensing lines. As a minimum, each pump shall be started automatically 10 times and manually 10 times, in accordance with NFPA 20. The fire pumps shall be operated for a period of a least 10 minutes for each of the starts; except that electric motors over 200 horsepower shall be operated for at least 15 minutes and shall not be started more than 2 times in 10 hours. Pressure settings that include automatic starting and stopping of the fire pump(s) shall be indicated on an etched plastic placard, attached to the corresponding pump controller.

3.9.3.3 Alarms

All pump alarms, both local and remote, shall be tested.

3.9.3.4 Miscellaneous

Valve tamper switches shall be tested. Pressure recorder operation relief valve settings, valve operations, operation and accuracy of meters and gauges, and other accessory devices shall be verified.

3.9.3.5 Alternate Power Source

On installations with an alternate source of power and an automatic transfer switch, loss of primary power shall be simulated and transfer shall occur while the pump is operating at peak load. Transfer from normal to emergency source and retransfer from emergency to normal source shall not cause opening of overcurrent devices in either line. At least half of the manual and automatic starting operations listed shall be performed with the fire pump connected to the alternate source.

3.9.3.6 Correction of Deficiencies

If equipment was found to be defective or non-compliant with contract requirements, perform corrective actions and repeat the tests. Tests shall be conducted and repeated if necessary until the system has been demonstrated to comply with all contract requirements.

3.9.3.7 Test Documentation

The Manufacturer's Representative shall supply a copy of the manufacturer's certified curve for each fire pump at the time of the test. The Fire Protection Specialist shall record all test results and plot curve of each pump performance during the test. Complete pump acceptance test data of each fire pump shall be recorded. The pump acceptance test data shall be on forms that give the detail pump information such as that which is indicated in Figure A.14.1.3(a) of NFPA 20. All test data records shall be submitted in a three ring binder.

3.9.4 Test Equipment

Provide all equipment and instruments necessary to conduct a complete final test, including 2.5 inch diameter hoses, playpipe nozzles, pitot tube gauges, portable digital tachometer, voltage and ampere meters, and calibrated oil-filled water pressure gauges. Water pressure gauges must have current certifications. Provide all necessary supports to safely secure hoses and nozzles during the test. The Government will furnish water for the tests.

3.10 SYSTEM STARTUP

Fully enclose or properly guard coupling, rotating parts, gears, projecting equipment, etc. so as to prevent possible injury to persons that come in close proximity of the equipment. Conduct testing of the fire pumps in a safe manner and ensure that all equipment is safely secured. Hoses and nozzles used to conduct flow tests shall be in excellent condition and shall be safely anchored and secured to prevent any misdirection of the hose streams.

Post operating instructions for pumps, drivers, controllers, and flow meters.

3.11 CLOSEOUT ACTIVITIES

3.11.1 Field Training

The Fire Protection Specialist and the Fire Pump Manufacturer's Representative shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Submit the proposed schedule for field training at least 14 days prior to the start of related training. Training shall be provided for a period of 8 hours of normal working time and shall start after the fire pump installation is functionally complete and after the Final Acceptance Test. The field instruction shall cover all of the items contained in the approved

Operating and Maintenance Instructions. Submit manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Data Package 3 shall be submitted for fire pumps and drivers in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Each service organization submitted shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

3.11.2 As-Built Drawings

Submit As-Built Drawings, no later than 14 days after completion of the Final Tests. Update he Fire Pump Installation Drawings to reflect as-built conditions after all related work is completed and shall be on reproducible full-size mylar film and in electronic PDF format.

3.12 PROTECTION

Carefully remove materials so as not to damage material which is to remain. Replace existing work damaged by the Contractor's operations with new work of the same construction.

-- 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.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 1010	(2002) Self-Contained, Mechanically Refrigerated Drinking-Water Coolers

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.10.3/CSA 4.3	(2019) Gas-Fired Water Heaters Vol.III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous
ANSI Z21.22/CSA 4.4	(2015) Relief Valves for Hot Water Supply Systems

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A112.1.2	(2012; R 2017) Air Gaps in Plumbing Systems (For Plumbing Fixtures and Water-Connected Receptors)
ASME A112.6.1M	(1997; R 2017) Floor Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use
ASME A112.6.3	(2019) Standard for Floor and Trench Drains
ASME A112.14.1	(2003; R 2017) Backwater Valves
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 A112.36.2M	(1991; R 2017) Cleanouts
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.18	(2018) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2016) Nonmetallic Flat Gaskets for Pipe

	Flanges
ASME B16.22	(2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.34	(2017) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.50	(2013) Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings
ASME B31.1	(2018) 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	(2016) Control and Safety Devices for Automatically Fired Boilers

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1001	(2016) Performance Requirements for Atmospheric Type Vacuum Breakers
ASSE 1003	(2009) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)
ASSE 1010	(2004) Performance Requirements for Water Hammer Arresters (ANSI approved 2004)
ASSE 1011	(2004; Errata 2004) Performance Requirements for Hose Connection Vacuum Breakers (ANSI approved 2004)
ASSE 1012	(2009) Performance Requirements for Backflow Preventer with an Intermediate Atmospheric Vent - (ANSI approved 2009)
ASSE 1013	(2011) Performance Requirements for Reduced Pressure Principle Backflow

	Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers - (ANSI approved 2010)
ASSE 1018	(2001) Performance Requirements for Trap Seal Primer Valves - Potable Water Supplied (ANSI Approved 2002
ASSE 1019	(2011; R 2016) Performance Requirements for Wall Hydrant with Backflow Protection and Freeze Resistance
ASSE 1020	(2020) Performance Requirements for Pressure Vacuum Breaker Assemblies

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA B300	(2010; Addenda 2011) Hypochlorites
AWWA B301	(2010) Liquid Chlorine
AWWA C203	(2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C606	(2015) Grooved and Shouldered Joints
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C652	(2019) Disinfection of Water-Storage Facilities
AWWA C700	(2015) Cold-Water Meters - Displacement Type, Metal Alloy Main Case
AWWA C701	(2015) Cold-Water Meters - Turbine Type for Customer Service

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 A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2018) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A74	(20207) Standard Specification for Cast Iron Soil Pipe and Fittings

ASTM A105/A105M	(2018) 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	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
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 A733	(2016) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM A888	(2020) Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B42	(2015a) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B88	(2016) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2018) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B117	(2016) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B306	(2013) Standard Specification for Copper Drainage Tube (DWV)
ASTM B370	(2012; R 2019) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM C564	(2014) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings

ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D1248	(2016) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
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 D3139	(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212	(2007; R 2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D4551	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM F477	(2014) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F891	(2016) Standard Specification for Coextruded Poly (Vinyl Chloride) (PVC) Plastic Pipe with a Cellular Core
ASTM F1760	(2016) Standard Specification for Coextruded Poly(Vinyl Chloride) (PVC) Non-Pressure Plastic Pipe Having Reprocessed-Recycled Content

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

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(2016; 14/17) Copper Tube Handbook

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)

IAPMO UPC	(2003) Uniform Plumbing Code

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1 COMM	(2017) Standard And Commentary Accessible and Usable Buildings and Facilities
ICC IPC	(2018) International Plumbing Code

INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION (ISEA)

ANSI/ISEA Z358.1	(2014) American National Standard for Emergency Eyewash and Shower Equipment

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air

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-83	(2014) Class 3000 Steel Pipe Unions Socket Welding and Threaded
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

NACE INTERNATIONAL (NACE)

NACE SP0169	(2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2018) 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 54	(2018) National Fuel Gas Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF 372	(2016) Drinking Water System Components - Lead Content
NSF/ANSI 61	(2020) Drinking Water System Components - Health Effects

PLUMBING AND DRAINAGE INSTITUTE (PDI)

PDI WH 201	(2010) Water Hammer Arresters Standard

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J1508	(2009) Hose Clamp Specifications

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA SM 9223	(2004) Enzyme Substrate Coliform Test
PL 93-523	(1974; A 1999) Safe Drinking Water Act

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

10 CFR 430	Energy Conservation Program for Consumer Products
40 CFR 141.80	National Primary Drinking Water Regulations; Control of Lead and Copper; General Requirements

UNDERWRITERS LABORATORIES (UL)

UL 430	(2015; Reprint Feb 2018) UL Standard for Safety Waste Disposers

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. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fixtures

List of installed fixtures with manufacturer, model, and flow rate.

Flush Valve Water Closets

WaterSense Label for Flush Valve Water Closet; S

Flush Valve Urinals

WaterSense Label for Urinal; S

Countertop Lavatories

Kitchen Sinks

Drinking-Water Coolers; G

Energy Star Label for Electric Water Cooler; S

Energy Star Label for Wheelchair Electric Water Cooler; S

Shower Pan

WaterSense Label for Showerhead; S

Water Heaters; G

Energy Star Label for Gas Instantaneous Water Heater; S

Pumps; G

Backflow Prevention Assemblies; G

Air Dryer; G

Shower Faucets; G

Welding

A copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators.

Vibration-Absorbing Features; G

Details of vibration-absorbing features, including arrangement, foundation plan, dimensions and specifications.

Plumbing System

Diagrams, instructions, and other sheets proposed for posting. Manufacturer's recommendations for the installation of bell and spigot and hubless joints for cast iron soil pipe.

SD-06 Test Reports

Tests, Flushing and Disinfection

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, completion and testing of the installed system. Each test report shall indicate the final position of controls.

Test of Backflow Prevention Assemblies; G.

Certification of proper operation shall be as accomplished in accordance with state regulations by an individual certified by the state to perform such tests. If no state requirement exists, the Contractor shall have the manufacturer's representative test the device, to ensure the unit is properly installed and performing as intended. The Contractor shall provide written documentation of the tests performed and signed by the individual performing the tests.

SD-07 Certificates

Materials and Equipment

Where 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 PERFORMANCE REQUIREMENTS

1.5.1 Welding

Piping shall be welded in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer, may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests, and the tests shall be performed at the work site if practicable. Welders or welding operators shall apply their assigned symbols near each weld they make as a permanent record.

1.6 REGULATORY REQUIREMENTS

Unless otherwise required herein, plumbing work shall be in accordance with ICC IPC.

1.7 PROJECT/SITE CONDITIONS

The Contractor shall become familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.8 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.

1.9 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 TABLES I and II. Pipe schedules shall be selected based on service requirements. Pipe fittings shall be compatible with the applicable pipe materials. Pipe threads (except dry seal) shall conform to 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 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.

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. Coupling for Steel Pipe: AWWA C606.

c. Couplings for Grooved Pipe: Malleable Iron ASTM A47/A47M, Grade 32510..

d. Flange Gaskets: Gaskets shall be made of non-asbestos material in accordance with ASME B16.21. Gaskets shall be flat, 1/16 inch thick, and contain Aramid fibers bonded with Styrene Butadiene Rubber (SBR) or Nitro Butadiene Rubber (NBR). Gaskets shall be the full face or self centering flat ring type. Gaskets used for hydrocarbon service shall be bonded with NBR.

e. Brazing Material: Brazing material shall conform to AWS A5.8/A5.8M, BCuP-5.

f. 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.

g. Solder Material: Solder metal shall conform to ASTM B32.

h. Solder Flux: Flux shall be liquid form, non-corrosive, and conform to ASTM B813, Standard Test 1.

i. PTFE Tape: PTFE Tape, for use with Threaded Metal.

j. Rubber Gaskets for Cast-Iron Soil-Pipe and Fittings (hub and spigot type and hubless type): ASTM C564.

k. Rubber Gaskets for Grooved Pipe: ASTM D2000, maximum temperature 230 degrees F.

l. Flexible Elastomeric Seals: ASTM D3139, ASTM D3212 or ASTM F477.

m. Bolts and Nuts for Grooved Pipe Couplings: Heat-treated carbon steel, ASTM A183.

n. 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.

o. Copper tubing shall conform to ASTM B88, Type K, L or M.

2.1.2 Miscellaneous Materials

Miscellaneous materials shall conform to the following:

a. Water Hammer Arrester: PDI WH 201. Water hammer arrester shall be piston type.

b. Copper, Sheet and Strip for Building Construction: ASTM B370.

c. Asphalt Roof Cement: ASTM D2822/D2822M.

d. Hose Clamps: SAE J1508.

e. Supports for Off-The-Floor Plumbing Fixtures: ASME A112.6.1M.

f. Metallic Cleanouts: ASME A112.36.2M.

g. Plumbing Fixture Setting Compound: A preformed flexible ring seal molded from hydrocarbon wax material. The seal material shall be nonvolatile nonasphaltic and contain germicide and provide watertight, gastight, odorproof and verminproof properties.

h. Coal-Tar Protective Coatings and Linings for Steel Water Pipelines: AWWA C203.

i. Hypochlorites: AWWA B300.

j. Liquid Chlorine: AWWA B301.

k. Gauges - Pressure and Vacuum Indicating Dial Type - Elastic Element: ASME B40.100.

l. Thermometers: ASTM E1. Mercury shall not be used in thermometers.

2.1.3 Pipe Insulation Material

Insulation shall be as specified in Section 22 07 19.00 40 PLUMBING PIPING INSULATION.

2.2 PIPE HANGERS, INSERTS, AND SUPPORTS

Pipe hangers, inserts, and supports shall conform to MSS SP-58.

2.3 VALVES

Valves shall be provided on supplies to equipment and fixtures. Valves 2-1/2 inches and smaller shall be bronze with threaded bodies for pipe and solder-type connections for tubing. Valves 3 inches and larger shall have flanged iron bodies and bronze trim. Pressure ratings shall be based upon the application. Grooved end valves may be provided if the manufacturer certifies that the valves meet the performance requirements of applicable MSS standard. Valves shall conform to the following standards:

Description	Standard
Cast-Iron Gate Valves, Flanged and Threaded Ends	MSS SP-70
Cast-Iron Swing Check Valves, Flanged and Threaded Ends	MSS SP-71
Ball Valves with Flanged Butt-Welding Ends for General Service	MSS SP-72
Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends	MSS SP-110
Cast-Iron Plug Valves, Flanged and Threaded Ends	MSS SP-78
Bronze Gate, Globe, Angle, and Check Valves	MSS SP-80
Steel Valves, Socket Welding and Threaded Ends	ASME B16.34
Cast-Iron Globe and Angle Valves, Flanged and Threaded Ends	MSS SP-85
Backwater Valves	ASME A112.14.1
Vacuum Relief Valves	ANSI Z21.22/CSA 4.4

Water Pressure Reducing Valves	ASSE 1003
Water Heater Drain Valves	ASME BPVC SEC IV, Part HLW-810: Requirements for Potable-Water Heaters Bottom Drain Valve
Trap Seal Primer Valves	ASSE 1018
Temperature and Pressure Relief Valves for Hot Water Supply Systems	ANSI Z21.22/CSA 4.4
Temperature and Pressure Relief Valves for Automatically Fired Hot Water Boilers	ASME CSD-1 Safety Code No., Part CW, Article 5

2.3.1 Backwater Valves

Backwater valves shall be either separate from the floor drain or a combination floor drain, P-trap, and backwater valve, as shown. Valves shall have cast-iron bodies with cleanouts large enough to permit removal of interior parts. Valves shall be of the flap type, hinged or pivoted, with revolving disks. Hinge pivots, disks, and seats shall be nonferrous metal. Disks shall be slightly open in a no-flow no-backwater condition. Cleanouts shall extend to finished floor and be fitted with threaded countersunk plugs.

2.3.2 Wall Faucets

Wall faucets with vacuum-breaker backflow preventer shall be brass with 3/4 inch male inlet threads, hexagon shoulder, and 3/4 inch hose connection. Faucet handle shall be securely attached to stem.

2.3.3 Wall Hydrants (Frostproof)

ASSE 1019 with vacuum-breaker backflow preventer shall have a nickel-brass or nickel-bronze wall plate or flange with nozzle and detachable key handle. A brass or bronze operating rod shall be provided within a galvanized iron casing of sufficient length to extend through the wall so that the valve is inside the building, and the portion of the hydrant between the outlet and valve is self-draining. A brass or bronze valve with coupling and union elbow having metal-to-metal seat shall be provided. Valve rod and seat washer shall be removable through the face of the hydrant. The hydrant shall have 3/4 inch exposed hose thread on spout and 3/4 inch male pipe thread on inlet.

2.3.4 Relief Valves

Water heaters shall have a combination pressure and temperature (P&T) relief valve. The pressure relief element of a P&T relief valve shall have adequate capacity to prevent excessive pressure buildup in the system when the system is operating at the maximum rate of heat input. The temperature element of a P&T relief valve shall have a relieving capacity which is at least equal to the total input of the heaters when operating at their maximum capacity. Relief valves shall be rated according to ANSI Z21.22/CSA 4.4. Relief valves for systems where the maximum rate of heat input is less than 200,000 Btuh shall have 3/4 inch minimum inlets, and 3/4 inch outlets. Relief valves for systems where the maximum rate of heat input is greater than 200,000 Btuh shall have 1 inch minimum inlets, and 1 inch outlets. The discharge pipe from the relief valve shall be the size of the valve outlet.

2.3.5 Thermostatic Mixing Valves

Provide thermostatic mixing valve for lavatory faucets. Mixing valves, thermostatic type, pressure-balanced or combination thermostatic and pressure-balanced shall be line size and shall be constructed with rough or finish bodies either with or without plating. Each valve shall be constructed to control the mixing of hot and cold water and to deliver water at a desired temperature regardless of pressure or input temperature changes. The control element shall be of an approved type. The body shall be of heavy cast bronze, and interior parts shall be brass, bronze, corrosion-resisting steel or copper. The valve shall be equipped with necessary stops, check valves, unions, and sediment strainers on the inlets. Mixing valves shall maintain water temperature within 5 degrees F of any setting.

2.4 FIXTURES

Water closet replacements in major renovations may have a flush valve of up to 1.28 GPF to accommodate existing plumbing capacity. Fixtures for use by the physically handicapped shall be in accordance with ICC A117.1 COMM. Vitreous China, nonabsorbent, hard-burned, and vitrified throughout the body shall be provided. Porcelain enameled ware shall have specially selected, clear white, acid-resisting enamel coating evenly applied on surfaces. No fixture will be accepted that shows cracks, crazes, blisters, thin spots, or other flaws. Fixtures shall be equipped with appurtenances such as traps, faucets, stop valves, and drain fittings. Each fixture and piece of equipment requiring connections to the drainage system, except grease interceptors, shall be equipped with a trap. Brass expansion or toggle bolts capped with acorn nuts shall be provided for supports, and polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Fixtures with the supply discharge below the rim shall be equipped with backflow preventers. Internal parts of flush valves and flushometer valves, shower mixing valves, shower head face plates, pop-up stoppers of lavatory waste drains, and pop-up stoppers and overflow tees may contain acetal resin, fluorocarbon, nylon, acrylonitrile-butadiene-styrene (ABS) or other plastic material, if the material has provided satisfactory service under actual commercial or industrial operating conditions for not less than 2 years. Plastic in contact with hot water shall be suitable for 180 degrees F water temperature.

2.4.1 Automatic Controls

Flushing and faucet systems shall consist of solenoid-activated valves with light beam sensors. Flush valve for water closet shall include an override pushbutton. Flushing devices shall be provided as described in paragraph FIXTURES AND FIXTURE TRIMMINGS.

2.4.2 Flush Valve Water Closets

ASME A112.19.2/CSA B45.1, white vitreous china, siphon jet, elongated bowl, wall mounted, wall outlet. Top of toilet seat height above floor shall be 14 to 15 inches, except 17 to 19 inches for wheelchair water closets. Provide wax bowl ring including plastic sleeve. Provide white solid plastic elongated open-front seat .

Water flushing volume of the water closet and flush valve combination shall not exceed 1.28 gallons per flush. Water closets must meet the EPA WaterSense product definition specified in http://www.epa.gov/watersense/partners/product_program_specs.html and must be EPA WaterSense labeled products. Provide data identifying WaterSense label for flush valve water closet.

Provide large diameter flush valve including angle control-stop valve, vacuum breaker, tail pieces, slip nuts, and wall plates; exposed to view components shall be chromium-plated or polished stainless steel. Flush valves shall be nonhold-open type. Mounted height of flush valve shall not interfere with the hand rail in ADA stalls. Provide hardwired, infrared sensor with override pushbutton flush valves.

2.4.3 Flush Valve Urinals

ASME A112.19.2/CSA B45.1, white vitreous china, ,wall-mounted, wall outlet, siphon jet, integral trap, and extended side shields. Provide urinal with the rim 17 inches above the floor. Water flushing volume of the urinal and flush valve combination shall not exceed 0.125 gallons per flush. Urinals must meet the specifications of http://www.epa.gov/watersense/partners/product_program_specs.html and must be EPA WaterSense labeled products. Provide data identifying WaterSense label for urinal. Provide ASME A112.6.1M concealed chair carriers with vertical steel pipe supports. Provide large diameter flush valve including angle control-stop valve, vacuum breaker, tail pieces, slip nuts, and wall plates; exposed to view components shall be chromium-plated or polished stainless steel. Flush valves shall be nonhold-open type. Provide hardwired, infrared sensor with override pushbutton flush valves.

2.4.4 Countertop Lavatories

Lavatories shall be integral to the countertop. Coordinate with architectural. Provide aerator with faucet. Provide lavatory faucets and accessories meeting the flow rate and product requirements of the paragraph LAVATORIES. Provide top-mounted, hardwired, solenoid-activated lavatory faucets including electrical-operated light-beam-sensor to energize the solenoid.

2.4.5 Kitchen Sinks

Kitchen sinks shall be integral to the countertop. Coordinate with architectural. Provide aerator with faucet. Water flow rate shall not exceed 1.5 gpm when measured at a flowing water pressure of 60 psi. Provide stainless steel drain outlets and stainless steel cup strainers. Provide separate 1.5 inch P-trap and drain piping to vertical vent piping from each compartment. Provide UL 430 waste disposer in right compartment.

2.4.6 Drinking-Water Coolers

AHRI 1010 with more than a single thickness of metal between the potable water and the refrigerant in the heat exchanger, wall-hung, bubbler style, air-cooled condensing unit, 4.75 gph minimum capacity, stainless steel splash receptor and basin, bottle filler and stainless steel cabinet. Bubblers shall be controlled by push levers or push bars, front mounted or side mounted near the front edge of the cabinet. Bubbler spouts shall be mounted at maximum of 36 inches above floor and at front of unit basin. Spouts shall direct water flow at least 4 inches above unit basin and trajectory parallel or nearly parallel to the front of unit. Provide ASME A112.6.1M concealed steel pipe chair carriers. Provide electric water cooler that is Energy Star labeled. Provide data identifying Energy Star label for electric water cooler.

2.4.7 Wheelchair Drinking Water cooler

AHRI 1010, wall-mounted bubbler style with ASME A112.6.1M concealed chair carrier, air-cooled condensing unit, 4.75 gph minimum capacity, stainless steel splash receptor, and all stainless steel cabinet, with 27 inch minimum knee clearance from front bottom of unit to floor and 36 inch maximum spout height above floor and bottle filler. Bubblers shall also be controlled by push levers, by push bars, or touch pads one on each side or one on front and both sides of the cabinet. Provide electric water cooler that is Energy Star labeled. Provide data identifying Energy Star label for wheelchair electric water cooler.

2.4.8 Precast Terrazzo Mop Sinks

Terrazzo shall be made of marble chips cast in white portland cement to produce 3000 psi minimum compressive strength 7 days after casting. Provide floor or wall outlet copper alloy body drain cast integral with terrazzo, with polished stainless steel strainers.

2.4.9 Emergency Eyewash and Shower

ANSI/ISEA Z358.1, floor supported free standing unit. Provide deluge shower head, stay-open ball valve operated by pull rod and ring or triangular handle. Provide eyewash and stay-open ball valve operated by foot treadle or push handle.

2.4.10 Emergency Eye and Face Wash

ANSI/ISEA Z358.1, pedestal mounted self-cleaning, nonclogging eye and face wash with quick opening, full-flow valves, stainless steel eye and face wash receptor. Unit shall deliver 3 gpm of aerated water at 30 psig flow pressure, with eye and face wash nozzles 33 to 45 inches above finished floor. Provide copper alloy control valves. Provide an air-gap with the lowest potable eye and face wash water outlet located above the overflow rim by not less than the International Plumbing Code minimum. Provide a pressure-compensated tempering valve, with leaving water temperature setpoint adjustable throughout the range 60 to 90 degrees F. Provide packaged, UL listed, alarm system; including an amber strobe lamp, horn with externally adjustable loudness and horn silencing switch, mounting hardware, and waterflow service within NEMA Type 3 or 4 enclosures and for explosion proof service within NEMA Type 7 or 9 enclosures.

2.5 BACKFLOW PREVENTERS

Backflow prevention devices must be approved by the State or local regulatory agencies. If there is no State or local regulatory agency requirements, the backflow prevention devices must be listed by the

Foundation for Cross-Connection Control & Hydraulic Research, or any other approved testing laboratory having equivalent capabilities for both laboratory and field evaluation of backflow prevention devices and assemblies.

Reduced pressure principle assemblies, double check valve assemblies, atmospheric (nonpressure) type vacuum breakers, and pressure type vacuum breakers shall be meet the above requirements.

Backflow preventers with intermediate atmospheric vent shall conform to ASSE 1012. Reduced pressure principle backflow preventers shall conform to ASSE 1013. Hose connection vacuum breakers shall conform to ASSE 1011. Pipe applied atmospheric type vacuum breakers shall conform to ASSE 1001. Pressure vacuum breaker assembly shall conform to ASSE 1020. Air gaps in plumbing systems shall conform to ASME A112.1.2.

2.6 DRAINS

2.6.1 Floor and Shower Drains

Floor and shower drains shall consist of a galvanized body, integral seepage pan, and adjustable perforated or slotted chromium-plated bronze, nickel-bronze, or nickel-brass strainer, consisting of grate and threaded collar. Floor drains shall be cast iron except where metallic waterproofing membrane is installed. Drains shall be of double drainage pattern for embedding in the floor construction. The seepage pan shall have weep holes or channels for drainage to the drainpipe. The strainer shall be adjustable to floor thickness. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or waterproofing membrane shall be provided when required. Drains shall be provided with threaded connection. Between the drain outlet and waste pipe, a neoprene rubber gasket conforming to ASTM C564 may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Floor and shower drains shall conform to ASME A112.6.3. Provide drain with trap primer connection, trap primer, and connection piping. Primer shall meet ASSE 1018. Where indicated on plans, provide a deep-seal trap consisting of a 4-inch seal when primer valves are not available.

2.6.1.1 Metallic Shower Pan Drains

Where metallic shower pan membrane is installed, polyethylene drain with corrosion-resistant screws securing the clamping device shall be provided. Polyethylene drains shall have fittings to adapt drain to waste piping. Polyethylene for floor drains shall conform to ASTM D1248. Drains shall have separate cast-iron "P" trap, circular body, seepage pan, and strainer, unless otherwise indicated.

2.6.1.2 Drains and Backwater Valves

Drains and backwater valves installed in connection with waterproofed floors or shower pans shall be equipped with bolted-type device to securely clamp flashing.

2.6.2 Shower Faucets

Provide single control pressure equalizing shower faucets with body mounted from behind the wall with threaded connections. Provide ball joint self-cleaning shower heads. Provide WaterSense labeled showerhead with a maximum flow rate of (1.75 gpm). Provide data identifying WaterSense label for showerhead. Provide separate globe valves or angle valves with union connections in each supply to faucet.

2.7 SHOWER PAN

2.7.1 Plasticized Polyvinyl Chloride Shower Pan Material

Material shall be sheet form. The material shall be 0.040 inch minimum thickness of plasticized polyvinyl chloride or chlorinated polyethylene and shall be in accordance with ASTM D4551.

2.8 TRAPS

Unless otherwise specified, traps shall be copper-alloy adjustable tube type with slip joint inlet and swivel. Traps shall be without a cleanout. Provide traps with removable access panels for easy clean-out at sinks and lavatories. Tubes shall be copper alloy with walls not less than 0.032 inch thick within commercial tolerances, except on the outside of bends where the thickness may be reduced slightly in manufacture by usual commercial methods. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level. Swivel joints shall be below the discharge level and shall be of metal-to-metal or metal-to-plastic type as required for the application. Nuts shall have flats for wrench grip. Outlets shall have internal pipe thread, except that when required for the application, the outlets shall have sockets for solder-joint connections. The depth of the water seal shall be not less than 2 inches. The interior diameter shall be not more than 1/8 inch over or under the nominal size, and interior surfaces shall be reasonably smooth throughout. A copper alloy "P" trap assembly consisting of an adjustable "P" trap and threaded trap wall nipple with cast brass wall flange shall be provided for lavatories. The assembly shall be a standard manufactured unit and may have a rubber-gasketed swivel joint.

2.9 WATER HEATERS

Water heater types and capacities shall be as indicated. Each water heater shall have replaceable anodes. Each primary water heater shall have controls with an adjustable range that includes 90 to 160 degrees F. Each gas-fired water heater and booster water heater shall have controls with an adjustable range that includes 120 to 180 degrees F. Hot water systems utilizing recirculation systems shall be tied into building off-hour controls. The thermal efficiencies and standby heat losses shall conform to TABLE III in PART 3 of this Section for each type of water heater specified. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. A factory pre-charged expansion tank shall be installed on the cold water supply to each water heater. Expansion tanks shall be specifically designed for use on potable water systems and shall be rated for 200 degrees F water temperature and 150 psi working pressure. The expansion tank size and acceptance volume shall be as indicated.

2.9.1 Instantaneous Water Heater

Heater shall be crossflow design with service water in the coil and hot water in the shell. An integral internal controller shall be provided, anticipating a change in demand so that the final temperature can be maintained under all normal load conditions when used in conjunction with pilot-operated temperature control system. Normal load conditions shall be as specified by the manufacturer for the heater. Unit shall be manufactured in accordance with ASME BPVC SEC VIII D1, and shall be certified for 150 psi working pressure in the shell and 150 psi working pressure in the coils. Shell shall be carbon steel with copper lining. Heads shall be carbon steel plate with copper lining. Coils shall be copper . Shell shall have metal sheathed fiberglass insulation, combination pressure and temperature relief valve, and thermometer. Insulation shall be as specified in Section 22 07 19.00 40 PLUMBING PIPING INSULATION. For gas service, provide Energy Star labeled gas instantaneous water heater. Provide data identifying Energy Star label for gas instantaneous water heater.

2.10 PUMPS

2.10.1 Circulating Pumps

Domestic hot water circulating pumps shall be electrically driven, single-stage, centrifugal, with mechanical seals, suitable for the intended service. Pump and motor shall be supported by the piping on which it is installed. The shaft shall be one-piece, heat-treated, corrosion-resisting steel with impeller and smooth-surfaced housing of bronze.

Motor shall be totally enclosed, fan-cooled and shall have sufficient horsepower for the service required. Each pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in cover.

2.10.2 Flexible Connectors

Flexible connectors shall be provided at the suction and discharge of each pump that is 1 hp or larger. Connectors shall be constructed of neoprene, rubber, or braided bronze, with Class 150 standard flanges. Flexible connectors shall be line size and suitable for the pressure and temperature of the intended service.

2.11 WASH WATER PRESSURE BOOSTER SYSTEM

2.11.1 Hydro-Pneumatic Water Pressure System

An ASME code constructed tank stamped for 150 psig water working pressure shall be provided. The tank shall have a flexible diaphragm made of material conforming to FDA requirements for use with potable water and shall be factory precharged to meet required system pressure.

2.11.2 Variable Speed Pumping System

Variable speed pumping system shall provide system pressure by varying speed and number of operating pumps. The factory prepiped and prewired assembly shall be mounted on a steel frame complete with pumps, variable speed drives, motors, and controls. The variable speed drives shall be the oil-filled type capable of power transmission throughout their complete speed range without vibration, noise, or shock loading. Each variable speed drive shall be run-tested by the manufacturer for rated performance, and the manufacturer shall furnish written performance certification. System shall have suppressors to prevent noise transmission over electric feed lines. Required electrical control circuitry and system function sensors shall be supplied by the variable speed drive manufacturer. The primary power controls and magnetic motor controllers shall be installed in the controls supplied by the drive manufacturer . The sensors shall be located in the system to control drive speed as a function of constant pump discharge pressure . Connection between the sensors and the variable speed drive controls shall be accomplished with copper wiring . Controls shall be in NEMA 250, Type 1 enclosures.

2.12 COMPRESSED AIR SYSTEM

2.12.1 Air Dryer

Provide mass-refrigerated air dryer that maintain the air in the system with a dew point low enough to prevent condensation at 13 degrees F at 18 psi main pressure. Locate the air dryer at the outlet of the tank. Ensure that the control air delivered to the system conforms to ISA 7.0.01.

2.12.2 Intake Air Supply Filter

Dry type air filter shall be provided having a collection efficiency of 99 percent of particles larger than 10 microns. Filter body and media shall withstand a maximum 125 psi, capacity as indicated.

2.12.3 Pressure Regulators

The air system shall be provided with the necessary regulator valves to maintain the desired pressure for the installed equipment. Regulators shall be designed for a maximum inlet pressure of 125 psi and a maximum temperature of 200 degrees F. Regulators shall be single-seated, pilot-operated with valve plug, bronze body and trim or equal, and threaded connections. The regulator valve shall include a pressure gauge and shall be provided with an adjustment screw for adjusting the pressure differential from 0 to 125 psi. Regulator shall be sized as indicated.

2.13 DOMESTIC WATER SERVICE METER

Cold water meters 2 inches and smaller shall be positive displacement type conforming to AWWA C700. Cold water meters 2-1/2 inches and larger shall be turbine type conforming to AWWA C701. Meter register may be round or straight reading type, as provided by the local utility. Meter shall be provided with a pulse generator, remote readout register and all necessary wiring and accessories.

Meters must be connected to the base wide energy and utility monitoring and control system (if this system exists) using the installation's advanced metering protocols.

2.14 ELECTRICAL WORK

Provide electrical motor driven equipment specified complete with motors, motor starters, and controls as specified herein and in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, corresponding to the applications in accordance with NEMA MG 11. In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide polyphase, squirrel-cage medium induction motors with continuous ratings, 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. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

Controllers and contactors shall have auxiliary contacts for use with the controls provided. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers, including the required monitors and timed restart.

Power wiring and conduit for field installed equipment shall be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.15 MISCELLANEOUS PIPING ITEMS

2.15.1 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.

2.15.2 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.

2.15.2.1 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.

2.15.2.2 Sleeves Not in Masonry and Concrete

Provide 26 gage galvanized steel sheet or PVC plastic pipe sleeves.

2.15.3 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.

2.15.4 Nameplates

Provide 0.125 inch thick melamine laminated plastic nameplates, black matte finish with white center core, for equipment, gages, thermometers, and valves; valves in supplies to faucets will not require nameplates. Accurately align lettering and engrave minimum of 0.25 inch high normal block lettering into the white core. Minimum size of nameplates shall be 1.0 by 2.5 inches. Key nameplates to a chart and schedule for each system. Frame charts and schedules under glass and place where directed near each system. Furnish two copies of each chart and schedule.

2.15.5 Labels

Provide labels for sensor operators at flush valves and faucets. Include the following information on each label:

a. Identification of the sensor and its operation with written description.

b. Range of the sensor.

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. The plumbing system shall be installed complete with necessary fixtures, fittings, traps, valves, and accessories. Water and drainage piping shall be extended 5 feet outside the building, unless otherwise indicated. A gate valve and drain shall be installed on the water service line inside the building approximately 6 inches above the floor from point of entry. Piping shall be connected to the exterior service lines or capped or plugged if the exterior service is not in place. Sewer and water pipes shall be laid in separate trenches, except when otherwise shown. Exterior underground utilities shall be at least 12 inches below the average local frost depth or as indicated on the drawings. If trenches are closed or the pipes are otherwise covered before being connected to the service lines, the location of the end of each plumbing utility shall be marked with a stake or other acceptable means. Valves shall be installed with control no lower than the valve body.

3.1.1 Water Pipe, Fittings, and Connections

3.1.1.1 Utilities

The piping shall be extended to fixtures, outlets, and equipment. The hot-water and cold-water piping system shall be arranged and installed to permit draining. The supply line to each item of equipment or fixture, except faucets, flush valves, or other control valves which are supplied with integral stops, shall be equipped with a shutoff valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures. Supply piping to fixtures, faucets, hydrants, shower heads, and flushing devices shall be anchored to prevent movement.

3.1.1.2 Cutting and Repairing

The work shall be carefully laid out in advance, and unnecessary cutting of construction shall be avoided. Damage to building, piping, wiring, or equipment as a result of cutting shall be repaired by mechanics skilled in the trade involved.

3.1.1.3 Protection of Fixtures, Materials, and Equipment

Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water, chemicals, and mechanical injury. Upon completion of the work, the fixtures, materials, and equipment shall be thoroughly cleaned, adjusted, and operated. Safety guards shall be provided for exposed rotating equipment.

3.1.1.4 Mains, Branches, and Runouts

Piping shall be installed as indicated. Pipe shall be accurately cut and worked into place without springing or forcing. Structural portions of the building shall not be weakened. Aboveground piping shall run parallel with the lines of the building, unless otherwise indicated. Branch pipes from service lines may be taken from top, bottom, or side of main, using crossover fittings required by structural or installation conditions. Supply pipes, valves, and fittings shall be kept a sufficient distance from other work and other services to permit not less than 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.

3.1.1.5 Pipe Drains

Pipe drains indicated shall consist of 3/4 inch hose bibb with renewable seat and full port ball valve ahead of hose bibb. At other low points, 3/4 inch brass plugs or caps shall be provided. Disconnection of the supply piping at the fixture is an acceptable drain.

3.1.1.6 Expansion and Contraction of Piping

Allowance shall be made throughout for expansion and contraction of water pipe. Each hot-water and hot-water circulation riser shall have expansion loops or other provisions such as offsets and changes in direction where indicated and required. Risers shall be securely anchored as required or where indicated to force expansion to loops. Branch connections from risers shall be made with ample swing or offset to avoid undue strain on fittings or short pipe lengths. Horizontal runs of pipe over 50 feet in length shall be anchored to the wall or the supporting construction about midway on the run to force expansion, evenly divided, toward the ends. Sufficient flexibility shall be provided on branch runouts from mains and risers to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that piping will spring enough to allow for expansion without straining. If mechanical grooved pipe coupling systems are provided, the deviation from design requirements for expansion and contraction may be allowed pending approval of Contracting Officer.

3.1.1.7 Commercial-Type Water Hammer Arresters

Commercial-type water hammer arresters shall be provided on hot- and cold-water supplies and shall be located as generally indicated, with precise location and sizing to be in accordance with PDI WH 201. Water hammer arresters, where concealed, shall be accessible by means of access doors or removable panels. Commercial-type water hammer arresters shall conform to ASSE 1010. Vertical capped pipe columns will not be permitted.

3.1.2 Compressed Air Piping (Non-Oil Free)

Compressed air piping shall be installed as specified for water piping and suitable for 125 psig working pressure. Compressed air piping shall have supply lines and discharge terminals legibly and permanently marked at both ends with the name of the system and the direction of flow.

3.1.3 Joints

Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints shall be made up with fittings of compatible material and made for the specific purpose intended.

3.1.3.1 Threaded

Threaded joints shall have American Standard taper pipe threads conforming to 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.

3.1.3.2 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.

3.1.3.3 Unions and Flanges

Unions, flanges and mechanical couplings shall not be concealed in walls, ceilings, or partitions. Unions shall be used on pipe sizes 2-1/2 inches and smaller; flanges shall be used on pipe sizes 3 inches and larger.

3.1.3.4 Grooved Mechanical Joints

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be products of the same manufacturer. 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, 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.

3.1.3.5 Cast Iron Soil, Waste and Vent Pipe

Bell and spigot compression and hubless gasketed clamp joints for soil, waste and vent piping shall be installed per the manufacturer's recommendations.

3.1.3.6 Copper Tube and Pipe

a. Brazed. Brazed joints shall be made in conformance with AWS B2.2/B2.2M, ASME B16.50, and CDA A4015 with flux and are acceptable for all pipe sizes. Copper to copper joints shall include the use of copper-phosphorus or copper-phosphorus-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorus, copper-phosphorus-silver or a silver brazing filler metal.

b. Soldered. Soldered joints shall be made with flux and are only acceptable for piping 2 inches and smaller. Soldered joints shall conform to ASME B31.5 and CDA A4015. Soldered joints shall not be used in compressed air piping between the air compressor and the receiver.

c. Copper Tube Extracted Joint. Mechanically extracted joints shall be made in accordance with ICC IPC.

d. Press connection. Copper press connections shall be made in **strict** accordance with the manufacturer's installation instructions for manufactured rated size. The joints shall be pressed using the tool(s) approved by the manufacturer **of that joint**. Minimum distance between fittings shall be in accordance with the manufacturer's requirements.

3.1.4 Dissimilar Pipe Materials

Connections between ferrous and non-ferrous copper water pipe shall be made with dielectric unions or flange waterways. Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways. Connecting joints between plastic and metallic pipe shall be made with transition fitting for the specific purpose.

3.1.5 Corrosion Protection for Buried Pipe and Fittings

Ductile iron, cast iron, and steel pipe, fittings, and joints shall have a protective coating. Additionally, ductile iron, cast iron, and steel pressure pipe shall have a cathodic protection system and joint bonding. The cathodic protection system, protective coating system, and joint bonding for cathodically protected pipe shall be in accordance with . Coatings shall be selected, applied, and inspected in accordance with NACE SP0169 and as otherwise specified. The pipe shall be cleaned and the coating system applied prior to pipe tightness testing. Joints and fittings shall be cleaned and the coating system applied after pipe tightness testing. For tape coating systems, the tape shall conform to AWWA C203 and shall be applied with a 50 percent overlap. Primer utilized with tape type coating systems shall be as recommended by the tape manufacturer.

3.1.6 Pipe Sleeves and Flashing

Pipe sleeves shall be furnished and set in their proper and permanent location.

3.1.6.1 Sleeve Requirements

Unless indicated otherwise, provide pipe sleeves meeting the following requirements:

Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors.

A modular mechanical type sealing assembly may be installed in lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve. The seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and sleeve using galvanized steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe and sleeve involved.

Sleeves shall not be installed in structural members, except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective floor, or roof, and shall be cut flush with each surface, except for special circumstances. Pipe sleeves passing through floors in wet areas such as mechanical equipment rooms, lavatories, kitchens, and other plumbing fixture areas shall extend a minimum of 4 inches above the finished floor.

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.

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.

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 concrete 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.

3.1.6.2 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.

3.1.6.3 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.

3.1.6.4 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.

3.1.6.5 Pipe Penetrations

Provide sealants for all pipe penetrations. All pipe penetrations shall be sealed to prevent infiltration of air, insects, and vermin.

3.1.7 Fire Seal

Where pipes pass through fire walls, fire-partitions, fire-rated pipe chase walls or floors above grade, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.1.8 Supports

3.1.8.1 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.

3.1.8.2 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 40 shields shall:

(1) Be used on insulated pipe less than 4 inches.

(2) Have a high density insert for all pipe sizes. High density inserts shall have a density of 8 pcf or greater.

h. 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. Horizontal pipe runs shall include allowances for expansion and contraction.

i. 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.

j. 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 less than 4 inches a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

k. 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.

l. 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.

3.1.8.3 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.

3.1.9 Welded Installation

Plumbing pipe weldments shall be as indicated. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connection may be made with either welding tees or forged branch outlet fittings. Branch outlet fittings shall be forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded. After filler metal has been removed from its original package, it shall be protected or stored so that its characteristics or welding properties are not affected. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.10 Pipe Cleanouts

Pipe cleanouts shall be the same size as the pipe except that cleanout plugs larger than 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 .

3.2 WATER HEATERS AND HOT WATER STORAGE TANKS

3.2.1 Relief Valves

No valves shall be installed between a relief valve and its water heater or storage tank. The P&T relief valve shall be installed where the valve actuator comes in contact with the hottest water in the heater. Whenever possible, the relief valve shall be installed directly in a tapping in the tank or heater; otherwise, the P&T valve shall be installed in the hot-water outlet piping. A vacuum relief valve shall be provided on the cold water supply line to the hot-water storage tank or water heater and mounted above and within 6 inches above the top of the tank or water heater.

3.2.2 Installation of Gas-Fired Water Heater

Installation shall conform to NFPA 54 for gas fired. Storage water heaters that are not equipped with integral heat traps and having vertical pipe risers shall be installed with heat traps directly on both the inlet and outlet. Circulating systems need not have heat traps installed. An acceptable heat trap may be a piping arrangement such as elbows connected so that the inlet and outlet piping make vertically upward runs of not less than 24 inches just before turning downward or directly horizontal into the water heater's inlet and outlet fittings. Commercially available heat traps, specifically designed by the manufacturer for the purpose of effectively restricting the natural tendency of hot water to rise through vertical inlet and outlet piping during standby periods may also be approved.

3.2.3 Heat Traps

Piping to and from each water heater and hot water storage tank shall be routed horizontally and downward a minimum of 2 feet before turning in an upward direction.

3.2.4 Connections to Water Heaters

Connections of metallic pipe to water heaters shall be made with dielectric unions or flanges.

3.2.5 Expansion Tank

A pre-charged expansion tank shall be installed on the cold water supply between the water heater inlet and the cold water supply shut-off valve. The Contractor shall adjust the expansion tank air pressure, as recommended by the tank manufacturer, to match incoming water pressure.

3.3 FIXTURES AND FIXTURE TRIMMINGS

Polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Angle stops, straight stops, stops integral with the faucets, or concealed type of lock-shield, and loose-key pattern stops for supplies with threaded, sweat or solvent weld inlets shall be furnished and installed with fixtures. Where connections between copper tubing and faucets are made by rubber compression fittings, a beading tool shall be used to mechanically deform the tubing above the compression fitting. Exposed traps and supply pipes for fixtures and equipment shall be connected to the rough piping systems at the wall, unless otherwise specified under the item. Floor and wall escutcheons shall be as specified. Drain lines and hot water lines of fixtures for handicapped personnel shall be insulated and do not require polished chrome finish. Plumbing fixtures and accessories shall be installed within the space shown.

3.3.1 Fixture Connections

Where space limitations prohibit standard fittings in conjunction with the cast-iron floor flange, special short-radius fittings shall be provided. Connections between earthenware fixtures and flanges on soil pipe shall be made gastight and watertight with a closet-setting compound or neoprene gasket and seal. Use of natural rubber gaskets or putty will not be permitted. Fixtures with outlet flanges shall be set the proper distance from floor or wall to make a first-class joint with the closet-setting compound or gasket and fixture used.

3.3.2 Flushometer Valves

Flushometer valves shall be secured to prevent movement by anchoring the long finished top spud connecting tube to wall adjacent to valve with approved metal bracket.

3.3.3 Height of Fixture Rims Above Floor

Wall-hung drinking fountains and water coolers shall be installed with rim 42 inches above floor. Wall-hung service sinks shall be mounted with rim 28 inches above the floor. Installation of fixtures for use by the physically handicapped shall be in accordance with ICC A117.1 COMM.

3.3.4 Fixture Supports

Fixture supports for off-the-floor urinals, water closets, and other fixtures of similar size, design, and use, shall be of the chair-carrier type. The carrier shall provide the necessary means of mounting the fixture, with a foot or feet to anchor the assembly to the floor slab. Adjustability shall be provided to locate the fixture at the desired height and in proper relation to the wall. Support plates, in lieu of chair carrier, shall be fastened to the wall structure only where it is not possible to anchor a floor-mounted chair carrier to the floor slab.

3.3.4.1 Support for Solid Masonry Construction

Chair carrier shall be anchored to the floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be imbedded in the masonry wall.

3.3.4.2 Support for Concrete-Masonry Wall Construction

Chair carrier shall be anchored to floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be fastened to the concrete wall using through bolts and a back-up plate.

3.3.4.3 Support for Steel Stud Frame Partitions

Chair carrier shall be used. The anchor feet and tubular uprights shall be of the heavy duty design; and feet (bases) shall be steel and welded to a square or rectangular steel tube upright. Wall plates, in lieu of floor-anchored chair carriers, shall be used only if adjoining steel partition studs are suitably reinforced to support a wall plate bolted to these studs.

3.3.4.4 Wall-Mounted Water Closet Gaskets

Where wall-mounted water closets are provided, reinforced wax, treated felt, or neoprene gaskets shall be provided. The type of gasket furnished shall be as recommended by the chair-carrier manufacturer.

3.3.5 Backflow Prevention Devices

Plumbing fixtures, equipment, and pipe connections shall not cross connect or interconnect between a potable water supply and any source of nonpotable water. Backflow preventers shall be installed where indicated and in accordance with IAPMO UPC at all other locations necessary to preclude a cross-connect or interconnect between a potable water supply and any nonpotable substance. In addition backflow preventers shall be installed at all locations where the potable water outlet is below the flood level of the equipment, or where the potable water outlet will be located below the level of the nonpotable substance. Backflow preventers shall be located so that no part of the device will be submerged. Backflow preventers shall be of sufficient size to allow unrestricted flow of water to the equipment, and preclude the backflow of any nonpotable substance into the potable water system. Bypass piping shall not be provided around backflow preventers. Access shall be provided for maintenance and testing. Each device shall be a standard commercial unit.

3.3.6 Access Panels

Access panels shall be provided for concealed valves and controls, or any item requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced, maintained, or replaced. Access panels shall be as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.3.7 Sight Drains

Sight drains shall be installed so that the indirect waste will terminate 2 inches above the flood rim of the funnel to provide an acceptable air gap.

3.3.8 Traps

Each trap shall be placed as near the fixture as possible, and no fixture shall be double-trapped. Traps installed on cast-iron soil pipe shall be cast iron. Traps installed on steel pipe or copper tubing shall be recess-drainage pattern, or brass-tube type. Traps for acid-resisting waste shall be of the same material as the pipe.

3.3.9 Shower Pans

Before installing shower pan, subfloor shall be free of projections such as nail heads or rough edges of aggregate. Drain shall be a bolt-down, clamping-ring type with weepholes, installed so the lip of the subdrain is flush with subfloor.

3.3.9.1 General

The floor of each individual shower, the shower-area portion of combination shower and drying room, and the entire shower and drying room where the two are not separated by curb or partition, shall be made watertight with a shower pan fabricated in place. The shower pan material shall be cut to size and shape of the area indicated, in one piece to the maximum extent practicable, allowing a minimum of 6 inches for turnup on walls or partitions, and shall be folded over the curb with an approximate return of 1/4 of curb height. The upstands shall be placed behind any wall or partition finish. Subflooring shall be smooth and clean, with nailheads driven flush with surface, and shall be sloped to drain. Shower pans shall be clamped to drains with the drain clamping ring.

3.4 VIBRATION-ABSORBING FEATURES

Mechanical equipment, including compressors and pumps, shall be isolated from the building structure by approved vibration-absorbing features, unless otherwise shown. Each foundation shall include an adequate number of standard isolation units. Each unit shall consist of machine and floor or foundation fastening, together with intermediate isolation material, and shall be a standard product with printed load rating. Piping connected to mechanical equipment shall be provided with flexible connectors. Isolation unit installation shall limit vibration to 40 percent of the lowest equipment rpm.

3.4.1 Tank- or Skid-Mounted Compressors

Floor attachment shall be as recommended by compressor manufacturer.

3.5 WATER METER REMOTE READOUT REGISTER

The remote readout register shall be mounted at the location indicated or as directed by the Contracting Officer.

3.6 IDENTIFICATION SYSTEMS

3.6.1 Identification Tags

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and valve number shall be installed on valves, except those valves installed on supplies at plumbing fixtures. Tags shall be 1-3/8 inch minimum diameter, and marking shall be stamped or engraved. Indentations shall be black, for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain, or plastic straps designed for that purpose.

3.6.2 Pipe Color Code Marking

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.7 ESCUTCHEONS

Escutcheons shall be provided at finished surfaces where bare or insulated piping, exposed to view, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

3.8 PAINTING

Painting of pipes, hangers, supports, and other iron work, either in concealed spaces or exposed spaces, is specified in Section 09 90 00 PAINTS AND COATINGS.

3.8.1 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.

3.8.1.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that 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 adhesion; and the specimen shall 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 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.

3.9 TESTS, FLUSHING AND DISINFECTION

3.9.1 Plumbing System

The following tests shall be performed on the plumbing system in accordance with IAPMO UPC, 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.

c. Water Supply Systems Tests.

3.9.1.1 Test of Backflow Prevention Assemblies

Backflow prevention assembly shall be tested using gauges specifically designed for the testing of backflow prevention assemblies.

Backflow prevention assembly test gauges shall be tested annually for accuracy in accordance with the requirements of State or local regulatory agencies. If there is no State or local regulatory agency requirements, gauges shall be tested annually for accuracy in accordance with the requirements of University of Southern California's Foundation of Cross Connection Control and Hydraulic Research or the American Water Works Association Manual of Cross Connection (Manual M-14), or any other approved testing laboratory having equivalent capabilities for both laboratory and field evaluation of backflow prevention assembly test gauges. Report form for each assembly shall include, as a minimum, the following:

Data on Device	Data on Testing Firm
Type of Assembly	Name
Manufacturer	Address
Model Number	Certified Tester
Serial Number	Certified Tester No.
Size	Date of Test
Location	

Test Pressure Readings	Serial Number and Test Data of Gauges

If the unit fails to meet specified requirements, the unit shall be repaired and retested.

3.9.1.2 Shower Pans

After installation of the pan and finished floor, the drain shall be temporarily plugged below the weep holes. The floor area shall be flooded with water to a minimum depth of 1 inch for a period of 24 hours. Any drop in the water level during test, except for evaporation, will be reason for rejection, repair, and retest.

3.9.1.3 Compressed Air Piping (Nonoil-Free)

Piping systems shall be filled with oil-free dry air or gaseous nitrogen to 150 psig and hold this pressure for 2 hours with no drop in pressure.

3.9.2 Defective Work

If inspection or test shows defects, such defective work or material shall be replaced or repaired as necessary and inspection and tests shall be repeated. Repairs to piping shall be made with new materials. Caulking of screwed joints or holes will not be acceptable.

3.9.3 System Flushing

3.9.3.1 During Flushing

Before operational tests or disinfection, potable water piping system shall be flushed with hot potable water. Sufficient water shall be used to produce a water velocity that is capable of entraining and removing debris in all portions of the piping system. This requires simultaneous operation of all fixtures on a common branch or main in order to produce a flushing velocity of approximately 4 fps through all portions of the piping system. In the event that this is impossible due to size of system, the Contracting Officer (or the designated representative) shall specify the number of fixtures to be operated during flushing. Contractor shall provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the facility. Contractor shall be responsible for any flood damage resulting from flushing of the system. Flushing shall be continued until entrained dirt and other foreign materials have been removed and until discharge water shows no discoloration. All faucets and drinking water fountains, to include any device considered as an end point device by NSF/ANSI 61, Section 9, shall be flushed a minimum of 0.25 gallons per 24 hour period, ten times over a 14 day period.

3.9.3.2 After Flushing

System shall be drained at low points. Strainer screens shall be removed, cleaned, and replaced. After flushing and cleaning, systems shall be prepared for testing by immediately filling water piping with clean, fresh potable water. Any stoppage, discoloration, or other damage to the finish, furnishings, or parts of the building due to the Contractor's failure to properly clean the piping system shall be repaired by the Contractor. When the system flushing is complete, the hot-water system shall be adjusted for uniform circulation. Flushing devices and automatic control systems shall be adjusted for proper operation according to manufacturer's instructions. Flow rates on fixtures must not exceed those stated in PART 2 of this Section. Unless more stringent local requirements exist, lead levels shall not exceed limits established by 40 CFR 141.80 (c)(1). The water supply to the building shall be tested separately to ensure that any lead contamination found during potable water system testing is due to work being performed inside the building.

3.9.4 Operational Test

Upon completion of flushing and prior to disinfection procedures, the Contractor shall subject the plumbing system to operating tests to demonstrate satisfactory installation, connections, adjustments, and functional and operational efficiency. Such operating tests shall cover a period of not less than 8 hours for each system and shall include the following information in a report with conclusion as to the adequacy of the system:

a. Time, date, and duration of test.

b. Water pressures at the most remote and the highest fixtures.

c. Operation of each fixture and fixture trim.

d. Operation of each valve, hydrant, and faucet.

e. Pump suction and discharge pressures.

f. Temperature of each domestic hot-water supply.

g. Operation of each floor drain by flooding with water.

h. Operation of each vacuum breaker and backflow preventer.

i. Compressed air readings at each compressor and at each outlet. Each indicating instrument shall be read at 1/2 hour intervals. The report of the test shall be submitted in quadruplicate. The Contractor shall furnish instruments, equipment, and personnel required for the tests; the Government will furnish the necessary water and electricity.

3.9.5 Disinfection

After all system components are provided and operational tests are complete, the entire domestic hot- and cold-water distribution system shall be disinfected. Before introducing disinfecting chlorination material, entire system shall be flushed with potable water until any entrained dirt and other foreign materials have been removed.

Water chlorination procedure shall be in accordance with AWWA C651 and AWWA C652 as modified and supplemented by this specification. The chlorinating material shall be hypochlorites or liquid chlorine. The chlorinating material shall be fed into the water piping system at a constant rate at a concentration of at least 50 parts per million (ppm). Feed a properly adjusted hypochlorite solution injected into the system with a hypochlorinator, or inject liquid chlorine into the system through a solution-feed chlorinator and booster pump until the entire system is completely filled.

Test the chlorine residual level in the water at 6 hour intervals for a continuous period of 24 hours. If at the end of a 6 hour interval, the chlorine residual has dropped to less than 25 ppm, flush the piping including tanks with potable water, and repeat the above chlorination procedures. During the chlorination period, each valve and faucet shall be opened and closed several times.

After the second 24 hour period, verify that no less than 25 ppm chlorine residual remains in the treated system. The 24 hour chlorination procedure must be repeated until no less than 25 ppm chlorine residual remains in the treated system.

Upon the specified verification, the system including tanks shall then be flushed with potable water until the residual chlorine level is reduced to less than one part per million. During the flushing period, each valve and faucet shall be opened and closed several times.

Take additional samples of water in disinfected containers, for bacterial examination, at locations specified by the Contracting Officer Test these samples for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with EPA SM 9223 . The testing method used shall be EPA approved for drinking water systems and shall comply with applicable local and state requirements.

Disinfection shall be repeated until bacterial tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

3.10 POSTED INSTRUCTIONS

Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

3.11 PERFORMANCE OF WATER HEATING EQUIPMENT

Standard rating condition terms are as follows:

EF = Energy factor, minimum overall efficiency.

ET = Minimum thermal efficiency with 70 degrees F delta T.

SL = Standby loss is maximum (Btu/h) based on a 70 degrees F temperature difference between stored water and ambient requirements.

Q = Nameplate input rate in kW (Btu/h)

3.11.1 Instantaneous Water Heater

3.11.1.1 Gas

a. Rating of 4,000 Btu/h/gal and greater and less than 2 gallons with an input greater than 50,000 Btu/h and less than 200,000 Btu/h shall have a minimum energy factor (EF) of 0.62-0.0019V per 10 CFR 430.

b. Rating of 4,000 Btu/h/gal and greater and less than 10 gallons with an input of 200,000 Btu/h and greater shall have a minimum thermal efficiency (ET) of 80 percent per ANSI Z21.10.3/CSA 4.3

c. Rating of 4,000 BTU/h/gal and greater and 10 gallons and greater with an input of 200,000 Btu/h and greater shall have a minimum thermal efficiency (ET) of 80 percent and the maximum SL shall be Q/800+110x(V^^1/2)) per ANSI Z21.10.3/CSA 4.3

3.12 TABLES

TABLE I

PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS

It #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F	SERVICE G
1	Cast iron soil pipe and fittings, hub and spigot, ASTM A74 with compression gaskets. Pipe and fittings shall be marked with the CISPI	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	Copper drainage tube, (DWV), ASTM B306							X
4	Polyvinyl Chloride plastic drain, waste and vent pipe and fittings, ASTM D2665, ASTM F891, (Sch	X	X	X	X	X	X	X

TABLE I								
PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS								
It #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE E	SERVICE F	SERVICE G

SERVICE:

A - Underground Building Soil, Waste and Storm Drain
B - Aboveground Soil, Waste, Drain In Buildings
C - Underground Vent
D - Aboveground Vent
E - Interior Rainwater Conductors Aboveground
F - Corrosive Waste And Vent Above And Belowground
G - Condensate Drain Aboveground

* - Hard Temper

TABLE II					
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS					
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
1	Malleable-iron threaded fittings:				
	a. Not galvanized for use with Item 2a			X	
2	Steel pipe:				
	a. Seamless, black, ASTM A53/A53M, Type S, Grade B			X	
3	Seamless copper pipe, ASTM B42	X	X		X
4	Seamless copper water tube, ASTM B88, ASTM B88M	X**	X**	X**	X***
5	Wrought copper and bronze solder-joint pressure fittings, ASME B16.22 for use with Items 5, 7 and 8	X	X	X	X
6	Cast copper alloy solder-joint pressure fittings, ASME B16.18 for use with Item 8	X	X	X	X

TABLE II

PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D
7	Carbon steel pipe unions, socket-welding and threaded, MSS SP-83	X	X	X	
8	Malleable-iron threaded pipe unions ASME B16.39	X	X		
9	Nipples, pipe threaded ASTM A733	X	X	X	
	SERVICE: A - Cold Water Service Aboveground B - Hot and Cold Water Distribution 180 degrees F Maximum Aboveground C - Compressed Air Lubricated D - Cold Water Service Belowground Indicated types are minimum wall thicknesses. ** - Type L - Hard *** - Type K - Hard temper with brazed joints only or type K-soft temper without joints in or under floors **** - In or under slab floors only brazed joints				

TABLE III

STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT

FUEL	STORAGE CAPACITY GALLONS	INPUT RATING	TEST PROCEDURE	REQUIRED PERFORMANCE
A. Instantaneous Water Heater				
Gas	4,000 (btu/h)/gal and 2 gal max.	50,000 Btu/h min 200,000 Btu/h max.	10 CFR 430	EF = 0.62-0.0019V
Gas	4,000 (btu/h)/gal and 2 gal max.	200,000 Btu/h min.	ANSI Z21.10.3,	ET = 80 percent
Gas	4,000 (btu/h)/gal and 2 gal max.	200,000 Btu/h min.	ANSI Z21.10.3,	ET = 80 percent SL = (Q/800+110x(V^^1/2))

TERMS:

EF = Energy factor, minimum overall efficiency.
ET = Minimum thermal efficiency with 70 degrees F delta T.
SL = Standby loss is maximum Btu/h based on a 70 degree F temperature difference between stored water and ambient requirements.
V = Rated storage volume in gallons
Q = Nameplate input rate in Btu/h

-- End of Section --

SECTION 22 05 48.00 20

MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL

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 D1.1/D1.1M	(2020) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM C94/C94M	(2020) Standard Specification for Ready-Mixed Concrete
ASTM D471	(2016a) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D2240	(2015; E 2017) Standard Test Method for Rubber Property - Durometer Hardness
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793	(2012) Architectural Sheet Metal Manual, 7th Edition

1.2 DEFINITIONS

1.2.1 Machinery

The vibration or noise producing equipment that must be isolated.

1.2.2 Manufacturer

The fabricator or supplier of vibration-isolation materials and equipment. For mechanical equipment and machinery the term machinery manufacturer will be used.

1.2.3 Micropascal uPa

10 to the minus 6 power newtons per square meter.

1.2.4 Picowatt pW

10 to the minus 12 power watts.

1.3 SYSTEM DESCRIPTION

1.3.1 Machinery Vibration Criteria

TABLE 1A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Reciprocating Air or Refrigeration Compressors						
500 to 750 rpm	S-R	1.75	S-R	2.5	S-R	3.5
751 rpm and up	S-R	1.5	S-R	2.5	S-R	3.5
NOTES:						
(1) Equipment Vibration Isolation Schedule Designations (Hyphenated designations are combinations of the following:)						
B - Welded structural steel bases.						
H - Spring isolators (suspended equipment and piping). Where required, provide with adjustable preloading devices.						
HR - Thrust restraints						
I - Concrete inertia bases with steel forms.						
NM - Neoprene mounts.						
NP - Neoprene pads.						
R - Structural steel rail for equipment mounts.						

TABLE 1A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
S - Freestanding spring isolators (floor-mounted equipment).						
SV - Freestanding spring isolators (floor-mounted equipment).						
SX - Freestanding spring isolators with adjustable cushioned vertical stops and cushioned horizontal stops (floor-mounted equipment. Protected spring isolators SX may be substituted wherever S or SV is specified and shall meet all requirements.						

TABLE 1B		
Class II Vibration Isolator Types and Minimum Static Deflection		
(MSD, inches) for basements below grade and floor slabs on earth		
Equipment	Type (Note (1))	MSD
Reciprocating Air or Refrigeration Compressors		
500 to 750 rpm	S	1.0
751 rpm and up	S	1.0
NOTES: Note (1) is same as for TABLE 1A.		

Provide vibration isolators for mechanical and electrical machinery and associated piping, to minimize transmission of vibrations and structure borne noise to the building structure or spaces or from the building structure to the machinery. Comply with the following vibration schedule.

1.3.2 Welding

AWS D1.1/D1.1M.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation;

submittals not having a "G" designation are for Contractor QC approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29, SUSTAINABITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Isolators

Flexible Connectors

Inertia Bases

Machinery Bases

Machinery Foundations and Subbases

SD-06 Test Reports

Equipment Vibration Tests

SD-08 Manufacturer's Instructions

Vibration and Noise Isolation Components

1.5 QUALITY ASSURANCE

1.5.1 Vibration Isolator Procurement

For each piece of machinery to be isolated from vibration, supply the inertia base, vibration isolators, and other associated materials and equipment as a coordinated package by a single manufacturer or by the machinery manufacturer. Select isolators that provide uniform deflection even when machinery weight is not evenly distributed. This requirement does not include the flexible connectors or the hangers for the associated piping.

1.5.2 Unitized Machinery Assemblies

Mounting of unitized assemblies directly on vibration isolation springs is acceptable if machinery manufacturer certifies that the end supports of the assemblies have been designed for such installation.

PART 2 PRODUCTS

2.1 CORROSION PROTECTION FOR STEEL PARTS

ASTM A653/A653M hot-dipped galvanized, or equivalent manufacturer standard coatings. Where steel parts are exposed to the weather, provide galvanized coating of at least 2 ounces of zinc per square foot of surface. Coat springs with neoprene.

2.2 NEOPRENE

ASTM D471 and ASTM D2240, Grade Durometer 40, 50, or 60, and oil resistant.

2.3 FLOOR-MOUNTED ISOLATORS

2.3.1 Neoprene Isolation Pads

Provide pads at least 1/4 inch thick with cross-ribbed or waffle design. For concentrated loads, provide steel bearing plates bonded or cold cemented to the pads.

2.3.2 Neoprene Isolators

Provide molded neoprene isolators having steel base plates with mounting holes and, at the top, steel mounting plates with mounting holes or threaded inserts. Provide elements of type and size coded with molded letters or color-coded for capacity identification. Embed metal parts completely in neoprene.

2.4 MACHINERY BASES

ASTM A36/A36M and AISC 360.

2.5 INERTIA BASES

ASTM A36/A36M steel, ASTM C94/C94M (2,500 psi) concrete.

2.6 FLEXIBLE CONNECTORS FOR PIPING

Straight or elbow flexible connectors rated for temperatures, pressures, and fluids to be conveyed. Provide flexible connectors with the strength 4 times operating pressure at highest system operating temperature. Provide elbow flexible connectors with a permanently set angle.

2.6.1 Elastomeric Flexible Connectors

Fabricated of multiple plies of tire cord fabric and elastomeric materials with integral reinforced elastomeric flanges with galvanized malleable iron back up rings.

2.6.2 Metal Flexible Connectors

Fabricated of Grade E phosphor bronze, monel or corrugated stainless steel tube covered with comparable bronze or stainless steel braid restraining and pressure cover.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Vibration and Noise Isolation Components

Install vibration-and-noise isolation materials and equipment as indicated and in accordance with machinery manufacturer's instructions.

3.1.2 Flexible Pipe Connectors

Install flexible connectors in accordance with the manufacturer's instructions. When liquid pulsation dampening is required, flexible connectors with spherical configuration may be used. Provide restraints for pipe connectors at pumps to prevent connector failure upon pump startup.

3.1.3 Machinery

Provide vibration isolators, flexible connectors in accordance with manufacturer's recommendations.

3.1.3.1 Stability

Isolators shall be stable during starting and stopping of machinery without traverse and eccentric movement of machinery that would damage or adversely affect the machinery or attachments.

3.1.3.2 Lateral Motion

The installed vibration isolation system for each piece of floor mounted machinery shall have a maximum lateral motion under machinery start up and shut down conditions of not more than 1/4 inch. Restrain motions in excess by approved spring mountings.

3.1.3.3 Nonrotating Machinery

Mount nonrotating machinery in systems which includes rotating or vibrating machinery on isolators having the same deflection as the hangers and supports for the pipe connected to.

3.1.3.4 Unitized Machinery Assemblies

TABLE 3A

Vibration Isolator Types and Minimum Static Deflection

(MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Reciprocating Air or Refrigeration Compressors						
500 to 750 rpm	S-R	1.75	S-R	2.5	S-R	3.5
751 rpm and up	S-R	1.5	S-R	2.5	S-R	3.5
Closed Coupled Pumps						
Up to 7-1/2 hp	S-I	1.0	S-I	1.0	S-I	1.0
Over 7-1/2 hp	S-I	1.5	S-I	2.5	S-I	2.5

TABLE 3A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
NOTES:						
(1) Equipment Vibration Isolation Schedule Designations (Hyphenated designations are combinations of the following:)						
B - Welded structural steel bases.						
H - Spring isolators (suspended equipment and piping). Where required, provide with adjustable preloading devices.						
HR - Thrust restraints						
I - Concrete inertia bases with steel forms.						
NM - Neoprene mounts.						
NP - Neoprene pads.						
R - Structural steel rail for equipment mounts.						
S - Freestanding spring isolators (floor-mounted equipment).						
SV - Freestanding spring isolators (floor-mounted equipment).						
SX - Freestanding spring isolators with adjustable cushioned vertical stops and cushioned horizontal stops (floor-mounted equipment. Protected spring isolators SX may be substituted wherever S or SV is specified and shall meet all requirements.						

3.1.3.5 Upper Floor Mounted Machinery

TABLE 3A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Reciprocating Air or Refrigeration Compressors						
500 to 750 rpm	S-R	1.75	S-R	2.5	S-R	3.5
751 rpm and up	S-R	1.5	S-R	2.5	S-R	3.5
NOTES:						
(1) Equipment Vibration Isolation Schedule Designations (Hyphenated designations are combinations of the following:)						
B - Welded structural steel bases.						
H - Spring isolators (suspended equipment and piping). Where required, provide with adjustable preloading devices.						
HR - Thrust restraints						
I - Concrete inertia bases with steel forms.						
NM - Neoprene mounts.						
NP - Neoprene pads.						
R - Structural steel rail for equipment mounts.						
S - Freestanding spring isolators (floor-mounted equipment).						
SV - Freestanding spring isolators (floor-mounted equipment).						
SX - Freestanding spring isolators with adjustable cushioned vertical stops and cushioned horizontal stops (floor-mounted equipment. Protected spring isolators SX may be substituted wherever S or SV is specified and shall meet all requirements.						

TABLE 3B

TABLE 3B
NOTES: Note (1) and Note (2) are same as for TABLE 3A.

On the roof or upper floors, mount machinery on isolators with vertical stops. Rest isolators on beams or structures designed and installed in accordance with the SMACNA 1793, Plate 61.

3.1.4 Pipe Hanger and Support Installation

3.1.4.1 Pipe Hangers

Provide eye-bolts or swivel joints for pipe hangers to permit pipe thermal or mechanical movement without angular misalignment of hanger vibration isolator.

3.1.4.2 Valves

Provide vibration isolation hangers and supports at modulating, pressure reducing, or control valves which will induce fluid pulsations. When required or indicated, isolate valves with flexible connectors.

3.1.4.3 Machinery Without Flexible Connections

When piping is not connected to vibrating machinery with flexible connectors, provide the first four hangers with isolation elements designed for deflections equal to equipment vibration isolator deflections (including static, operating, and start-up).

3.1.5 Equipment Room Sound Isolation

Do not allow direct contact between pipe and walls, floor slabs, roofs, ceilings or partitions of equipment rooms.

3.1.5.1 Pipe Penetrations

Provide galvanized Schedule 40 pipe sleeves and tightly pack annular space between sleeves and pipe with insulation having a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E84, maximum effective temperature 1000 degrees F, bulk density 6 pounds/cu. ft. minimum. Provide uninsulated pipe with a one inch thick mineral fiber sleeve the full length of the penetration and seal each end with an interior or exterior and weather resistant non-hardening compound. Provide sealant and mineral-fiber sleeve of a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E84.

3.1.6 Machinery Foundations and Subbases

Provide cast in place anchor bolts as recommended by the machinery manufacturer.

3.1.6.1 Machinery Subbases

Provide concrete subbases at least 4 inches high for floor mounted equipment . Rest subbases on structural floor and reinforce with steel rods interconnected with floor reinforcing bars by tie bars hooked at both ends. Provide at least 2 inch clearance between subbases and inertia bases, steel bases, and steel saddles with machinery in operation.

3.1.6.2 Common Machinery Foundations

Mount electrical motors on the same foundations as driven machinery. Support piping connections, strainers, valves, and risers on the same foundation as the pumps.

3.1.6.3 Foundation and Subbase Concrete

Cast concrete foundations and subbases of ASTM C94/C94M 2500 psi concrete reinforced with steel bars as indicated or recommended by machinery manufacturer.

3.1.6.4 Anchor Bolts and Grout

Secure machinery to foundations and inertia bases with anchor bolts. Grout equipment with baseplates, the full area under baseplates with premixed non-shrinking grout. After grout has set, remove wedges, shims, and jack bolts and fill spaces with grout.

3.1.7 Inertia Bases

Install inertia bases in accordance with the recommendations of the machinery manufacturer or inertia base manufacturer, as applicable.

3.1.8 Electrical Connections

Provide flexible conduit or multiple conductor cable connections for machinery with sufficient extra length to permit 2 inch minimum displacement in any direction without damage.

3.1.9 Systems Not To Be Vibration Isolated

Do not provide vibration isolation for electrical raceways and conduits or for fire protection, storm, sanitary, and domestic water piping systems which do not include pumps or other vibrating, rotating, or pulsating equipment including control and pressure reducing valves.

3.2 FIELD QUALITY CONTROL

Provide equipment and apparatus required for performing inspections and tests. Notify Contracting Officer 14 days prior to machinery vibration testing. Rebalance, adjust, or replace machinery with noise or vibration levels in excess of those given in the machinery specifications, or machinery manufacturer's data.

3.2.1 Field Inspections

Prior to initial operation, inspect the vibration isolators for conformance to drawings, specifications, and manufacturer's data and instructions. Check for vibration and noise transmission through connections, piping, foundations, and walls. Check connector alignment before and after filling of system and during operation. Correct misalignment without damage to connector and in accordance with manufacturer's recommendations.

3.2.2 Tests

Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.

3.2.2.1 Equipment Vibration Tests

Perform vibration tests to determine conformance with vibration isolation schedule specified .

-- End of Section --

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SECTION 22 07 19.00 40

PLUMBING PIPING INSULATION

PART 1 GENERAL

Section 22 00 00 PLUMBING, GENERAL PURPOSE 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.

ASTM INTERNATIONAL (ASTM)

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 C449	(2007; R 2013) Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
ASTM C547	(2019) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C647	(2008; R 2013) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM C795	(2008; R 2018) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C916	(2014) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C921	(2010) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM C1136	(2017a) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM D579/D579M	(2015) Standard Specification for Greige Woven Glass Fabrics
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	(2016) Standard Test Methods for Water Vapor Transmission of Materials

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 220	(2018) Standard on Types of Building Construction

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS 3779	(2016; Rev B) Tape Adhesive, Pressure Sensitive Thermal Radiation Resistant, Aluminum Foil/Glass Cloth

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
MIL-PRF-19565	(1988; Rev C) Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

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. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G

SD-03 Product Data

Adhesives; G

Insulating Cement; G

Insulation Materials; G

Jacketing; G

Tape; G

SD-08 Manufacturer's Instructions

Installation Manual; G

SD-11 Closeout Submittals

Record Drawings

Adhesives; S

Insulation Materials; S

Recycled Materials; S

1.3 QUALITY CONTROL

1.3.1 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 recycled material content of the following insulation types are:

a. Rock Wool - 75 percent slag by weight

b. Fiberglass - 20-25 percent glass cullet by weight

c. Plastic Rigid Foam - 9 percent recovered material

d. Polyisocyanurate/Polyurethane - 9 percent recovered material

e. Rigid Foam - 9 percent recovered material

Submit recycled materials documentation indicating percentage of post-industrial and post-consumer recycled content per unit of product. Indicate relative dollar value of recycled content products to total dollar value of products included in project.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Performance Requirements

Provide noncombustible thermal-insulation system materials, as defined by NFPA 220. Provide adhesives, coatings, sealants, facings, jackets, and thermal-insulation materials, except cellular elastomers, with a flame-spread classification (FSC) of 25 or less , and a smoke-developed classification (SDC) of 50 or less . Determine these maximum values in accordance with ASTM E84 . Provide coatings and sealants that are nonflammable in their wet state.

Provide adhesives, coatings, and sealants with published or certified temperature ratings suitable for the entire range of working temperatures normal for the surfaces to which they are to be applied.

2.2 COMPONENTS

2.2.1 Insulation

2.2.1.1 Mineral Fiber Insulation

Provide mineral fiber insulation conforming to ASTM C547 and suitable for surface temperatures up to 370 degrees F. Provide insulation with a density not less than 4-pound per cubic foot and with thermal conductivity not greater than 0.26 Btu-inch per hour per square foot per degree F at 150 degrees F mean.

2.2.1.2 Fiberglass Insulation

Conform to ASTM C547. Ensure the apparent thermal conductivity does not exceed 0.54 Btu-inch per hour per square foot per degree F at 200 degrees F mean.

Fiber glass pipe insulation having an insulating efficiency not less than that of the specified thickness of mineral fiber pipe insulation may be provided in lieu of mineral fiber pipe insulation for aboveground piping.

2.2.1.3 Pipe Fittings

Provide molded pipe fitting insulation covering for use at temperatures up to and including 1200 degrees F.

2.2.2 Adhesives

2.2.2.1 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, ensure lagging adhesive conforms to ASTM D5590 with 0 growth rating. Provide nonflammable and fire-resistant lagging adhesives with a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Adhesive are MIL-A-3316, Class 1, pigmented white and 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. Apply lagging adhesives in strict accordance with the manufacturer's recommendations for pipe and duct insulation.

2.2.2.2 Vapor-Barrier Material Adhesives

Ensure adhesives conform to the requirements of ASTM C916, Type I, when attaching fibrous-glass insulation to metal surfaces or attaching insulation to itself, to metal, and to various other substrates.

2.2.3 Insulating Cement

2.2.3.1 General Purpose Insulating Cement

Provide general purpose insulating cement, mineral fiber, conforming to ASTM C195. Ensure composite is rated for1800 degrees F service, with a thermal-conductivity maximum of 0.85 Btu per inch per hour per square foot for each degree F temperature differential at 200 degrees F mean temperature for a 1 inch thickness.

2.2.3.2 Finishing Insulating Cement

Provide finishing insulating cement of a mineral-fiber, hydraulic-setting type conforming to ASTM C449.

2.2.4 Caulk

Provide elastomeric joint sealant in accordance with ASTM C920, Type S, Grade NS, Class 25, Use A.

2.2.5 Corner Angles

Provide a nominal 0.016 inch thick aluminum 1 by 1 inch corner angle piping insulation with factory applied kraft backing. Ensure aluminum conforms to ASTM B209, Alloy 3003 or 5005.

2.2.6 Jacketing

2.2.6.1 Aluminum Jacket

Provide aluminum jackets conforming ASTM B209, Temper H14, minimum thickness of 0.016 inch, with factory-applied polyethylene and kraft paper moisture barrier on the inside surface. Provide smooth surface jackets for jacket outside diameters less than 8 inches. Provide stainless steel bands, minimum width of 0.5 inch. Provide factory prefabricated aluminum covers for insulation on fittings, valves, and flanges.

2.2.6.2 Glass Cloth Jacket

Provide plain-weave glass cloth conforming to ASTM D579/D579M, Style 141, weighing not less than 7.23 ounces per square yard before sizing. Factory apply cloth wherever possible.

Provide leno weave glass reinforcing cloth, 26-end and 12-pick thread conservation, with a warp and fill tensile strength of 45 and 30 pounds per inch of width, respectively, and a weight of not less than 1.5 ounces per square yard.

2.2.7 Coatings

2.2.7.1 Indoor Vapor-Barrier Finishing

Provide a pigmented resin and solvent compound coatings conforming to ASTM C1136, Type II.

2.2.7.2 Indoor Nonvapor-Barrier Finishing (NBF)

Provide a pigmented polymer-emulsion as recommended by the insulation material manufacturer for the surface to be coated.

2.2.7.3 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 0.013 perms or less at 43 mils dry film thickness as determined according to procedure

B of ASTM E96/E96M utilizing apparatus described in ASTM E96/E96M. 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 in accordance with ASTM C647.

2.2.7.4 Coating Color

Provide white for the coating color.

2.2.8 Tape

Provide a knitted elastic cloth glass lagging specifically suitable for continuous spiral wrapping of insulated pipe bends and fittings that produces a smooth, tight, wrinkle-free surface. Conform to requirements of SAE AMS 3779, ASTM D579/D579M, and ASTM C921 for tape, weighing not less than 10 ounces per square yard.

2.3 MATERIALS

Submit manufacturer's catalog data for the following items:

a. Adhesives

b. Insulating Cement

c. Insulation Materials

d. Jacketing

e. Tape

Provide compatible materials that do not contribute to corrosion, soften, or otherwise attack surfaces to which applied, in either the wet or dry state. Meet ASTM C795 requirements for materials to be used on stainless steel surfaces. Provide materials that are asbestos free.

PART 3 EXECUTION

Apply insulation only to the system or component surfaces that have previously been tested and approved by the Contracting Officer.

3.1 PREPARATION

Submit installation drawings for pipe insulation, conforming with the adhesive manufacturer's written instructions for installation. Submit installation manual clearly stating the manufacturer's instructions for insulation materials.

Clean surfaces to remove oil and grease before insulation adhesives or mastics are applied. Provide solvent cleaning required to bring metal surfaces to such condition.

3.2 INSTALLATION OF INSULATION SYSTEMS

Apply materials in conformance with the recommendations of the manufacturer.

Install smooth and continuous contours on exposed work. Smoothly and securely paste down cemented laps, flaps, bands, and tapes. Apply adhesives on a full-coverage basis.

Install insulation lengths tightly butted against each other at joints. Where lengths are cut, provide smooth and square and without breakage of end surfaces. Where insulation terminates, neatly taper and effectively seal ends, or finish as specified. Direct longitudinal seams of exposed insulation away from normal view.

Use insulation meeting maximum value conductance as tested at any point, do not use an average. Meet or exceed the specified maximum conductance by adding additional insulation thickness.

3.2.1 Hot-Water Piping

Install 1 inch mineral fiber insulation with glass cloth jacket, Type T-2, with a thickness of not less than 1. Insulate aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces.

Install 1 inch mineral fiber insulation with aluminum jacket, Type T-6, exposed in mechanical rooms. Insulate aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces.

3.2.2 Cold-Water and Condensate-Drain Piping

Insulate aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces.

Provide 1 inch mineral fiber insulation with glass cloth jacket, Type T-2, with a thickness of not less than 1.

Provide 1 inch mineral fiber insulation with aluminum jacket, Type T-6, exposed in mechanical rooms.

3.3 APPLICATION

3.3.1 Type T-2, Mineral Fiber with Glass Cloth Jacket

Apply factory attached presized, white, glass cloth jacket to piping insulated with mineral fiber. Securely cement jackets, jacket laps, flaps, and bands in place with vapor-barrier adhesive. Provide jacket overlaps not less than 1-1/2 inches and jacketing bands for butt joints 3 inches wide.

Insulate exposed-to-view fittings with preformed mineral-fiber of the same thickness as the pipe insulation. Temporarily secure in place with light cord ties. Install impregnated glass lagging tape with indoor vapor-barrier on 50 percent overlap basis. Blend tape smoothly into the adjacent jacketing. Apply additional coating as needed, using rubber gloved hands to a smooth fillets or contour coatings. Tape ends of insulation to the pipe at valves 2 inches and smaller. Field fabricate and install insulation for concealed fittings and special configurations. Build up insulation from mineral fiber and a mixture of insulating cement and lagging adhesive, diluted with 3 parts water. Finish surfaces with glass cloth or tape lagging.

Finish exposed-to-view insulation with a minimum 6-mil dry-film thickness of nonvapor-barrier coating suitable for painting.

3.3.2 Type T-6, Mineral Fiber with Aluminum Jacket

Apply factory or field attached aluminum jacket to piping insulated with mineral fiber.

Insulate fittings and valve bodies with preformed mineral-fiber of the same thickness as the pipe-barrel insulation. Temporarily secure fitting insulation in place with light cord ties. Apply a 60-mil coating of vapor-barrier mastic, and while still tacky, wrap with glass lagging tape.

Apply additional mastic as needed using rubber-gloved hands to smooth fillets or contour coatings. Field fabricate and install insulation for special configurations. Build up insulation from mineral fiber and a mixture of insulating cement and lagging adhesive diluted with 3 parts water. Only where standard aluminum jacketing cannot be used, make the surfaces vapor-tight by using mastic and glass lagging cloth or tape as specified above with an added finish coat of mastic.

Install continuous vapor barrier over all surfaces, including areas inside pipe sleeves, hangers, and other concealment.

Apply piping insulation to both sides of pipe hangers. Insulate junctions with a special mastic mixture, glass cloth mesh tape, and mastic as previously specified.

Securely cement jacket laps, flaps, and bands in place with aluminum jacket sealant. Provide 6 inch wide minimum jacketing bands for butt joints.

Stiffen exposed longitudinal edges of aluminum jacketing by bending a 1 inch hem on one edge.

Provide expansion joints for maximum and minimum dimensional fluctuations.

To prevent corrosion, do not allow the aluminum jacketing to come in direct contact with other types of metal.

Use screws at each corner of each sheet, at fitting jackets, and as necessary for the service. Place Number 7, 3/8 inch long, binding-head aluminum sheet metal screws through the mastic seal.

3.4 CLOSEOUT ACTIVITIES

Final acceptance of the performed work is dependent upon providing Record Drawings details to the Contracting Officer. Include construction details, by building area, the insulation material type, amount, and installation method. An illustration or map of the pipe routing locations may serve this purpose.

Provide a cover letter/sheet clearly marked with the system name, date, and the words "Record Drawings Insulation/Material" for the data. Forward to the Contracting Officer's Representitive for inclusion in the Maintenance Database."

-- End of Section --

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	(2015) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2017) 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 B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.3	(2016) 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
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS WHB-2.9	(2004) Welding Handbook; Volume 2, Welding Processes, Part 1

ASTM INTERNATIONAL (ASTM)

ASTM A6/A6M	(2017a) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A53/A53M	(2018) 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	(2014; E 2017) 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 B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B88	(2016) Standard Specification for Seamless Copper Water Tube
ASTM B117	(2016) 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	(2014) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products
ASTM C67/C67M	(2020) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile

ASTM C109/C109M	(2020a) 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	(2019) 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	(2019) 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

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-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

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) 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" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. 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; G

Connection Diagrams

Coordination Drawings

Fabrication Drawings

Installation Drawings

SD-03 Product Data

Pipe and Fittings; G

Piping Specialties; G

Valves; G

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; G

Air Tests; G

Valve-Operating Tests; G

Drainage Tests; G

Pneumatic Tests

Non-Destructive Electric Tests

System Operation Tests; G

SD-07 Certificates

Record of Satisfactory Field Operation; G

List of Qualified Permanent Service Organizations

Listing of Product Installations

Records of Existing Conditions; G

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; G

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 pipe 1/8 through 10 inches is Schedule 40 seamless or electric-resistance welded black carbon steel, conforming to ASTM A53/A53M, Type E, Grade B (electric-resistance welded) or Type S (seamless). Grade A should be used for permissible field bending, in both cases.

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 unions 2 inches and under are 250 pounds per square inch, wsp female, screwed, black malleable iron with brass-to-iron seat, and ground joint, conforming to ASME B16.39.

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.

Use solder, alloy Sb-5, conforming to ASTM B32.

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 Separator

Provide a commercially constructed separator, designed and certified to separate not less than 80 percent of entrained air on the first passage of water and not less than 80 percent of residual on each successive pass. Provide shop drawings detailing all piping connections proposed for this work.

Ensure the air separator is carbon steel, designed, fabricated, tested, and stamped in conformance with ASME BPVC SEC VIII D1 for service pressures not less than 125 psi.

2.2.2 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.

2.2.3 Expansion Tank

Provide compression tank designed, fabricated, tested, and stamped for a working pressure of not less than 125 psi in accordance with ASME BPVC SEC VIII D1. Ensure tank is hot-dip galvanized after fabrication to produce not less than 1.5 ounces of zinc coating per square foot of single-side surface.

Tank accessories include red-lined gage-glass complete with glass protectors and shutoff valves, air charger and drainer, and manual vent.

2.2.4 Dielectric Connections

Electrically insulate dissimlar pipe metals from each other by couplings, unions, or flanges commercially manufactured for that purpose and rated for the service pressure and temperature.

2.2.5 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 chlorosulphinated 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.

Fill arches with soft chloroprene.

Ensure joint, single-arch, movement limitations and size-related, pressure characteristics conform to FSA-0017.

2.2.6 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 chlorosulphinated 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:

INSIDE DIAMETER	UNIT PIPE LENGTH
To 2-1/2 inches, inclusive	12 inches
3 to 4 inches, inclusive	18 inches
5 to 12 inches, inclusive	24 inches

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 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.

2.2.9 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.

2.2.10 Line Strainers, Water Service

Install Y-type strainers with removable basket. Ensure strainers in sizes 2-inch ips and smaller have screwed ends; in sizes 2-1/2-inch ipsand 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 304 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.

2.3.1 Ball and Butterfly Valves

Ensure ball valves conform to MSS SP-72 for Figure 1B, vertically split body and are rated for service at not less than 175 psig at 200 degrees F. Balls and stems of valves 2 inches and smaller are manufacturer's standard with hard chrome plating finish. Valves 2-1/2 inches and larger are to be butterfly type. 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-67and are the lug 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.

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 fitted with 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.

2.3.7 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.

2.4 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, UNS Alloy Number L50049 (intended for use in laboratories and shops in general application).

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, 21, 28, 29, or 30.

When it is not possible to use center-loading beam clamps, eccentric-loading beam clamps, MSS SP-58 Type 19, 20, 25, or 27 may be used for piping sizes 2 inches and less and for piping sizes 2 through 10 inches provided two counterbalancing clamps are used per point of pipe support. Where more than one rod is used per point of pipe support, determine rod diameter in accordance with referenced standards.

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 ips 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, 3, or 4 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 41, 44 through 46, or 49 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 be of commercially available, proprietary design, rolled steel.

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 with dielectric couplings (or unions) or flanged with gaskets rated for the service.

Make final connections to equipment with unions or flanges provided every 100 feet of straight run. Provide 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.

Provide 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.

Accomplish preheat and postheat treatment of welds in accordance with ASME BPVC SEC IX and ASME B31.3.

Take all necessary precautions during installation of flexible pipe and hose including flushing and purging with water, steam, and compressed air to preclude bellows failure due to pipe line debris lodged in bellows. Ensure installation conforms to manufacturer's instructions.

3.2 VALVES

Provide valves in piping mains and all branches and at equipment where indicated and as specified.

Provide valves to permit isolation of branch piping and each equipment item from the balance of the system.

Provide 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.

Provide 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

Provide 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 hangars 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:

PIPE SIZE INCHES	ROD SIZE INCHES	STEEL PIPE FEET	COPPER PIPE FEET
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

Provide 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, provide 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

Provide 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.

Accomplish sound stopping and vapor-barrier sealing of pipe shafts and large floor and wall openings by packing to high density with properly supported fibrous-glass insulation or, where ambient or surface temperatures do not exceed 120 degrees F, by foaming-in-place with self-extinguishing, 2-pound density polyurethane foam to a depth not less than 6 inches. Finish foam with a rasp. Ensure vapor barrier is not less than 1/8-inch thick vinyl coating applied to visible and accessible surfaces. Where high temperatures and fire stopping are a consideration, use only mineral wool with openings covered by 16-gage sheet metal.

3.5 SLEEVES

Provide sleeves where piping passes through roofs, masonry, concrete walls and floors.

Continuously weld 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). Provide 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.

Ensure sleeve height above roof surface is a minimum of 12 and a maximum of 18-inches.

3.6 ESCUTCHEONS

Provide escutcheons at all penetrations of piping into finished areas. Where finished areas are separated by partitions through which piping passes, provide escutcheons on both sides of the partition. Where suspended ceilings are installed, provide 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

Provide flashings at penetrations of building boundaries by mechanical systems and related work.

3.8 REFRIGERANT REPORTING

a. The Contractor shall comply with the applicable requirements of sections 608 and 609 of the Clean Air Act (42 U.S.C. 7671g and 7671h) as each or both apply to this contract. Implement requirements of FAR Clause 52.223-12 and 52.223-11, as appropriate.

b. Management of recovered refrigerants must be consistent with the requirements as specified in AFMAN 32-7002 (i.e. - Installations will not transfer any Class I ODS and R-22 (CFCs, Halon and HCFC-22) out of government ownership in accordance with DoD I4715.06).

c. All refrigerant system records must be provided to the government within 10 business days of service, regarding refrigerants added, removed, or lost, and AC/R equipment in service, repaired, replaced, and decommissioned. When refrigerant system records are provided to the government, they must be provided to the COR as well as 127th Wing Civil Engineering HVAC Shop, and 127th Wing Environmental management Office via e-mail. If the contractor has questions concerning point of contacts and/or e-mail addresses for submittal of refrigerant system records they should inquire with the contracting officer's representative before providing records.

Refrigerant Records 127th CE HVAC and 127th Environmental POCs are as follows:

1. Refrigerant Manager, 127 CES/CEOIH, Worley, Scott T, scott.worley@us.af.mil.
2. Refrigerant Manager/HVAC Superintendent, 127 CES/CEOIH, Vanneste, Richard, richard.vanneste.1@us.af.mil
3. SANGB Air Quality Program Manager, 127 CES/CEV, Baker, Kenneth, kenneth.baker.22@us.af.mil
4. SANGB Environmental Manager, 127 CES/CEV, Paasche, Mark, mark.paasche@us.af.mil

3.9 DISINFECTION

Disinfect water piping, including all valves, fittings, and other devices, with a solution of chlorine and water. Ensure the solution contains not less than 50 parts per million (ppm) of available chlorine. Hold solution for a period of not less than 8 hours, after which the solution contains not less than 10 ppm of available chlorine or redisinfect the piping. After successful sterilization, thoroughly flush the piping before placing into service. Flushing is complete when the flush water contains less than 0.5 ppm of available chlorine. Water for disinfected will be furnished by the Government. Approve disposal of contaminated flush water in accordance with written instructions received from the Environmental authority having jurisdiction through the Contracting Officer and all local, State and Federal Regulations.

Flush piping with potable water until visible grease, dirt and other contaminants are removed (visual inspection).

3.10 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.

3.11 PAINTING OF NEW EQUIPMENT

Factory or shop apply new equipment painting, as specified herein, and provided under each individual section.

3.11.1 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.

3.11.2 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.

-- End of Section --

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SECTION 23 05 48.00 40

VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section to the extent applicable.

Section 23 05 15 COMMON PIPING FOR HVAC applies to work specified in this section to the extent applicable.

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 S2.71	(1983; R 2006) Guide to the Evaluation of Human Exposure to Vibration in Buildings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE HVAC APP IP HDBK	(2016) HVAC Applications Handbook, I-P Edition

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB PROCEDURAL STANDARDS	(2015) Procedural Standards for TAB (Testing, Adjusting and Balancing) Environmental Systems

1.2 ADMINISTRATIVE REQUIREMENTS

Within ten working days of Contract Award, submit equipment and performance data for vibration isolator systems including equipment base design; inertia-block mass relative to support equipment weight; spring loads and free, operating, and solid heights of spring; spring diameters; nonmetallic isolator loading and deflection; disturbing frequency; natural frequency of mounts; deflection of working member; and anticipated amount of physical movement at the reference points.

Ensure the data includes information on the following:

a. Mountings

b. Bases

c. Isolators

d. Floor-Mounted Piping

e. Vertical Piping

Five working days prior to commencement of installation, submit installation drawings for vibration isolator systems including equipment and performance requirements.

Indicate within outline drawings for vibration isolator systems, overall physical features, dimensions, ratings, service requirements, and weights of 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-02 Shop Drawings

Installation Drawings

Outline Drawings

SD-03 Product Data

Equipment and Performance Data; G

SD-06 Test Reports

Type of Isolator; G

Type of Base; G

Allowable Deflection; G

Measured Deflection; G

1.4 QUALITY CONTROL

Ensure all vibration-control apparatus is the product of a single manufacturing source, where possible. Human exposure levels should be considered using ASA S2.71 and NEBB PROCEDURAL STANDARDS.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Scheduled isolation mounting is in inches and is a minimum static deflection.

Spans referred to in paragraph EQUIPMENT, means longest bay dimension.

Determine exact mounting sizes and number of isolators by the isolator manufacturer based on equipment that will be installed. Check equipment revolutions per minute (rpm) and spring deflections to verify that resonance cannot occur.

2.1.1 Design Requirements

Design for vibration isolation using ASHRAE HVAC APP IP HDBK, Chapter 48, as applicable to the following sections.

2.1.1.1 Mountings

Provide the following mountings:

Type B: Double elastomer-in-shear with molded-in steel reinforcement in top and bottom. Maximum deflections up to 0.50-inch are allowed.

Type C: Free-standing laterally stable open-spring type for deflections over 0.50-inch, with built-in bearing and leveling provisions, 0.25-inch thick Type A base elastomer pads, and accessories. Ensure outside diameter of each spring is equal to or greater than 0.9 times the operating height of the spring under rated load.

Type D: Partially housed type, containing one or more vertically restrained springs with at least 0.50-inch clearance maintained around springs, with adjustable limit stops, 0.25-inch thick Type A base elastomer pads, and accessories.

Type F: Combination spring and elastomer-in-shear steel framed for hanger-rod mounting, with minimum total static deflection of 1-inch.

2.1.1.2 Bases

Provide the following bases:

Type U: Unit isolators without rails, structural-steel bases, or inertia blocks.

Type R: Rails, connected mill-rolled structural steel, of sufficient dimension to preclude deflection at midpoint of unsupported span in excess of 1/1,440th of the span between isolators, power transmission, component misalignment, and any overhung weight. Where Type R bases are specified and the equipment proposed requires additional base support, use a Type S base.

Type S: Structural-steel bases common to a supported assembly, made from welded-joint mill-rolled structural steel with closed-perimeter configuration, isolators attached to outrigger supports.

Ensure height of steel members is sufficient to provide stiffness required to maintain equipment manufacturer's recommended alignment and duty efficiency of power-transmission components. Ensure height of steel member does not result in member deflection at midpoint of unsupported span of more than 1/1,440th of the span between isolators. Minimum height is 5-inches.

Type CIB: Provide concrete inertia blocks common to the entire assembly, with welded-joint construction, mill-rolled structural-steel perimeters, welded-in No. 4 reinforcing bars 8-inches on center each way near the bottom of the block, outrigger-isolator mounting provisions, anchor bolts. Fill with 3,000 psi cured-strength concrete.

Configure rectangular inertia bases to accommodate equipment supported.

Ensure minimum thickness of inertia base, in addition to providing suitable mass, is sufficient to provide stiffness to maintain equipment manufacturer's recommended alignment and duty efficiency of power-transmission components, and is sufficient to result in base deflection at midpoint of unsupported span of not more than 1/1,440th of the span between isolators. Verify minimum thickness, the preceding requirements not withstanding, is 8 percent of the longest base dimension.

Ensure pumps with flexible couplings do not have inertia base less than 8-inches thick, and the minimum mass of concrete inertia block is equal in weight to supported equipment.

2.2 EQUIPMENT

Vibration isolation design per ASHRAE HVAC APP IP HDBK, Chapter 37,.

2.2.1 Reciprocating Compressor/Condenser Locations

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON/ABOVE GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
500 to 750 rpm	D-U-1.0	D-U-1.5	D-U-2.5	D-CIB-2.75
750 rpm and Over	D-U-1.0	D-U-1.0	D-U-2.0	D-CIB-2.5
*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES				

2.2.2 Centrifugal Pump Locations

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON/ABOVE GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
Close-couple through 5 hp	None	-R-0.35	C-S-1.0	C-S-1.0
Bedplate-mounted through 5 hp	None	C-CIB-1.0	C-CIB-1.5	C-CIB-1.75
7-1/2 hp	None	C-CIB-1.0	C-CIB-1.75	C-CIB-2.5
*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES				

2.2.3 Air-Cooled Condensing Unit Locations

TYPE EQUIPMENT	20-FOOT ROOF-SPAN PROVISIONS*	30-FOOT ROOF-SPAN PROVISIONS*	40-FOOT ROOF-SPAN PROVISIONS*
Through 5 hp over 900 rpm	B-U-0.5	D-U-1.0	D-U-1.75
Over 5 hp to 500 rpm	B-U-0.5	D-U-1.75	D-U-2.5
500 rpm and over	B-U-0.5	D-U-1.0	D-U-1.75

TYPE EQUIPMENT	20-FOOT ROOF-SPAN PROVISIONS*	30-FOOT ROOF-SPAN PROVISIONS*	40-FOOT ROOF-SPAN PROVISIONS*
*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES			

2.2.4 Low-Pressure Suspended Air-Handling Unit (AHU) Locations

Vibration-isolation provisions apply to ceiling-suspended Air Moving and Conditioning Association Class A packaged central-station units.

TYPE EQUIPMENT	20-FOOT ROOF-SPAN PROVISIONS*	30-FOOT ROOF-SPAN PROVISIONS*	40-FOOT ROOF-SPAN PROVISIONS*
Through 5 hp	F-U-1.0	F-U-1.0	F-U-1.0
7-1/2 hp and over 250 to 500 rpm	F-U-1.75	F-U-1.75	F-U-1.75
500 rpm and over	F-U-1.0	F-U-1.25	F-U-1.55
*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES			

2.2.5 Low-Pressure AHU Locations

Vibration-isolation provisions apply to floor-mounted Air Moving and Conditioning Association Class A packaged central-station units.

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON/ABOVE GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
Through 5 hp	B-U-0.35	C-U-1.0	C-U-1.0	C-U-1.0
7-1/2 hp and over 250 to 500	B-U-0.35	C-U-1.75	C-U-1.75	C-U-1.75
500 rpm	B-U-0.35	C-U-1.0	C-U-1.5	
*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES				

2.2.6 Air-Moving Device Locations

Vibration-isolation provisions apply to housed free-standing fans of any pressure rating, located in field-erected factory- fabricated central-station units.

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON/ABOVE GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
Through 20 hp 250 to 300 rpm	B-U-0.35	C-S-2.5	C-S-2.5	C-S-3.5

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON/ABOVE GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
300 to 500 rpm	B-U-0.35	C-S-1.75	C-S-1.75	C-S-2.5
500 rpm and over	B-U-0.35	C-S-1.0	C-S-1.5	C-S-1.75
Over 20 hp 250 to 300 rpm	B-U-0.35	C-S-2.75	C-CIB-3.5	C-CIB-5.0
300 to 500 rpm	B-U-0.35	C-S-1.75	C-CIB-2.5	C-CIB-3.5
500 rpm and over	B-U-0.35	C-S-1.0	C-CIB-1.75	C-CIB-2.5
*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES				

2.3 MATERIALS

Ensure rubber is natural rubber and elastomer is chloroprene. Shore A durometer measurement of both materials and range between 40 and 60.

Inorganic materials such as precompressed, high-density, fibrous glass encased in a resilient moisture-impervious membrane may be used in lieu of specified natural rubber and elastomers. Where this substitution is made, ensure specified deflections are modified by the manufacturing source to accommodate physical characteristics of inorganic materials and to provide equal or better vibration isolation.

Ensure weather-exposed metal vibration-isolator parts are corrosion protected. Chloroprene coat springs.

2.4 TESTS, INSPECTIONS, AND VERIFICATIONS

Submit test reports for testing vibration isolation for each type of isolator and each type of base. Meet referenced standards contained within this section. Include in test reports allowable deflection and measured deflection also meeting referenced standards within this section.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment in accordance with manufacturer's recommendations.

Ensure rails, structural steel bases, and concrete inertia blocks are raised not less than 1-inch above the floor and are level when equipment supported is under operating load.

Ensure vibration-isolation installation and deflection testing after equipment start-up is directed by a competent representative of the manufacturer.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests and Reports

Ensure vibration-isolation devices are deflection tested. Submit test reports substantiating that all equipment has been isolated as specified and that minimum specified deflections have been met. Make all measurements in the presence of the Contracting Officer.

-- End of Section --

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SECTION 23 05 48.19

BRACING 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.

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2018) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A490	(2014a) Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
ASTM A500/A500M	(2018) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A603	(2019) Standard Specification for Zinc-Coated Steel Structural Wire Rope
ASTM E488/E488M	(2015) Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
ASTM F1554	(2018) Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

ICC EVALUATION SERVICE, INC. (ICC-ES)

ICC ES AC193	(2012) Acceptance Criteria for Mechanical Anchors in Concrete Elements

METAL FRAMING MANUFACTURERS ASSOCIATION (MFMA)

MFMA-4	(2004) Metal Framing Standards Publication

VIBRATION ISOLATION AND SEISMIC CONTROL MANUFACTURERS ASSOCIATION (VISCMA)

VISCMA 412	(2014) Installing Seismic Restraints for Mechanical Equipment

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Apply the requirements for bracing measures described in this section and on the drawings to the mechanical equipment and mechanical systems both inside and outside of the building along with exterior utilities and systems listed below. Where there is a conflict between the specifications and the drawings, the specifications will take precedence.

1.2.2 Mechanical Equipment

Mechanical equipment to be braced must include all overhead utilities and other fixtures weighing 31 pounds or more (excluding distributed systems such as piping networks that collectively exceed that weight) to minimize the likelihood that they will fall and injure building occupants. Design all equipment mountings to resist forces of 0.5 times the equipment weight in any horizontal direction and 1.5 times the equipment weight in the downward direction.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Coupling and Bracing

Equipment Restraint

SD-03 Product Data

Coupling and Bracing

Equipment Restraint

Anchor Bolts

Vibration Isolators

SD-06 Test Reports

Anchor Bolts

PART 2 PRODUCTS

2.1 EQUIPMENT RESTRAINT

Equipment must be rigidly or flexibly mounted as indicated in the specifications and/or drawings depending on vibration isolation requirements as follows below.

Roof mounted equipment, both vibration isolated and nonisolated, must have support members designed and anchored to building structural steel or concrete as required for wind loads.

2.1.1 Rigidly (Base and Suspended) Mounted Equipment

Anchor bolts must conform to ASTM F1554. For any rigid equipment which is rigidly anchored, provide flexible joints for piping, ductwork, electrical conduit, etc., that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions. Suspended equipment bracing attachments should be located just above the center of gravity to minimize swinging.

2.1.2 Nonrigid or Flexibly-Mounted Equipment

Select vibration isolation devices so that the maximum movement of equipment from the static deflection point is 1/4 inch. Equipment flexibly mounted on vibration isolators must have a bumper restraint or snubber in each horizontal direction and vertical restraints must be provided where required to resist overturning. Isolator housing and restraints must be constructed of ductile materials. A viscoelastic pad or similar material of appropriate thickness must be used between the bumper and components to limit the impact load. Restraints must be designed to resist the calculated horizontal lateral and vertical forces.

2.2 BOLTS AND NUTS

Hex head bolts, and heavy hexagon nuts must be ASTM A325 or ASTM A490 bolts and ASTM A563 nuts. Provide bolts and nuts galvanized in accordance with ASTM A153/A153M when used underground or exposed to weather.

2.3 SWAY BRACING MATERIALS

Material used for members listed in this section and on the drawings, must be structural steel conforming with the following:

a. Plates, rods, and rolled shapes, ASTM A36/A36M.

b. Wire rope, ASTM A603 pre-stretched. Class B galv coating Ferrule clamps must be qualified by testing for use in seismic applications per VISCMA 412. A minimum of two clamps are required on each end of wire rope.

c. Tubes, ASTM A500/A500M, Grade B.

d. Pipes, ASTM A53/A53M, Grade B.

e. Angles, ASTM A36/A36M.

f. Channels (Struts) with in-turned lips and associated hardware for fastening to channels at random points conforming to MFMA-4

PART 3 EXECUTION

3.1 COUPLING AND BRACING

a. Size bracing components as required for the total load carried by the common supports. Bracing rigidly attached to pipe flanges, or similar, must not be used where it would interfere with thermal expansion of piping. Design all equipment mountings to resist forces of 0.5 times the equipment weight in any horizontal direction and 1.5 times the equipment weight in the downward direction.

b. Adjust isolators and restraints after piping systems has been filled and equipment is at its operating weight, following the manufacturer's written instructions.

c. Install cables at a 45-degree slope. Where interference is present, the slope may be minimum of 30 degrees or a maximum of 60 degrees per VISCMA 412.

3.2 PIPE SLEEVES

Size pipe sleeves in interior non-fire rated walls as indicated on the drawings to provide clearances that will permit differential movement of piping without the piping striking the pipe sleeve. Pipe sleeves in fire rated walls must conform to the requirements in Section 07 84 00 FIRESTOPPING.

3.3 ANCHOR BOLTS

3.3.1 Cast-in-Place Anchor Bolts

Use templates to locate cast-in-place bolts accurately and securely in formwork. Anchor bolts must have an embedded straight length equal to at least 12 times nominal diameter of the bolt. Anchor bolts that exceed the normal depth of equipment foundation piers or pads must either extend into concrete floor or the foundation or be increased in depth to accommodate bolt lengths.

3.3.2 Drilled-In Anchor Bolts

Drill holes with rotary impact hammer drills Drill bits must be of diameters as specified by the anchor manufacturer. Unless otherwise shown on the Drawings, all holes must be drilled perpendicular to the concrete surface. Where anchors are permitted to be installed in cored holes, use core bits with matched tolerances as specified by the manufacturer. Properly clean cored hole per manufacturer's instructions. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Exercise care in coring or drilling to avoid damaging existing reinforcing or embedded items. Notify the COR if reinforcing steel or other embedded items are encountered during drilling. Take precautions as necessary to avoid damaging prestressing tendons, electrical and telecommunications conduit, and gas lines. Unless otherwise specified, do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength. Perform anchor installation in accordance with manufacturer instructions.

3.3.2.1 Wedge Anchors, Heavy-Duty Sleeve Anchors, and Undercut Anchors

Protect threads from damage during anchor installation. Heavy-duty sleeve anchors must be installed with sleeve fully engaged in part to be fastened. Set anchors to manufacturer's recommended torque, using a torque wrench. Following attainment of 10% of the specified torque, 100% of the specified torque must be reached within 7 or fewer 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.

3.3.2.2 Cartridge Injection Adhesive Anchors

Clean all holes per manufacturer instructions to remove loose material and drilling dust prior to installation of adhesive. Inject adhesive into holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive. Follow manufacturer recommendations to ensure proper mixing of adhesive components. Sufficient adhesive must be injected in the hole to ensure that the annular gap is filled to the surface. Remove excess adhesive from the surface. Shim anchors with suitable device to center the anchor in the hole. Do not disturb or load anchors before manufacturer specified cure time has elapsed.

3.3.2.3 Capsule Anchors

Perform drilling and setting operations in accordance with manufacturer instructions. Clean all holes to remove loose material and drilling dust prior to installation of adhesive. Remove water from drilled holes in such a manner as to achieve a surface dry condition. Capsule anchors must be installed with equipment conforming to manufacturer recommendations. Do not disturb or load anchors before manufacturer specified cure time has elapsed.

Observe manufacturer recommendations with respect to installation temperatures for cartridge injection adhesive anchors and capsule anchors.

3.4 ANCHOR BOLT TESTING

Test in place expansion and chemically bonded anchors not more than 24 hours after installation of the anchor, conducted by an independent testing agency; testing must be performed on random anchor bolts as described below.

3.4.1 Torque Wrench Testing

Perform torque wrench testing on not less than 50 percent of the total installed applied torque expansion anchors and at least one anchor for every piece of equipment containing more than two anchors. The test torque must equal the minimum required installation torque as required by the bolt manufacturer. Calibrate torque wrenches at the beginning of each day the torque tests are performed. Recalibrate torque wrenches for each bolt diameter whenever tests are run on bolts of various diameters. Apply torque between 20 and 100 percent of wrench capacity. Reach the test torque within one half turn of the nut, except for 3/8 inch sleeve anchors which must reach their torque by one quarter turn of the nut. If any anchor fails the test, test similar anchors not previously tested until 20 consecutive anchors pass. Failed anchors must be retightened and retested to the specified torque; if the anchor still fails the test it must be replaced.

3.4.2 Pullout Testing

Test expansion and chemically bonded anchors by applying a pullout load using a hydraulic ram attached to the anchor bolt. Testing must be in accordance with ASTM E488/E488M or ICC ES AC193. At least 10 percent of each type and size of anchors, but not less than 3 per day must be tested. Apply the load to the anchor without removing the nut; when that is not possible, the nut must be removed and a threaded coupler must be installed of the same tightness as the original nut. Check the test setup to verify that the anchor is not restrained from withdrawing by the baseplate, the test fixture, or any other fixtures. The support for the testing apparatus must be at least 1.5 times the embedment length away from the bolt being tested. Load each tested anchor to 1 times the design tension value for the anchor. The anchor must have no observable movement at the test load. If any anchor fails the test, similar type and size anchors not previously tested must be tested until 10 percent of those type consecutive anchors pass. Remove and replace failed anchors. Fill empty anchor holes and patch failed anchor locations with high-strength non-shrink, nonmetallic grout.

-- 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.

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 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. 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

SIMILAR TERMS			
Contract Term	AABC Term	NEBB Term	TABB Term
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 and existing 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.

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.

Systems to be addressed for TAB work include all air systems excluding those existing systems within the 2 hangars and the entire hydronic system including existing components and the existing components within the hangars.

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-graph

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.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

TAB Schematic Drawings and Report Forms

SD-03 Product Data

Equipment and Performance Data; G

SD-06 Test Reports

Completed Pre-Final DALT Report

Certified Final DALT Report; G

SD-07 Certificates

Independent TAB Agency and Personnel Qualifications; 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.

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 DALT Coordination

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.

It is acceptable for an entire duct system to be DALT'd instead of disassembling that system in order to DALT only the 20 percent portion specified above.

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. 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.

Systems to be addressed for TAB work include all air systems excluding those existing systems within the 2 hangars and the entire hydronic system including existing components and the existing components within the hangars.

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 and DX 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 Rooftop Air Conditioning

Rooftop air conditioning systems including fans, coils, ducts, enthalpy wheels, plenums, and air distribution devices for supply air, return air, exhaust air, and outside air.

For refrigeration compressors/condensers/condensing units/evaporators, report data as required by NEBB, AABC, and TABB standard procedures, including refrigeration operational data.

3.4.3.3 Heating and Ventilating Units

Heating and ventilating unit systems including fans, coils, ducts, plenums, roof vents, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.

3.4.3.4 Makeup Air Units

Makeup air unit systems including fans, coils, ducts, plenums, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.

3.4.3.5 Exhaust Fans

Exhaust fan systems including fans, ducts, plenums, grilles, and hoods for exhaust air.

3.4.4 TAB Water Distribution Systems

3.4.4.1 Heating Hot Water

Heating hot water systems including boilers, pumps, coils, system balancing valves and flow measuring devices.

3.4.5 TAB Work on Performance Tests Without Seasonal Limitations

3.4.5.1 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.

3.4.5.2 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 TAB Work on Performance Tests With Seasonal Limitations

3.4.6.1 Performance Tests

Accomplish proportional 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.

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.

3.4.6.2 Season Of Maximum Load

Visit the contract site for at least two TAB work sessions for Season 1 and Season 2 field measures. 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.

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.

3.4.6.3 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 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.

3.4.8 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.

3.4.9 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.

3.4.10 Quality Assurance - COTR TAB Field Acceptance Testing

3.4.10.1 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,) 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 boilers, 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.

3.4.10.2 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.

3.4.10.3 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 --

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 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 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	(2017; E 2018) Standard Specification for Cellular Glass 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	(2014) Standard Specification for Adhesives for Duct Thermal Insulation

ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C921	(2010) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM C1136	(2017a) 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	(2016) Standard Test Methods for Water Vapor Transmission of Materials
ASTM E2231	(2019) 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

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	(2018) 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

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY (TAPPI)

TAPPI T403 OM	(2015) Bursting Strength of Paper

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) 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 Sep 2017) 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

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" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. 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-03 Product Data

- Pipe Insulation Systems; G
- Duct Insulation Systems; G
- Equipment Insulation Systems; 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 exceed 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, 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 monel.

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.

2.2.8.2 Polyvinyl Chloride (PVC) Jackets

Polyvinyl chloride (PVC) jacket and fitting covers shall have high impact strength, ultraviolet (UV) resistant rating or treatment and moderate chemical resistance with minimum thickness 0.030 inch.

2.2.8.3 Vapor Barrier/Weatherproofing Jacket

Vapor barrier/weatherproofing jacket shall be laminated self-adhesive, greater than 3 plies standard grade, silver, white, black and embossed or greater than 8 ply (minimum 2.9 mils adhesive); with 0.0000 permeability when tested in accordance with ASTM E96/E96M, using the water transmission rate test method; heavy duty, white or natural; and UV resistant. Flexible Elastomeric exterior foam with factory applied, UV Jacket made with a cold weather acrylic adhesive. Construction of laminate designed to provide UV resistance, high puncture, tear resistance and excellent Water Vapor Transmission (WVT) rate.

2.2.8.4 Vapor Barrier/Vapor Retarder

Apply the following criteria to determine which system is required.

a. On ducts, piping and equipment operating below 85 degrees F or located outside shall be equipped with a vapor barrier.

b. Ducts, pipes and equipment that are located inside and that always operate above 85 degrees F shall be installed with a vapor retarder where required as stated in paragraph VAPOR RETARDER REQUIRED.

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 TAPPI T403 OM. 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 schedule on drawings and minimum insulation thickness as listed in schedule on drawings 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

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 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.

2.3.2.2 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.

2.3.3 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.

2.4 DUCT INSULATION SYSTEMS

2.4.1 Factory Applied Insulation

Provide factory-applied ASTM C552, cellular glass thermal 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.

2.4.3.3 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 as scheduled or specified,, 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 schedules on drawings. 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

Insulation shall only be applied to unheated and uncooled piping and equipment. Flexible elastomeric cellular insulation shall not be compressed at joists, studs, columns, ducts, hangers, etc. The insulation shall not pull apart after a one hour period; any insulation found to pull apart after one hour, shall be replaced.

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 specified 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. ASME stamps.

b. Access plates of fan housings.

c. 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.

3.2.1.3 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 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.

3.2.1.3.3 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 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. Other areas that specifically require protection to the 6 foot level are hangar, fire protection room, storate rooms shop spaces, and any occupiable space that piping insulation is exposed.

3.2.1.6 Pipe Insulation Material and Thickness

Pipe insulation materials must be as scheduled on drawings and must meet or exceed the requirements of ASHRAE 90.1.

3.2.2 Aboveground Cold Pipelines

The following cold pipelines for minus 30 to plus 60 degrees F, shall be insulated in accordance with schedule on drawings except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted. This includes but is not limited to the following:

a. Make-up water.

b. Refrigerant suction lines.

c. Air conditioner condensate drains.

3.2.2.1 Insulation Material and Thickness

Insulation thickness for cold pipelines shall be determined using schedule on drawings.

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, sliver, 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.

3.2.2.5 Optional PVC Fitting Covers

At the option of the Contractor, premolded, one or two piece PVC fitting covers may be used in lieu of the vapor retarder and embedded glass tape. Factory precut or premolded insulation segments shall be used under the fitting covers for elbows. Insulation segments shall be the same insulation as the pipe insulation including same density, thickness, and thermal conductivity. The covers shall be secured by PVC vapor retarder tape, adhesive, seal welding or with tacks made for securing PVC covers. Seams in the cover, and tacks and laps to adjoining pipe insulation jacket, shall be sealed with vapor retarder tape to ensure that the assembly has a continuous vapor seal.

3.2.3 Aboveground Hot Pipelines

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 schedule on drawings. 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.

3.2.4.3 PVC Jacket

PVC jacket shall be ultraviolet resistant and adhesive welded weather tight with manufacturer's recommended adhesive. Installation shall include provision for thermal expansion.

3.3 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. Duct insulation shall be omitted on exposed supply and return ducts in air conditioned spaces where the difference between supply air temperature and room air temperature is less than 15 degrees F unless otherwise shown. Air conditioned spaces shall be defined as those spaces directly supplied with cooled conditioned air (or provided with a cooling device such as a fan-coil unit) and heated conditioned air (or provided with a heating device such as a unit heater, radiator or convector).

3.3.1 Duct Insulation Minimum Thickness

Duct insulation minimum thickness in accordance with schedule on drawings.

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.

a. Supply ducts.

b. Return air ducts.

c. Relief 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 (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 any 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

Exposed in conditioned areas does not require insulation.

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.

3.4 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 Hot Equipment

Insulation shall be furnished on equipment handling media above 60 degrees F including the following:

a. Pumps handling media above 130 degrees F.

b. Air separation tanks.

3.4.2.1 Insulation

Insulation shall be suitable for the temperature encountered.

Insulation thickness for hot equipment shall be as scheduled on drawings.

3.4.2.2 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.

3.4.2.3 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 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.

3.4.3 Equipment Handling Dual Temperature Media

Below and above 60 degrees F: equipment handling dual temperature media shall be insulated as specified for cold equipment.

3.4.4 Equipment Exposed to Weather

3.4.4.1 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.

3.4.4.2 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.

-- End of Section --

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 93 SEQUENCES OF OPERATION FOR HVAC CONTROL, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for 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. A system of multiple boilers 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 functionaliality 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.

1.1.2 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 using DDC hardware to control mechanical and electrical equipment

b. The existing basewide DDC system is Automated Logic Corporation (ALC). Upgrade or replace the existing server, operator workstation, or software as necessary to be compatible with the manufacturer's latest software version for all used applications. Upgrade hardware, memory, and operating systems if required. Extend existing base DDC system to control new equipment installed per the project scope. Update existing DDC software and firmware to current standards. Include all new programming and graphics to make the front-end fully functional with all the new control equipment.

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.

h. DDC Sysems shall be routed via an ALC LAN Gate Router (LGR-250).

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 without Niagara Framework.

b. Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

c. Section 23 09 93 SEQUENCES OF OPERATIONS FOR HVAC CONTROLS

d. Section 25 08 10 UTILITY MONITORING AND CONTROL SYSTEMS TESTING

e. Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEMS (UMCS) FRONT END AND INTEGRATION

f. Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS

g. Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING

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	(2016) BACnet—A Data Communication Protocol for Building Automation and Control Networks
ASHRAE FUN IP	(2017) 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	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)

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 5085-3	(2006; Reprint Nov 20121) 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)

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)

The following is a list of some BIBBs used by this or referenced Sections:	
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; these dates are specified in the contract documents.

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
1	S	Existing Conditions Report	
2	S	DDC Contractor Design Drawings	
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

TABLE II. PROJECT SEQUENCING			
ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE
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
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

TABLE II. PROJECT SEQUENCING			
ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE
19	S	Closeout QC Checklist	ACO #18

1.6 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. 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

Manufacturer's Product Data; G

SD-05 Design Data

Boiler Plant Gateway Request

SD-06 Test Reports

Existing Conditions Report

Start-Up Testing Report; G

PVT Procedures; G

PVT Report; G

Pre-Construction Quality Control (QC) Checklist; G

Post-Construction Quality Control (QC) Checklist; 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 2 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 2 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 2 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 2 copies of the Controller Application Programs CD-ROM.

1.9 BOILER PLANT GATEWAY REQUEST

If requesting the use of a gateway to a boiler plant as indicated in paragraph Proprietary Systems Exempted From Open Protocol Requirements, submit a Boiler 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. All new equipment MUST be 100% fully compatible with the existing base-wide system.

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 3 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 matter 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 Government. Provide a Password Summary Report documenting the password for each device and describing the procedure to change the password for each device.

Provide two 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 ISO A1 34 by 22 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: 4 hard copies and 2 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: 4 hard copies and 2 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: 4 hard copies and 2 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 and each M&C Client 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 based on Section 25 08 10 UTILITY MONITORING AND CONTROL SYSTEM TESTING 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. HVAC control system sequences of operation formatted as indicated.

c. 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.

d. As-built HVAC control system detail drawings formatted as indicated.

e. 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.

f. Qualified service organization list, including at a minimum company name, contact name and phone number.

g. Start-Up Testing Report.

h. Performance Verification Test (PVT) Procedures and Report.

Submit 2 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 MAINTENANCE AND SERVICE

Provide services, materials and equipment as necessary to maintain the entire system in an operational state as indicated for a period of one year after successful completion and acceptance of the Performance Verification Test. Minimize impacts on facility operations.

a. The integration of the system specified in this section into a Utility Monitoring and Control System must not, of itself, void the warranty or otherwise alter the requirement for the one year maintenance and service period. Integration into a UMCS includes but is not limited to establishing communication between devices in the control system and the front end or devices in another system.

b. The changing of configuration properties must not, of itself, void the warranty or otherwise alter the requirement for the one year maintenance and service period.

3.8.1 Description of Work

Provide adjustment and repair of the system including the manufacturer's required sensor and actuator (including transducer) calibration, span and range adjustment.

3.8.2 Personnel

Use only service personnel qualified to accomplish work promptly and satisfactorily. Advise the Government in writing of the name of the designated service representative, and of any changes in personnel.

3.8.3 Scheduled Inspections

Perform two inspections at six-month intervals and provide work required. Perform inspections in June and December. During each inspection perform the indicated tasks:

a. Perform visual checks and operational tests of equipment.

b. Clean control system equipment including interior and exterior surfaces.

c. Check and calibrate each field device. Check and calibrate 50 percent of the total analog inputs and outputs during the first inspection. Check and calibrate the remaining 50 percent of the analog inputs and outputs during the second major inspection. Certify analog test instrumentation accuracy to be twice the specified accuracy of the device being calibrated. Randomly check at least 25 percent of all binary inputs and outputs for proper operation during the first inspection. Randomly check at least 25 percent of the remaining binary inputs and outputs during the second inspection. If more than 20 percent of checked inputs or outputs failed the calibration check during any inspection, check and recalibrate all inputs and outputs during that inspection.

d. Run system software diagnostics and correct diagnosed problems.

e. Resolve any previous outstanding problems.

3.8.4 Scheduled Work

This work must be performed during regular working hours, Monday through Friday, excluding Federal holidays.

3.8.5 Emergency Service

The Government will initiate service calls when the system is not functioning properly. Qualified personnel must be available to provide service to the system. A telephone number where the service supervisor can be reached at all times must be provided. Service personnel must be at the site within 24 hours after receiving a request for service. The control system must be restored to proper operating condition as required per Section 01 78 00 CLOSEOUT SUBMITTALS.

3.8.6 Operation

After performing scheduled adjustments and repairs, verify control system operation as demonstrated by the applicable tests of the performance verification test.

3.8.7 Records and Logs

Keep dated records and logs of each task, with cumulative records for each major component, and for the complete system chronologically. Maintain a continuous log for all devices, including initial analog span and zero calibration values and digital points. Keep complete logs and provide logs for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

3.8.8 Work Requests

Record each service call request as received and include 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. Submit a record of the work performed within 5 days after work is accomplished.

3.8.9 System Modifications

Submit recommendations for system modification in writing. Do not make system modifications, including operating parameters and control settings, without prior approval of the Government.

3.9 TRAINING

Conduct a training course for 4 operating staff members designated by the

Government in the maintenance and operation of the system, including specified hardware and software. Conduct 32 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.

3.9.1 Training Documentation

Prepare training documentation consisting of:

a. Course Attendee List: Develop the list of course attendees in coordination with and signed by the Controls 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.

3.9.2 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.

3.9.3 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 2 additional copies for archive at the project site. Provide 2 copies of the Course Attendee List with the archival copies. Training Documentation may be submitted as a Technical Data Package.

APPENDIX A

	QC CHECKLIST FOR BACNET SYSTEMS	
	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.	
9	O&M Instructions have been completed and submitted.	|____|
10	Training course has been completed.	|____|

QC CHECKLIST FOR BACNET SYSTEMS		
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 --

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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 01 30 00 ADMINISTRATIVE REQUIREMENTS

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) Certified Ratings Program for Air Control Devices

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.34	(2017) 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	(2013) 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 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 5085-3	(2006; Reprint Nov 20121) 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

Perform all work in this section in accordance with the paragraph entitled CONTRACTOR SPECIAL REQUIREMENTS in Section 01 30 00 ADMINISTRATIVE 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.

The existing basewide DDC system is Automated Logic Corporation (ALC). All new equipment MUST be 100 percent fully compatible with the existing base-wide system.

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 -35 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.

2.4.2 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.

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

2.4.5 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 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 Duct-Coil and Terminal-Unit-Coil Valves

For duct or terminal-unit coils provide control valves with either screw type or solder-type ends.

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.

2.6 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 23.02 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 Heating Hot 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 and function.

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

Provide minimum 3 inch immersion. 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 3 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 -20 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 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.

2.6.7.3 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.

2.6.7.4 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.

2.6.7.5 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.

2.6.7.6 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.

2.6.9 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.

2.6.10 Temperature Switch

2.6.10.1 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.

2.6.10.2 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.

2.6.11 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.

2.7 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 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 Switches

3.1.5.1 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.

3.1.5.2 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.

3.1.6 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.

3.1.6.1 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 54 inches above the floor to meet ADA requirements. Non user-adjustable sensors can be mounted as indicated in paragraph ROOM INSTRUMENT MOUNTING.

3.1.6.2 Duct Temperature Sensors

3.1.6.2.1 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.

3.1.6.2.2 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.

3.1.6.3 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.

3.1.6.4 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.

3.1.7 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.

3.1.8 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.

3.1.9 Relative Humidity Sensors

Install relative humidity sensors in supply air ducts at least 10 feet downstream of humidity injection elements.

3.1.10 Meters

3.1.10.1 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 Dampers

3.1.11.1 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 nay 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.

3.1.11.2 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.

3.1.12 Valves

Install the valves in accordance with the manufacturer's instructions.

3.1.12.1 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.

3.1.13 Thermometers and Gauges

3.1.13.1 Thermometers

Mount devices to allow reading while standing on the floor or ground, as applicable.

3.1.14 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

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.

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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	(2016) 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	(2018) 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) Standard for 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.

2.1.3 Ethernet Switch

Ethernet Switches must autoconfigure between 10,100 and 1000 megabits per second (MBPS).

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, or twisted pair with shield (2-wire media) wiring and use half-wave rectification.

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.

2.3.2 Additional Spare Input/Output Connections

Provide a minimum of 15% spare I/O connections on each DDC controller.

2.3.3 Hardware Input-Output (I/O) Functions

DDC Hardware incorporating hardware input-output (I/O) functions must meet the following requirements:

2.3.3.1 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.

2.3.3.2 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 mAdc or 0-10 Vdc. 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

2.3.3.3 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.

2.3.3.4 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.

2.3.3.4.1 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.

2.3.3.4.2 Triac Outputs

Triac outputs must provide at least 180 V of isolation. Minimum contact rating must be 0.5 amperes at 24 Vac.

2.3.3.5 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.

2.3.3.6 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.)

2.3.3.7 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.

2.3.4 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.

2.3.5 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.

2.3.6 Supervisory Control Requirements

2.3.6.1 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.

2.3.6.2 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.

2.3.6.3 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 Ethernet Switches in lockable enclosures. Install the Building Control Network (BCN) IP Backbone such 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 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 Government and provide recommended alternatives for approval.

3.1.2.3 Hand-Off-Auto (H-O-A) Switches

Provide Hand-Off-Auto (H-O-A) switches 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 eternal H-O-A switches used for analog outputs, provide for overriding through the range of 0 percent to 100 percent.

3.1.2.4 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.

3.1.2.5 MS/TP Slave Devices

Configure all MS/TP devices as Master devices. Do not configure any devices to act as slave devices.

3.1.2.6 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.

3.1.2.7 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)

3.1.2.8 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.

3.1.2.9 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.

3.1.2.10 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.

3.1.2.11 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-OCD-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) or group of stand-alone Terminal Units acting according to a common schedule.

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 singe 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 4 additional Trend Log Objects.

(2) Provide 4 additional Trend Log Objects 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 09 93

SEQUENCES OF OPERATION FOR HVAC CONTROL

PART 1 GENERAL

1.1 DEFINITIONS

For definitions related to this Section, see Section 23 09 00 INTRUMENTATION AND CONTROL FOR HVAC.

1.2 SUBMITTALS

Submittals related to this Section are specified in Section 23 09 00 INTRUMENTATION AND CONTROL FOR HVAC.

1.3 PERFORMANCE REQUIREMENTS

Control System: Unless specifically indicated otherwise, all sequences shall be DDC based, through the Building Automation System (BAS).

A value in this specification followed by the word "adjustable" means the value can be changed manually through the DDC system by the Government.

All duct mounted smoke detectors shall be provided by the Division 28 Contractor and installed by this Contractor. This includes ALL power, temperature control, and alarm wiring.

The AHU DDC control systems shall be connected to the main fire suppression control panel (coordinate final panel location with Fire Protection Contractor). When this fire suppression system is activated, the fire suppression system shall shut down ALL AHU and exhaust fan motors via the DDC temperature control system. This Contractor shall provide all materials and labor required for this control feature. The fire suppression system panel and its programming shall be by others.

All control points shall be exposed as BACnet objects and shall be viewable and editable over the internet from a remote location with a standard web browser.

For pushbutton switches mentioned in the sections below, provide the Government with a sample of each type used for approval prior to installation.

When filter pressure monitoring and control is required for a unit,filter monitoring and control shall apply to all filter banks in the unit.

1.4 DDC System Graphics

The operator interface shall provide graphic based displays of each system. The point data associated with each system shall dynamically update at a minimum of every 30 seconds. Graphic displays shall be linked to each other to provide capability from main graphic displays to more specific system based displays. Provide a building level graphic display that links to system graphics. Provide a building floor plan with systems, system schematic layouts, points, settings, schedules, etc. Points, schedules, settings, etc. provided in the graphic shall have the override and adjust capability specified under operator commands.

PART 2 PRODUCTS

Products related to this Section are specified in Section 23 09 00 INTRUMENTATION AND CONTROL FOR HVAC and related Sections 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC and 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

PART 3 EXECUTION

3.1 INSTALLATION

Perform the installation under the supervision of competent technicians regularly employed in the installation of DDC systems.

3.2 GENERAL CONTROL SEQUENCES

When a device is required to run, the control system shall command the device to start by energizing a discrete output to the motor starter and/or variable frequency drive (VFD). The device shall run until the control system commands the device to stop by de-energizing the discrete output to the motor starter, a hardwired emergency device (pressure switch, freeze stat, smoke detector, etc.) interrupts power, or an equipment failure occurs. Equipment failure shall be detected by opening a current switch when the device is commanded on or is operating.

Provide each switch/alarm trip point with an adjustable time delay to prevent nuisance tripping or short cycling. These time delays apply to all switchable hardware or software points and are for normal operation. Additional or longer delays maybe necessary during startup as noted.

3.3 GENERAL FAILURE MODES

Power Failure: Put all devices in failure positions. Stagger restart upon restoration of power.

Fire Alarm: Put all devices in failure positions.

Duct smoke detectors: Put all devices in failure positions.

3.4 VARIABLE FREQUENCY (SPEED) DRIVES

Each variable frequency drive (VFD) shall be integrated into the Building Automation System (BAS) via a communication gateway to allow all information available from the VFD panel to be viewed and all settings and adjustments to be made through the BAS. Initially, the BAS shall be arranged to poll the VFD for the following information at a minimum.

Speed Feedback (Hz)

VFD failure/alarm

A motor speed control signal and start/stop control signal from the BAS controller shall be hardwired directly to the input terminals of the VFD and shall not be sent via the BAS network.

The Control Contractor shall coordinate the communication protocol and all the interfacing materials with the VFD manufacturer.

3.5 SPECIFIC EQUIPMENT CONTROL SEQUENCES

Sequences of operation for specific equipment can be found in Appendix 230993A, which immediately follows this section.

-- End of Section --

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APPENDIX 23 09 93A – SEQUENCES OF OPERATION FOR HVAC CONTROL

PART 1 – EXECUTION

1.1 CENTRAL HEATING CONTROL SEQUENCES

A. Boiler/Primary Pump Control:

1. Delegated Control:

   a. Primary boiler control to be by the existing boiler manufacturer’s boiler control package, monitored by the BAS, and to meet the criteria below as a minimum. A gateway provided by the boiler manufacturer shall integrate with the BAS to provide supervisory control, rudimentary setpoint changes, and on/off scheduling parameters through the BAS.

2. Input Devices:

   a. Supply water temperature sensor.
   b. Return water temperature sensor.
   c. Water flow sensors.
   d. Outside air temperature sensor.

3. Setpoints:

   a. Supply Water Temperature:

      1) 160 deg F (adjustable) supply water temperature when the outside air temperature is 20 deg F (adjustable) or below.
      2) 120 deg F (adjustable) when the outside air temperature is 50 deg F (adjustable) or above. Coordinate minimum hot water temperature with boiler manufacturers’ recommendations.
      3) Linear relationship between the two points above.

4. Boilers and Primary Pumps:

   a. Sequence and modulate boilers to maintain heating-water supply temperature. Energize boilers and associated pumps at outdoor air temperature below 45 deg F (adjustable).
   b. Start associated primary pump before enabling boiler. Enable boiler when flow is proven.
   c. When the lead boiler is unable to maintain heating-water supply temperature at 65% fire (adjustable) for more than five minutes, and the lead boiler has been running at least 30 minutes (adjustable), start the lag boiler and associated pump.

d. When multiple boilers are firing, modulate boilers together at the same rate.
e. When multiple boilers are firing at less than 15% (adjustable) of full fire, shut down the lag boiler and pump.
f. Switch lead/lag boiler and pump assignments weekly at a time when maintenance personnel are available. Verify scheduled times with maintenance personnel.
g. Prove new lead boiler and primary pump operating before allowing former lead boiler and primary pump to shut down.
h. Boiler/Pump Shutdown:

   1) Initiate boiler shutdown sequence.
   2) Continue running pump for two minutes (adjustable) after boiler shutdown, then shut off pump.
   3) Do not allow boiler to restart until 15 minutes (adjustable) after shutdown.

i. Conditions:

   1) Disable boilers and primary pumps when both secondary pumps are off.
   2) Disable boilers and primary pumps when Emergency Shut-Off button is activated.

5. Safeties:

   a. All safety controls shall come factory installed and be integral with boiler and shall not be overridden by the BAS.
   b. Provide integration of boiler flame safeguard controls with BAS. Integration shall provide monitoring of all data available at these controllers via the BAS. Install Communications Interface furnished by the boiler manufacturer. Provide all necessary wiring between communications interface and burner controllers (provided by boiler manufacturer)
   c. Flame Safeguard: Flame safeguard microprocessor shall annunciate discrete alarm conditions.
   d. Annunciate off-normal alarm whenever boiler status does not equal command.

6. Failures:

   a. Communication or equipment failure of lead boiler, boiler control panel shall automatically switch lead/lag boiler and primary pump assignments and signal a BAS alarm.
   b. Boiler Failure or Primary Pump Failure (as sensed by pressure switch): Disable pump and boiler and signal

an alarm. Switch the lead/lag assignments of the boiler and primary pump.

c. Sensor Failure: Upon the failure of an analog sensor, associated fire rates shall remain at their last position and alarm shall be annunciated.

7. Display:

a. See Points List on drawings.

B. Secondary Hot Water Pump Control:

1. Each pump controlled by VFD through the BAS.

a. Pump speed shall be controlled through the BAS to maintain a differential pressure setpoint of 10 psig (adjustable) between the supply and return piping in the distribution piping system. Locate differential pressure sensor near the far end of the main hot water piping distribution system.

b. Pump shall run continuously whenever the outdoor air temperature is 70 deg (adjustable) or less.

c. Minimum run time shall be 5 minutes (adjustable).

d. VFD shall start at minimum speed setting and shall ramp to control point. Unless otherwise noted, VFD shall ramp up and down full scale over 60 seconds. VFD shall not be allowed to operate at less than 15 Hz (adjustable).

2. Primary/Standby Control:

a. Provide primary/standby sequencing for pumps.

b. Primary pump to operate continuously.

c. Switch primary/standby pump assignments weekly at a time when maintenance personnel are available. Verify scheduled times with maintenance personnel.

d. Switch the primary/standby secondary pumps at a slightly different time than the boilers and primary pumps. At time of switch-over of primary and standby pumps, standby pump shall be started and speed (frequency) shall be increased while primary pump speed (frequency) is decreased simultaneously. When both pumps achieve the same speed, the original primary pump shall be stopped.

3. Failures:

a. Secondary Pump or VFD Failure: Disable pump and signal an alarm. Switch the primary/standby assignments of the secondary pumps.

4. Display:

   a. See Points List on drawings.

C. Hot Water Bypass Valve Control:

   1. Input Device:

      a. VFD frequency of active system pump.
      b. Hot water system differential pressure sensor.

   2. Output Device: Automatic control bypass valve.
   3. Action:

      a. When associated pump VFD frequency operation is at minimum setpoint, modulate the hot water bypass valve to maintain hot water system differential pressure setpoint at +3 psig (adjustable) above setpoint.
      b. Hot water bypass valve to be fully closed when associated pump VFD frequency is above its' minimum setpoint.

1.2 VAV AIR HANDLING UNIT CONTROL SEQUENCES, DDC CONTROL (RTU-1)

A. General:

   1. System is designed as heating-cooling, single duct, variable volume reheat system.
   2. System is designed for minimum outside air with outside air economizer.
   3. Temperature controls shall be controlled individually at each unit.

B. Delegated Control:

   1. Primary unit control to be by the air handling unit manufacturer's packaged control system, monitored by the BAS, and to meet the criteria below as a minimum. A gateway provided by the AHU manufacturer shall integrate with the BAS to provide supervisory control, rudimentary setpoint changes, on/off scheduling parameters, and alarm monitoring through the BAS.

C. Operating Modes:

   1. Occupied or unoccupied as determined by the DDC system occupancy time schedule. When any zone is in occupied mode, the system shall be in occupied mode.

D. Unit Operation:

   1. Unit operation shall be automatic and activated through the BAS.

2. Units shall run continuously during occupied mode.
3. Whenever an air handling unit is manually commanded to stop by BAS operator or is shut down by any safety device:

   a. Supply fan, exhaust fan, and energy recovery wheel shall stop.
   b. RTU outside air damper and exhaust air damper shall be commanded closed.
   c. Associated air-cooled condensing unit shall be off.

E. Supply Air Temperature Control:

   1. Supply Air Temperature Setpoint:

      a. 65 deg F (adjustable) when the exhaust air temperature is 70 deg F (adjustable) or below.
      b. 55 deg F (adjustable) when the exhaust air temperature is 75 deg F (adjustable) or above.
      c. Linear relationship between the two points above.

F. Supply Fan (w/ VFD):

   1. Fail Position: Off.
   2. Action:

      a. Fan Start: Ramp up speed slowly - no faster than full speed after 5 minutes.
      b. Fan On: Run the fan under any of the following conditions:

         1) Occupied mode initiated by occupancy schedule.
         2) Warm-up / Cool-down mode.
         3) During unoccupied periods when heating or cooling is called for, as determined by a signal from any VAV box in the system thru the BAS.

      c. Fan Off: All other times.

   3. Speed Control - PI Loop Control:

      a. Input Device: Static-pressure transmitter located near the end of the supply air system referenced to the conditioned-space static pressure.

         1) Setpoint: Floating Point Control - 1.0” wg (adjustable) +/-0.1” wg (adjustable).

      b. Output Device: DDC system analog output to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
      c. Action: Modulate fan speed to maintain supply duct static pressure at setpoint.

1) Static Pressure Setpoint Reset:

a) Identify critical zone AT box damper (the most open damper of AT boxes on the system) every 5 minutes and determine its percent open.
b) When the critical zone AT box damper is less than 85% (adjustable) open, then the static pressure setpoint shall be lowered 0.1” wg.
c) When the critical zone AT box damper is more than 95% (adjustable) open, then the static pressure setpoint shall be raised 0.1” wg.
d) Otherwise, the static pressure setpoint shall remain unchanged.

G. Limits:

1. High Pressure:

a. Input Device: Static-pressure switch sensing supply duct static pressure referenced to static pressure outside the duct.
b. Output Device: DDC system binary output and motor starter/VFD to supply fan and DDC system alarm.
c. Action: Disable fan and signal alarm when static pressure rises above excessive-static-pressure setpoint of 3.5” wg (adjustable).

2. Low discharge air temperature protection:

a. Input device: Temperature sensor located at unit discharge.
b. Action: Disable fans, close gas valve, and signal alarm through control system if sensed temperature is below 40 deg F (adjustable).

3. Smoke Control:

a. Input Device: Duct-mounted smoke detector located in the supply and return air ducts.
b. Output Device: Hard wired through motor starters to both supply and exhaust fans; DDC system alarm.
c. Action: Disable fans if smoke is sensed in the supply or return air duct and signal fire alarm panel.

4. Emergency Shutdown:

a. Input Device: Emergency Shutdown Pushbutton.
b. Action: Disable supply and exhaust fans, put AHU in failure position, and signal an alarm.

H. Exhaust Fan

1. Fail Position: Off.
2. Action:

   a. Start 5 seconds (adjustable) after the supply fan is commanded to run when in occupied mode.
   b. Exhaust fan is disabled in unoccupied mode.

I. Return Air Damper:

1. Fail Position: Open.
2. Economizer: See Economizer sequence of operation below.
3. Unoccupied, No Economizer: Open.
4. Otherwise: Open.

J. Outside Air Damper:

1. Fail Position: Closed.
2. Occupied: Modulate to maintain minimum outside air flow rate at setpoint using a PI loop as sensed by the respective air flow measuring station located in the outside air intake of the unit. Refer to RTU schedule on drawings for minimum outside air flow rate (adjustable).
3. Unoccupied, No Economizer: Closed.
4. Economizer: See Economizer sequence of operation below.

K. Economizer:

1. Action:

   a. Enable economizer mode when the outdoor dry bulb air temperature is below the return air dry bulb temperature by 2 deg F (adjustable). Otherwise disable economizer mode.
   b. Modulate outside air damper and return air damper to maintain the mixed air temperature 2 deg F (adjustable) below the discharge air temperature setpoint using a PI loop.
   c. Open bypass dampers at energy recovery wheel.
   d. Activate relief exhaust fan EF-9 (see sequences below).
   e. Energy wheel to stop.

L. Gas Heating Control Valve:

1. Fail Position: Closed.
2. Action:

   a. Modulate to maintain discharge air temperature setpoint.

3. Conditions:

a. Per factory-installed safety control.
b. Close valve when supply fan is off.
c. Locked out when OA sensor reads 60 deg F (adjustable) or greater.

M. DX Cooling Coil Control:

1. Cooling Compressors(s):

a. Fail Position: Off.
b. Action: When discharge air temperature is above setpoint, modulate/cycle compressor(s) until temperature equals setpoint, then off.
c. Otherwise: Off.

2. Conditions:

a. Disable compressor(s) when heating valve is open.
b. Disable compressor(s) when supply fan is off.
c. Per ACCU manufacturer’s factory-installed safety conditions.

N. Filters:

1. Differential Pressure (each filter bank):

a. Input Device: Pressure transmitter.
b. Output Device: DDC system alarm.
c. Action: Signal alarm on low and high pressure conditions.

O. Energy Recovery Wheel:

1. Operate continuously whenever unit is in occupied mode, supply air fan is operating, and unit is not in economizer mode.

P. Warm-up / Cool-down Mode:

1. Damper Positions: Same as unoccupied mode.
2. Fans and Zone Temperature Setpoints: Same as occupied mode.

Q. Coordination of Air-Handling Unit Sequences: Ensure that controls have common inputs and do not overlap in function.

R. Safeties:

1. The unit shall run subject to the unit manufacturer’s safeties.

S. Failure Modes:

1. Power Failure: Put all devices in failure positions. Stagger restart upon restoration of power.
2. Fire Alarm: Put all devices in failure positions.
3. Supply Fan Failure:

   a. Input Device: Current sensor on supply fan.
   b. Output Device: DDC system alarm.
   c. Action: If fan is not running 30 seconds (adjustable) after command to start, put all devices in failure position and signal an alarm with manual reset.

T. Operator Station Display: Indicate the following on operator workstation display terminal:

1. See Points List on drawings.

1.3 GAS-FIRED MAKE-UP AIR UNIT CONTROL SEQUENCES (MAU-1)

A. General: Packaged single-speed, direct-fired make-up air unit with 100% outdoor air and associated interlocked exhaust fans.

B. Delegated Control:

1. Primary unit control to be by the unit manufacturer’s packaged control system, monitored by the BAS, and to meet the criteria below as a minimum. An interlock with the unit controls with the BAS shall provide rudimentary setpoint changes and on/off scheduling parameters through the BAS.

C. Fail Position: Off.

D. Operating Modes:

1. Occupied or unoccupied as determined by the DDC system occupancy time schedule.

E. Discharge Air Temperature Setpoint:

1. Input Device: Discharge air temperature sensor.
2. Setpoint: 60 deg F (adjustable).

F. Supply Fan:

1. Fail Position: Off.
2. Action: Single-speed; controlled by HAND-OFF-AUTO switch.

   a. HAND: On.
   b. OFF: Off.
   c. AUTO: Run in accordance with the unit occupancy schedule.

G. Outside Air Damper:

1. Fail Position: Closed.
2. Action: Two-position; interlocked with associated MAU.

    a. Open when make-up air unit is on.
    b. Closed when make-up air unit is off.

H. Gas Heating Control Valve:

1. Fail Position: Closed.
2. Action:

    a. Modulate to maintain discharge air temperature setpoint.

3. Conditions:

    a. Per factory-installed safety control.
    b. Close valve when supply fan is off.
    c. Locked out when OA sensor reads 60 deg F (adjustable) or greater.
    d. Lock out burners of MAU-1 whenever hangar doors are open, even partially, and OA sensor reads 40 deg F (adjustable) or greater.

I. Filters:

1. Differential Pressure:

    a. Input Device: Pressure transmitter.
    b. Output Device: DDC system alarm.
    c. Action: Signal alarm on high pressure condition.

J. Limits:

1. Low discharge air temperature protection:

    a. Input device: Temperature sensor located at unit discharge.
    b. Action: Disable fan, close gas valve, and signal alarm through control system if sensed temperature is below 40 deg F (adjustable).

2. High temperature automatic shut-off:

    a. Input device: Temperature sensor located at unit discharge.
    b. Action: Disable fan, close gas valve, and signal alarm through control system if sensed temperature is above 130 deg F (adjustable).

3. Smoke Control:

a. Input device: Duct-mounted smoke detector located in supply duct.
b. Action: Disable MAU and signal alarm through control system if smoke is detected in duct.

4. Safeties:

   a. The unit shall run subject to the unit manufacturer's safeties.

5. Failure Modes:

   a. Power Failure: Put all devices in failure positions.
   b. Fire Alarm: Put all devices in failure positions.
   c. Supply Fan Failure:

      1) Input Device: Current sensor on supply fan.
      2) Output Device: DDC system alarm.
      3) Action: If fan is not running for 30 seconds (adjustable) after command to start, put all devices in failure position and signal an alarm with manual reset.

K. Operator Station Display: Indicate the following on operator workstation display terminal:

   1. See Points List on drawings.

1.4 TERMINAL UNIT OPERATING SEQUENCES

A. Variable Air Volume Air Terminal Flow Supply with Reheat (AT-'x'):

   1. Occupancy: Occupied or unoccupied as determined by DDC system occupancy time schedule and temporary occupancy override buttons. Temporary occupancy override shall last 3 hours (adjustable) for the associated AHU system.
   2. Room Temperature Control:

      a. Input Device:

         1) Electronic temperature space sensor.
         2) Discharge air temperature sensor.
         3) AT box differential pressure sensor.

      b. Setpoints:

         1) Occupied Room Temperature:

            a) Heating: 70 deg F (adjustable); Allowable Range: 55 to 85 deg F.

b) Cooling: 75 deg F (adjustable); Allowable Range: 55 to 85 deg F.
c) Deadband: Plus or minus 2.5 deg F; Allowable range: 0 to 5 deg F.

2) Unoccupied Room Temperature:

a) Heating: 60 deg F (adjustable); Allowable Range: 55 to 85 deg F.
b) Cooling: 80 deg F (adjustable); Allowable Range: 55 to 85 deg F.
c) Deadband: Plus or minus 2.5 deg F; Allowable range: 0 to 5 deg F.

3) Allowable Deviation Above Cooling Setpoint or Below Heating Setpoint Before Alarm: 4 deg F (adjustable). Allowable range: 1 to 10 deg F.

c. Damper:

1) Fail Position: Last.
2) Heating Mode: Adjust airflow setpoint to maintain heating setpoint temperature using PI loop, subject to the heating and minimum airflow limits (adjustable) as shown on the equipment schedule.
3) Cooling Mode: Adjust airflow setpoint to maintain cooling setpoint temperature using PI loop, subject to the maximum and minimum airflow limits (adjustable) as shown on the equipment schedule.
4) For AT boxes in systems that use damper position in a static pressure setpoint reset optimization strategy, close the damper each day at midnight to re-zero the damper position indicator, then re-open to last position and resume normal control.

d. Reheat Coil Valve:

1) Fail Position: Open.
2) Modulate to maintain space heating setpoint using PI loop.
3) Reheat coil valve to be closed when the associated AHU is off.

e. When in unoccupied mode and the room temperature is above the unoccupied cooling setpoint plus the deadband or below the unoccupied heating setpoint minus the deadband, signal the air handling unit controller to run the air handling unit. When the temperature is satisfied, signal the air handling unit controller that the temperature is satisfied and the air handling unit does not need to run for this zone. (The air handler will continue running if another zone temperature is not satisfied.)

3. Operator Station Display: Indicate the following on operator workstation display terminal:

   a. See Points List on drawings.

B. Cabinet Unit Heater, Hydronic (CUH-1):

1. Room Temperature:

   a. Input Device: Electronic temperature space sensor.
   b. Setpoint:

      1) Occupied: 70 deg F (adjustable).
      2) Unoccupied: 60 deg F (adjustable).

   c. Control Valve:

      1) Fail Position: Open.
      2) Action: Modulate to maintain space temperature setpoint based on room thermostat.

   d. Fan:

      1) Fail Position: Off.
      2) Action:

         a) Cycle to maintain room temperature at setpoint.

2. Display:

   a. See Points List on drawings.

C. Convectors, Hydronic (C-1,2,3,4):

1. Room Temperature:

   a. Input Device: Electronic temperature space sensor.
   b. Setpoint:

      1) Occupied: 70 deg F (adjustable).
      2) Unoccupied: 60 deg F (adjustable).

   c. Output Device: Electronic control-valve operators.

1) Fail Position: Open.
2) Action: Modulate valve to maintain setpoint temperature.

2. Display:

a. See Points List on drawings.

D. Finned Tube Radiation (FTR-1,2,3):

1. Room Temperature:

a. Input Device: Electronic temperature space sensor.
b. Setpoint:

1) Occupied: 70 deg F (adjustable).
2) Unoccupied: 60 deg F (adjustable).

c. Output Device: Electronic control-valve operators.

1) Fail Position: Open.
2) Action: Modulate valve to maintain setpoint temperature.

2. Display:

a. See Points List on drawings.

E. Unit Heater, Hydronic (UH-1,2):

1. Room Temperature:

a. Input Device: Electronic temperature space sensor.
b. Setpoint: 65 deg F (adjustable).
c. Control Valve:

1) Fail Position: Open.
2) Action: Modulate to maintain space temperature setpoint based on room thermostat.

d. Fan:

1) Fail Position: Off.
2) Action:

a) Cycle to maintain room temperature at setpoint.

2. Display;

a. See Points List on drawings.

F. Unit Heater, Hydronic (EUH-1,2,3):

1. Room Temperature:

   a. Input Device: Electronic temperature space sensor.
   b. Setpoint: 55 deg F (adjustable).
   c. Heating Element:

      1) Fail Position: Off.
      2) Action: Modulate to maintain room temperature setpoint based on room thermostat.

   d. Fan:

      1) Fail Position: Off.
      2) Action:

         a) Cycle to maintain room temperature at setpoint.

2. Display;

   a. See Points List on drawings.

G. Unit Heater, Gas-Fired (GUH-1):

1. Room Temperature:

   a. Input Device: Electronic temperature space sensor.
   b. Setpoint: 60 deg F (adjustable).

2. Gas Heating Control Valve:

   a. Fail Position: Closed.
   b. Action:

      1) Cycle to maintain room temperature at setpoint.

   c. Conditions:

      1) Per factory-installed safety control.
      2) Close valve when supply fan is off.
      3) Locked out when OA sensor reads 60 deg F (adjustable) or greater.

   d. Fan:

      1) Fail Position: Off.
      2) Action:

         a) Cycle to maintain room temperature at setpoint.

3. Display:

a. See Points List on drawings.

1.5 VENTILATION SEQUENCES

A. Exhaust Fan (EF-1,2,3,8): With H-O-A switch and directly interlocked with room thermostat and exhaust and intake dampers.

1. Failure Position: Off.
2. Input Device: Room Temperature Setpoint: 80 deg F (adjustable).
3. Controlled by HAND-OFF-AUTO switch.

   a. HAND: On.
   b. OFF: Off.
   c. AUTO:

      1) On when the room temperature is above setpoint:

         a) Fully open associated motor operated exhaust damper.
         b) Fully open associated motor operated intake damper.

      2) Off when the room temperature falls below setpoint:

         a) Fully close associated motor operated exhaust damper.
         b) Fully close associated motor operated intake damper.

4. Operator station display: Indicate the following on operator workstation display terminal:

   a. See Points List on drawings.

B. Exhaust Fan (EF-4): With H-O-A switch and directly interlocked with associated equipment schedule and exhaust dampers.

1. Failure Position: Off.
2. Controlled by HAND-OFF-AUTO switch.

   a. HAND: On.
   b. OFF: Off.
   c. AUTO:

      1) On when the associated equipment is in occupied mode:

         a) Fully open associated motor operated exhaust damper.

2) Off when the associated equipment is in unoccupied mode:

a) Fully close associated motor operated exhaust damper.

3. Operator station display: Indicate the following on operator workstation display terminal:

a. See Points List on drawings.

C. Relief Exhaust Fan (EF-9): With H-O-A switch and directly interlocked with exhaust damper and RTU-1 economizer mode.

1. Failure Position: Off.
2. Controlled by HAND-OFF-AUTO switch.

a. HAND: On.
b. OFF: Off.
c. AUTO:

1) On when RTU-1 economize mode is activated:

a) Fully open associated motor operated damper.

2) Off when RTU-1 economizer mode is not activated:

a) Fully close associated motor operated exhaust damper.

3. Speed Control: Ramp up speed slowly - no faster than full speed after 3 minutes.

a. Input Device: Static pressure sensor in the return air duct.
b. Output Device: DDC system analog output to motor speed controller.
c. Action: Modulate speed to maintain return airflow at setpoint as sensed by air flow measuring station in the relief air duct.

1) Return airflow setpoint to be figured as the quantity of air being introduced to the space less the exhaust airflow of 900 cfm.

d. Limits:

1) Do not allow the relief exhaust fan to run less than 15% of design (225 cfm).

4. Operator station display: Indicate the following on operator workstation display terminal:

a. See Points List on drawings.

1.6 MISCELLANEOUS SEQUENCES

A. Destratification Fans:

1. Each fan shall operate individually through the manufacturer's provided wall speed switch.

B. Outdoor Air Monitoring:

1. Provide air flow monitoring in the outdoor air intakes of each air handling unit.
2. Operator station display: Indicate the following on operator workstation display terminal:

   a. See Points List on drawings.

C. Manual Emergency Shutdown:

1. Input Device:

   a. Emergency Shutdown Pushbutton.
   b. Switch from within Civil Engineering B1210 BAS front-end computer.

2. Output Device: DDC system alarm.
3. Action: Put all RTU, MAU, DF, and EF devices in failure position and signal an alarm. Manual reset through the DDC system shall silence the alarm and a separate manual reset through the DDC system to re-enable the equipment.

D. Plumbing Equipment

1. Circulating Pump:

   a. Provide status monitoring and trending for recirculation pump.
   b. HAND-OFF-AUTO Switch: The hot water circulation pump starter shall have an H-O-A switch:

      1) HAND: With the H-O-A switch in HAND position, the pump shall start and run continuously.
      2) OFF: With the H-O-A switch in OFF position, the pump shall stop.
      3) AUTO: With the H-O-A switch in AUTO position, the pump shall run subject to the operating schedule as set up in the BAS.

2. Provide monitoring, trending, and high limit alarm for hot water supply temperature.
3. Operator station display:

a. See Points List on drawings.

1.7 UTILITY SERVICE MONITORING DEVICES, DDC SYSTEM

A. Water, Gas, and Electric Utility Devices:

1. Provide utility service monitoring devices.
2. Monitor, record, and trend water utility consumption (main water meter) thru DDC system.
3. Monitor, record, and trend gas utility consumption (main gas meter) thru DDC system.
4. Monitor, record, and trend electrical utility consumption (main electrical meter) thru DDC system.
5. At a minimum, furnish programming, software, check out and start up to integrate gas, water, and electric metering/monitoring devices to the central control system.
6. Integrate Advanced Energy Meters for Utilities with both the BAS and the AEMRS. Verify Advanced Energy Meters are operational and producing reliable information at the AEMRS front end.

END OF APPENDIX 23 09 93A

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 ANSI B109.1	(2000) Diaphragm Type Gas Displacement Meters (Under 500 cubic ft./hour Capacity)
AGA ANSI B109.2	(2000) Diaphragm Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
AGA ANSI B109.4	(2016) Self-Operated Diaphragm-Type Natural Gas Service Regulators for Nominal Pipe Size 1¼ inches (32 mm) and Smaller with Outlet Pressures of 2 psig (13.8 kPa) and Less
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	(2009; Addenda A 2012, Addenda B 2013; R 2019) Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves
ANSI Z21.18/CSA 6.3	(2007; R 2017) Gas Appliance Pressure Regulators
ANSI Z21.24/CSA 6.10	(2015; Errata 2017) 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	(2009; Addenda A 2012; R 2014) Connectors for Movable Gas Appliances
ANSI Z21.78/CSA 6.20	(2010; R 2020) Standard Specification for Combination Gas Controls for Gas Appliances
ANSI Z21.80/CSA 6.22	(2019) Line Pressure Regulators
ANSI Z21.93/CSA 6.30	(2017) Excess Flow Valves for Natural Gas and Propane Gas with Pressures up to 5 psig

AMERICAN PETROLEUM INSTITUTE (API)

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 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 B16.1	(2015) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2016) 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	(2015) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.8	(2018; Supplement 2018) Gas Transmission and Distribution Piping Systems
ASME B31.9	(2017) Building Services Piping
ASME B36.10M	(2015; Errata 2016) Welded and Seamless Wrought Steel Pipe
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

ASTM INTERNATIONAL (ASTM)

ASTM A105/A105M	(2018) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A181/A181M	(2014) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
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	(2020) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
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 3.11-M88	(2015) Lever Operated Pressure Lubricated Plug Type Gas Shut-Off Valves

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	(2018) National Fuel Gas Code
NFPA 58	(2020) 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; 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" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. 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

Gas Piping System

Pipe Coating Materials

Pressure Regulators

Risers

Transition Fittings

Valves

Warning and Identification Tape

SD-06 Test Reports

Testing

Pressure Tests; G

Test with Gas; G

SD-07 Certificates

Welders Procedures and Qualifications

Assigned Number, Letter, or Symbol

SD-08 Manufacturer's Instructions

Pipe Coating Materials

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.

1.5.2 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.

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

Provide steel pipe conforming to ASME B36.10M; and malleable-iron threaded fittings conforming to ASME B16.1 and ASME B16.3. Provide steel pipe flanges and flanged fittings, including bolts, nuts, and bolt pattern in accordance with ASME B16.5 and ASTM A105/A105M. Provide wrought steel buttwelding fittings conforming to ASME B16.9. Provide socket welding and threaded forged steel fittings conforming to ASME B16.11 and ASTM A181/A181M, Class 60.

2.2.2 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.

2.2.3 Warning and Identification

Provide pipe flow markings, warning and identification tape, and metal tags as required.

2.2.4 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.

2.2.5 Pipe Threads

Provide pipe threads conforming to ASME B1.20.1.

2.2.6 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.

2.2.7 Gas Transition Fittings

a. Provide lever operated pressure lubricated plug type gas shut-off valve conforming to CGA 3.11-M88.

2.2.8 Insulating Pipe Joints

2.2.8.1 Insulating Joint Material

Provide insulating joint material between flanged or threaded metallic pipe systems where shown to control galvanic or electrical action.

2.2.8.2 Threaded Pipe Joints

Provide threaded pipe joints of steel body nut type dielectric unions with insulating gaskets.

2.2.8.3 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.

2.2.9 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. Provide combination gas controls for gas appliances conforming to ANSI Z21.78/CSA 6.20.

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 ANSI Z21.18/CSA 6.3 for appliances ANSI Z21.78/CSA 6.20 for combination gas controls for gas appliances , 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 .

2.7 NATURAL GAS SERVICE

2.7.1 Service Regulators

a. Provide ferrous bodied pressure regulators for individual service lines, capable of reducing distribution line pressure to pressures required for users. Provide service regulators conforming to AGA ANSI B109.4 CGA-6.18-M95 with full capacity internal relief and overpressure shutoff. Set pressure relief at a lower pressure than would cause unsafe operation of any connected user.

b. Adjust regulators for liquified petroleum gas to 2.5 to 3 kPa 10 to 12 inches of water column, with pressure relief set at 4 kPa 16 inches of water column.

c. Provide regulator(s) having a single port with orifice diameter no greater than that recommended by the manufacturer for the maximum gas flow rate at the regulator inlet pressure. Provide regulator valve vent of resilient materials designed to withstand flow conditions when pressed against the valve port, capable of regulating downstream pressure within limits of accuracy and limiting the buildup of pressure under no-flow conditions to 50 percent or less of the discharge pressure maintained under flow conditions. Provide a self-contained service regulator, and pipe not exceeding exceed 2 inch size.

2.7.2 Gas Meter

AGA ANSI B109.1 or AGA ANSI B109.2 pedestal mounted, diaphragm style, cast-iron case. Provide diaphragm-type meter conforming to AGA ANSI B109.1 for required flow rates less than 500 cfh, or AGA ANSI B109.2, for flow rates 500 cfh and above as required by local gas utility supplier. Provide combined register totalizer index, UV-resistant index cover, water escape hole in housing, and means for sealing against tampering. Provide temperature-compensated type meters sized for the required volumetric flow rate and suitable for accurately measuring and handling gas at pressures, temperatures, and flow rates indicated. Provide meters with over-pressure protection as specified in 49 CFR 192 and ASME B31.8. Provide meters that are tamper-proof with frost protection and fungus protection. Provide meters with a pulse switch initiator capable of operating up to speeds of 500 maximum pulses per minute with no false pulses and requiring no field adjustments. Provide not less than one pulse per 100 cubic feet of gas. Minimum service life must be 30,000,000 cycles.

2.7.2.1 Utility Monitoring and Control System (UMCS) / Energy Monitoring and Control (EMCS) or Automatic Meter Reading Interfaces

Provide gas meters capable of interfacing the output signal, equivalent to volumetric flow rate, with the existing UMCS / EMCS for data gathering in units of cubic meters cubic feet. Provide meters that do not require power to function and deliver data. Output signal must be either a voltage or amperage signal that can be converted to volumetric flow by using an appropriate scaling factor.

2.7.2.2 Measurement Configuration

For buildings that already have a gas meter with a pulse output, ensure that the pulse output is connected to a data gathering device (i.e. electric meter). For buildings where a natural gas meter already exists but does not have a pulse output, add a pulse kit to the existing meter and tie the output to a data gathering device. If the existing gas meter will not accept a pulse kit or if no meter exists a new natural gas meter must be installed, also requiring a pulse output to a data gathering device. Ensure the pulse frequency and electronic characteristics are compatible with the existing data gathering device, if any.

2.8 AUTOMATIC GAS SHUT-OFF

Provide low pressure automatic gas shutoff or excess flow valve (EFV) downstream of the point of delivery after the meter/regulator conforming to ANSI Z21.93/CSA 6.30 and UL listed or CSA listed or International Association of Plumbing and Mechanical Officials (IAPMO) listed. The EFV may be either a bypass (automatic reset) or a non-bypass type (manual reset).

2.9 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.

2.10 GASKETS

Fluorinated elastomer, compatible with flange faces.

2.11 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, as specified under "Gas Service" within this specification, to the connections to each gas utilization device that is in compliance with NFPA 54.

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 Aboveground Metallic Piping Systems

3.4.1.1 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.

3.4.1.2 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 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.

3.5.2.1 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.

3.5.3 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.

3.5.4 Final Gas Connections

Unless otherwise specified, make final connections with rigid metallic pipe and fittings. Flexible connectors may be used for final connections to residential dryers. In addition to cautions listed in instructions required by ANSI standards for flexible connectors, insure that flexible connectors do not pass through equipment cabinet. Provide accessible gas shutoff valve and coupling for each gas equipment item.

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.

3.7 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 FIRESTOPPINGG.

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.

3.17.1 Service Line

Install service line, branch connection to the main, and riser in accordance with 49 CFR 192 and ASME B31.8. Provide a minimum of 18 inches cover or encase the service line so that it is protected. Install service line so that no undue stress is applied to the pipe, connection, or riser. Install approved riser and terminate with an approved isolation valve, EFV and automatic shutoff device. After laying of pipe and testing, backfill the trench in accordance with Section 31 00 00 EARTHWORK.

Were steel pipe is used as service line, install corrosion prevention coating and cathodic protect for the steel service line. Where connected to an existing cathodically protected steel pipe, ensure electrical continuity from the riser to the branch connection to the main. Install a dielectric fitting on the riser to prevent electrical continuity to the above ground piping.

Where plastic pipe is used as the service line, make joints in accordance with procedures qualified by test. Personnel joining plastic pipe must be qualified by making a satisfactory specimen joint that passes the required inspection and test listed in 49 CFR 192.285. Inspection must be made by inspectors qualified in evaluating joints made under the specific joining procedure, as required by 49 CFR 192.287.

3.17.2 Service Regulator

Install service regulator in accordance with 49 CFR 192 and ASME B31.8 and this specification ensuring that the customer's piping is protected from over pressurization should the service regulator fail. A 3/8 inch tapped fitting equipped with a plug must be provided on both sides of the service regulator for installation of pressure gauges for adjusting the regulator.

For inside installations, route the regulator vent pipe through the exterior wall to the atmosphere, and seal building penetrations for service line and vent. Terminate the regulator vent so that it is protected from precipitation and insect intrusion, so that it is not submerged during floods, and so that gas escaping will not create a hazard or enter the building through openings.

3.17.3 Gas Meter

Install shutoff valve, meter set assembly, and service regulator on the service line outside the building, 18 inches above the ground on the riser. An insulating joint (dielectric connection) must be installed on the inlet side of the meter set assembly and service regulator and must be constructed to prevent flow of electrical current.

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 HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 189.1	(2014) Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A307	(2014; E 2017) 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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2018) Motors and Generators
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 Jan 2019) UL Standard for Safety Motor-Operated Water Pumps

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. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

System Coordination

SD-03 Product Data

Instructions; G

Equipment Data; G

Training Period

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, single-stage type, designed for HVAC service as scheduled.

2.3.1 Circulator

Provide pumps with capacities as indicated of a horizontal, in-line, three piece oil lubricated or wet rotor circulator type specifically designed for quiet operation. Suitable for 225 degrees F operation at 125 psig working pressure. The pump must be single stage with flanged piping connections. The pump internals must be capable of being serviced without disturbing piping connections.

a. The three piece pump must be composed of three separable components a motor, bearing assembly, and cast iron

2.3.1.1 Seal Assembly

Pump must be equipped with an internally flushed mechanical seal assembly. Seal assembly must have a brass housing, Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

2.3.1.2 Motor Mount

To ensure alignment, mount the motor to the bearing assembly via a bolted motor bracket assembly. Use a replaceable resilient rubber motor mount to assist in aligning the motor shaft with the pump shaft.

2.3.1.3 Motors

Motors must meet scheduled horsepower, speed, voltage, and enclosure design. Motors must be drip proof, maintenance free, premium efficiency and meet NEMA MG 1 specifications.

Pump must be driven by an electrically commutated electrical motor (ECM) with permanent magnet rotor. The rotor magnets must be time stable, non-toxic ceramic magnets. Drive the electrically commuted electrical motor by a frequency converter with an integrated PFC filter.

2.3.2 Small In-Line

Provide pumps with capacities as indicated,suitable for 225 degrees F operation at 175 psig working pressure. The pump must be single stage, in-line design, in cast iron bronze fitted construction. The pump internals must be capable of being serviced without disturbing piping connections.

2.3.2.1 Pump Shaft

The pump must have a solid steel shaft with a coupler between the pump and motor shafts. For non-stainless steel shafts, employ a non-ferrous shaft sleeve to completely cover the wetted area under the seal.

2.3.2.2 Bearing

The bearing assembly must house maintenance-free permanently lubricated bearings.

2.3.2.3 Seal Assembly

Equip the pump with an internal self-flushing mechanical seal assembly. Seal assembly must have Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

2.3.2.4 Impeller

Provide impeller of cast bronze or brass material. Impeller must be hydraulically and dynamically balanced to HI 9.6.4 balance grade G6.3, keyed to the shaft and secured by a locking capscrew or nut.

2.3.2.5 Volute

Pump volute must be of cast iron. The connection style on cast iron pumps must be flanged.

2.3.2.6 Motor Mount

To ensure alignment, mount the motor to the bearing assembly via a bolted motor bracket assembly. Use a replaceable resilient rubber motor mount to assist in aligning the motor shaft with the pump shaft.

2.3.2.7 Motors

NEMA MG 1; premium efficiency; non-overloading at any point on the pump curve; maintenance free with permanently lubricated bearings; and resilient mounted for smaller sizes, rigid mounted otherwise.

2.3.3 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 check valve and a 72 inch minimum, electrical power cord with plug for 120V/1PH/60HZ electrical service.

2.3.3.1 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 ASHRAE 189.1, Table C-13. 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 electrical 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.

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.

3.3 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 4 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 --

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 260 I-P	(2012) Sound Rating of Ducted Air Moving and Conditioning Equipment
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 68	(1997) Laboratory Method of Testing to Determine the Sound Power In a Duct
ASHRAE 70	(2006; R 2011) Method of Testing for Rating the Performance of Air Outlets and Inlets
ASHRAE 84	(2013; Addenda A 2013) Method of Testing Air-to-Air Heat Exchangers
ASHRAE 90.1 - IP	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2018) 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	(2019) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B117	(2016) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B280	(2019) 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 C916	(2014) Standard Specification for Adhesives for Duct Thermal Insulation
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 E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E2016	(2015) 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	(2018) Motors and Generators
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	(2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications

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)

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 Apr 2017) 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 Oct 2018) UL Standard for Safety Power Ventilators
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
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
Rooftop Unit Number	RTU - XXX
Make-Up Air Unit Number	MAU - XXX
Control and instrument air	CONTROL AND INSTR.
Exhaust Fan Number	EF - XXX
Air Terminal Unit Box Number	AT - XXX
Hot Water Boiler Number	HWB - XXX
Hot Water Pump Number	HWP - XXX
Unit Heater Number	UH - XXX

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:

a. Each point of entry and exit of pipe passing through walls.

b. Each change in direction, i.e., elbows, tees.

c. In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard.

d. 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 MIL-STD-101.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. 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; G

Manual Balancing Dampers; G

Acoustical Duct Liner

Diffusers; G

Registers and Grilles; G

Louvers

Air Vents, Penthouses, and Goosenecks

Centrifugal Fans; G

In-Line Centrifugal Fans; G

Panel Type Power Wall Ventilators; G

Centrifugal Type Power Wall Ventilators; G

Centrifugal Type Power Roof Ventilators; G

Destratification Fans; G

Rooftop Air Handling Units; G; G

Variable Volume, Single Duct Terminal Units; G

Reheat Units; G

Energy Recovery Devices; G

Test Procedures

Diagrams; G

Indoor Air Quality for Duct Sealants; S

SD-06 Test Reports

Performance Tests; G

Damper Acceptance Test; 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

Centrifugal Fans; G

In-Line Centrifugal Fans; G

Panel Type Power Wall Ventilators; G

Centrifugal Type Power Wall Ventilators; G

Centrifugal Type Power Roof Ventilators; G

Rooftop Air Handling Units; G

Variable Volume, Single Duct Terminal Units; G

Energy Recovery Devices; 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. Paint in accordance with Section 09 90 00 PAINTS AND COATINGS.

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.

a. 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.

b. 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.

c. 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.

d. 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.

e. 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.

2.8.1.3 Aluminum Ducts

ASTM B209, alloy 3003-H14 for aluminum sheet and alloy 6061-T6 or equivalent strength for aluminum connectors and bar stock.

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 single, blade type or multi-blade type 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, of 3 cfm per square foot at 1.0 inch w.g. across the damper.

2.8.6 Air Deflectors (Volume Extractors) and Branch Connections

Provide air deflectors (volume extractors) at all duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections are allowed in lieu of deflectors for branch connections. Furnish all air deflectors (volume extractors), except those installed in 90 degree elbows, with an approved means of adjustment. Provide easily accessible means for adjustment inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, provide external adjustments with stand-off mounting brackets, integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Provide factory-fabricated air deflectors consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Provide factory or field assembled air deflectors (volume extractors). Make adjustment from the face of the diffuser or by position adjustment and lock external to the duct. Provide stand-off brackets on insulated ducts as described herein. Provide fixed air deflectors (volume extractors), also called turning vanes, in 90 degree elbows.

2.8.7 Sound Attenuation Equipment

2.8.7.1 Acoustical Duct Liner

Use fibrous glass designed or flexible elastomeric duct liner for lining ductwork and conforming to the requirements of ASTM C1071, Type I and II. Provide uniform density, graduated density, or dual density liner composition, as standard with the manufacturer. Provide not less than 1 inch thick coated lining. Where acoustical duct liner is used, provide the thermal equivalent of the insulation specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS for liner or combination of liner and insulation applied to the exterior of the ductwork. Increase duct sizes shown to compensate for the thickness of the lining used. In lieu of sheet metal duct with field-applied acoustical lining, provide acoustically equivalent lengths of fibrous glass duct, elastomeric duct liner or factory fabricated double-walled internally insulated duct with perforated liner.

2.8.8 Diffusers, Registers, and Grilles

Provide factory-fabricated units of steel or aluminum, as scheduled, 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.

2.8.8.1 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.

2.8.8.2 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.

2.8.9 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.

2.8.10 Air Vents, Penthouses, and Goosenecks

Fabricate air vents, penthouses, and goosenecks from galvanized steel sheets with galvanized structural shapes. Provide sheet metal thickness, reinforcement, and fabrication that conform to SMACNA 1966. Accurately fit and secure louver blades to frames. Fold or bead edges of louver blades for rigidity and baffle these edges to exclude driving rain. Provide air vents, penthouses, and goosenecks with bird screen.

2.8.11 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 Centrifugal Fans

Provide fully enclosed, single-width single-inlet, or double-width double-inlet centrifugal fans, with AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Provide impeller wheels that are rigidly constructed and accurately balanced both statically and dynamically. Provide forward curved or backward-inclined airfoil design fan blades in wheel sizes up to 30 inches. Provide backward-inclined airfoil design fan blades for wheels over 30 inches in diameter. Provide open-wheel radial type booster fans for exhaust dryer systems, and fans suitable for conveying lint and the temperatures encountered. Equip the fan shaft with a heat slinger to dissipate heat buildup along the shaft. Install an access (service) door to facilitate maintenance to these fans. Provide fan wheels over 36 inches in diameter with overhung pulleys and a bearing on each side of the wheel. Provide fan wheels 36 inches or less in diameter that have one or more extra long bearings between the fan wheel and the drive. Provide sleeve type, self-aligning and self-oiling bearings with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Connect grease fittings to tubing for serviceability from a single accessible point. Provide L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide steel, accurately finished fan shafts, with key seats and keys for impeller hubs and fan pulleys. Provide fan outlets of ample proportions, designed for the attachment of angles and bolts for attaching flexible connections. Unless otherwise indicated, provide motors that do not exceed 1800 rpm and have open dripproof enclosures. Provide magnetic across-the-line type motor starters with weather-resistant enclosure.

2.9.1.2 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.

2.9.1.3 Panel Type Power Wall Ventilators

Provide propeller type fans, assembled on a reinforced metal panel with venturi opening spun into panel. Provide direct or V-belt driven fans with wheels less than 24 inches in diameter and provide V-belt driven fans with wheels 24 inches in diameter and larger. Provide fans with wall mounting collar. Provide lubricated bearings. Equip fans with wheel and motor side metal or wire guards which have a corrosion-resistant finish. Install motor operated backdraft dampers where indicated.

2.9.1.4 Centrifugal Type Power Wall Ventilators

Provide direct or V-belt, as scheduled, driven centrifugal type fans with backward inclined, non-overloading wheel. Provide removable and weatherproof motor housing. Provide unit housing that is designed for sealing to building surface and for discharge and condensate drippage away from building surface. Construct housing of heavy gauge aluminum. Equip unit with an aluminum or plated steel wire discharge bird screen, disconnect switch, manufacturer's standard motor-operated damper, an airtight and liquid-tight metallic wall sleeve. Use only lubricated bearings.

2.9.1.5 Centrifugal Type Power Roof Ventilators

Provide direct or V-belt, as scheduled, driven 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 birdscreen, disconnect switch, motorized dampers, roof curb, and extended base. Provide dripproof or explosion-proof, as scheduled, type motor enclosure. Provide centrifugal type kitchen exhaust fans according to UL 705, fitted with V-belt drive, round hood, and windband upblast discharge configuration, integral residue trough and collection device, with motor and power transmission components located in outside positively air ventilated compartment. Use only lubricated bearings.

2.9.1.6 Paddle Type Destratification Fans

Provide heavy-duty paddle type destratification fan specifically designed to reduce temperature destratification in the spaces identified. Unit to have cast iron yoke, sealed stamped steel motor housing, be thermally protected, and have aerodynamically curved aluminum blades.

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 copper tube wall thickness that is a minimum of 0.020 inches. Provide aluminum fins that are 0.0055 inch minimum thickness. 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 Cartridge Type Filters

Provide 12 inch depth, sectional, replaceable dry media type filters of the size indicated with a MERV of 13 when tested according to ASHRAE 52.2. Provide initial resistance at 500 fpm that does not exceed 0.56 inches, water gauge. Provide UL class 1 filters, and pleated microglass paper media with corrugated aluminum separators, sealed inside the filter cell to form a totally rigid filter assembly. Fluctuations in filter face velocity or turbulent airflow have no effect on filter integrity or performance. Install each filter with an extended surface pleated media panel filter as a prefilter in a factory preassembled side access housing, or a factory-made sectional frame bank, as indicated.

2.9.3.3 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 tips with integral compression fittings, two molded plastic vent valves, two 5 foot minimum lengths of 1/4 inch diameter vinyl tubing, and all hardware and accessories for gauge mounting.

2.10 ROOFTOP 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, pre- and final filters, adjustable V-belt drives, belt guards for externally mounted motors, access sections where indicated, 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.

e. Casing insulation that conforms to NFPA 90A. Insulate single-wall casing sections handling conditioned air with not less than 1 inch thick, 1-1/2 pound density coated fibrous glass material having a thermal conductivity not greater than 0.23 Btu/hr-sf-F. Insulate double-wall casing sections handling conditioned air with not less than 2 inches of the same insulation specified for single-wall casings. Foil-faced insulation is not an acceptable substitute for use with double wall casing. Seal double wall insulation completely by inner and outer panels.

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.

g. Duct liner material, coating, and adhesive that conforms to fire-hazard requirements specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Protect exposed insulation edges and joints where insulation panels are butted with a metal nosing strip or coat to meet erosion resistance requirements of ASTM C1071.

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. Motor sheaves that are variable pitch for 25 hp and below and fixed pitch above 25 hp as defined by AHRI Guideline 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 open enclosures.

e. Motor starters of magneticacross-the-line type with watertight enclosure. Select unit fan or fans to produce the required capacity at the fan static pressure with sound power level as indicated. Obtain the sound power level values according to AMCA 300, ASHRAE 68, or AHRI 260 I-P.

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 Air Terminal (AT) Units

a. Provide VAV air terminal units that are the type, size, and capacity shown, mounted in the ceiling and are suitable for single duct system applications. Provide actuators and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS.

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. Provide reheat coils as indicated.

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 ENERGY RECOVERY DEVICES

2.12.1 Rotary Wheel

Provide unit that is a factory fabricated and tested assembly for air-to-air energy recovery by transfer of sensible and latent heat from exhaust air to supply air stream, with device performance according to ASHRAE 84 and that delivers an energy transfer effectiveness of not less than 70 percent with cross-contamination not in excess of 0.1 percent of exhaust airflow rate at system design differential pressure, including purging sector if provided with wheel. Provide exchange media that is chemically inert, moisture-resistant, fire-retardant, laminated, nonmetallic material which complies with NFPA 90A. Isolate exhaust and supply streams by seals which are static, field adjustable, and replaceable. Equip chain drive mechanisms with ratcheting torque limiter or slip-clutch protective device. Fabricate enclosure from galvanized steel and include provisions for maintenance access. Provide recovery control and rotation failure provisions as indicated.

2.13 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.

2.14 SUPPLEMENTAL COMPONENTS/SERVICES

2.14.1 Water Heating System Accessories

The requirements for water heating accessories such as expansion tanks and steam traps are specified in Section 23 52 00 HEATING BOILERS.

2.14.2 Condensate Drain Lines

Provide and install condensate drainage for each item of equipment that generates condensate in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE except as modified herein.

2.14.3 Backflow Preventers

The requirements for backflow preventers are specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.14.4 Insulation

The requirements for shop and field applied insulation are specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.14.5 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 Acoustical Duct Lining

Apply lining in cut-to-size pieces attached to the interior of the duct with nonflammable fire resistant adhesive conforming to ASTM C916, Type I, NFPA 90A, UL 723, and ASTM E84. Provide top and bottom pieces that lap the side pieces and are secured with welded pins, adhered clips of metal, nylon, or high impact plastic, and speed washers or welding cup-head pins installed according to SMACNA 1966. Provide welded pins, cup-head pins, or adhered clips that do not distort the duct, burn through, nor mar the finish or the surface of the duct. Make pins and washers flush with the surfaces of the duct liner and seal all breaks and punctures of the duct liner coating with the nonflammable, fire resistant adhesive. Coat exposed edges of the liner at the duct ends and at other joints where the lining is subject to erosion with a heavy brush coat of the nonflammable, fire resistant adhesive, to prevent delamination of glass fibers. Apply duct liner to flat sheet metal prior to forming duct through the sheet metal brake. Additionally secure lining at the top and bottom surfaces of the duct by welded pins or adhered clips as specified for cut-to-size pieces. Other methods indicated in SMACNA 1966 to obtain proper installation of duct liners in sheet metal ducts, including adhesives and fasteners, are acceptable.

3.2.7 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.

3.2.8 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 up to the point where the outdoor air reaches the conditioning unit.

3.2.9 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.

3.2.10 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.

3.2.11 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 14 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.

3.7.4 Color Coding Scheme for Locating Hidden Utility Components

Use scheme in buildings having suspended grid ceilings. Provide color coding scheme that identifies points of access for maintenance and operation of components and equipment that are not visible from the finished space and are accessible from the ceiling grid, consisting of a color code board and colored metal disks. Make each colored metal disk approximately 3/8 inch diameter and secure to removable ceiling panels with fasteners. Insert each fastener into the ceiling panel so as to be concealed from view. Provide fasteners that are manually removable without the use of tools and that do not separate from the ceiling panels when the panels are dropped from ceiling height. Make installation of colored metal disks follow completion of the finished surface on which the disks are to be fastened. Provide color code board that is approximately 3 foot wide, 30 inches high, and 1/2 inches thick. Make the board of wood fiberboard and frame under glass or 1/16 inch transparent plastic cover. Make the color code symbols approximately 3/4 inch in diameter and the related lettering in 1/2 inch high capital letters. Mount the color code board in the mechanical or equipment room.

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 DUCTWORK LEAK TEST

Perform ductwork leak test for the entire air distribution and exhaust system, including fans, coils, filters, etc. Provide test procedure, apparatus, and report that conform to SMACNA 1972 CD. The maximum allowable leakage rate is (9.8 x total duct surface area of the section being tested in sq. ft.) cfm. Complete ductwork leak test with satisfactory results prior to applying insulation to ductwork exterior or concealing ductwork.

3.10 DAMPER ACCEPTANCE TEST

Submit the proposed schedule, at least 2 weeks prior to the start of test. Operate all fire dampers and smoke dampers under normal operating conditions, prior to the occupancy of a building to determine that they function properly. Test each fire damper equipped with fusible link by having the fusible link cut in place. Test dynamic fire dampers with the air handling and distribution system running. Reset all fire dampers with the fusible links replaced after acceptance testing. To ensure optimum operation and performance, install the damper so it is square and free from racking.

3.11 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.

3.12 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.

3.13 CLEANING AND ADJUSTING

Provide a temporary bypass for water coils to prevent flushing water from passing through coils. Inside of 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.

3.14 OPERATION AND MAINTENANCE

3.14.1 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

3.14.2 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 16 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 --

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.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.20	(2017) Metallic Gaskets for Pipe Flanges
ASME B31.1	(2018) Power Piping
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

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2018) 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 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

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2018) National Fuel Gas Code

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

UNDERWRITERS LABORATORIES (UL)

UL 1738	(2010; Reprint Feb 2020) 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" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. 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; G

Spare Parts

Water Treatment System; G

Boiler Water Treatment; G

Heating System Tests

Fuel System Tests

Unit Heaters; G

Qualifications

Field Instructions

Tests

SD-06 Test Reports

Heating System Tests

Fuel System Tests

Water Treatment Testing

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions; G

Water Treatment System; G

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.3 QUALITY ASSURANCE

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. 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) Unit Heaters
   (2) Fuel Burning Equipment
   (3) Pumps
   (4) 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 PUMPS

2.2.1 Hot Water and Boiler Circulating Pumps

Pumps are specified in Section 23 21 23 HYDRONIC PUMPS.

2.3 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.

2.4 RADIATORS AND CONVECTORS

The radiator and convector must be the type and size indicated. The supply and return connections must be the same size. Cast iron radiators and nonferrous convectors must be tested hydrostatically at the factory and proved tight under a pressure of not less than 30 psig or 150 percent of the system operating pressure, whichever is greater. Furnish a certified report of these tests in accordance with paragraph SUBMITTALS.

2.4.1 Convectors

Convectors must be constructed of cast iron or of nonferrous alloys, and must be installed where indicated. Capacity of convectors must be as indicated. Overall space requirements for convectors must not be greater than the space provided. Convectors must be complete with heating elements and enclosing cabinets having bottom recirculating opening, manual control damper and top supply grille. Convector cabinets must be constructed of black sheet steel not less than 20 gauge.

2.4.2 Radiant Ceiling Panels

Panels to be linear sheet-metal panel with serpentine water piping, suitable for installation flush with ceiling system. Panels to be constructed of minimum 0.0396 inch thick aluminum sheet. Backing insulation to be minimum 1 inch thick mineral fiber bonded with a thermosetting resin complying with ASTM C 612, Type IA or Type IB with factory-applied jackerd. Exposed side of panel finish to be baked enamel finish in manufacturer's standard paint color as selected by Architect. Factory piping to meet ASTM B 88 Type L copper tubing with ASME B16.22 wrought copper fittings and brazed joints. Piping shall be mechanically bonded to panel.

2.4.3 Radiators and Convectors Control

Provide controls as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

2.5 UNIT HEATERS

Heaters shall be as specified below, and shall have a heating capacity not in excess of 125 percent of the capacity indicated.

2.5.1 Propeller Fan Heaters

Heaters shall be designed for suspension and arranged for horizontal or vertical discharge of air as indicated. Casings shall be not less than 20 gauge black steel and finished with lacquer or enamel. Suitable stationary deflectors shall be provided to assure proper air and heat penetration capacity at floor level based on established design temperature.

Suspension from heating pipes will not be permitted. Fans for vertical discharge type heaters shall operate at speeds not in excess of 1,200 rpm, except that units with 80,000 Btu output capacity or less may operate at speeds up to 1,800 rpm. Horizontal discharge type unit heaters shall have discharge or face velocities not in excess of the following:

Unit Capacity, cfm	Face Velocity, fpm
Up to 1000	800
1,001 to 3,000	900
3001 and over	1,000

2.5.2 Centrifugal Fan Heaters

Heaters must be arranged for floor, wall, or ceiling mounting as indicated. Heating elements and fans must be housed in steel cabinets of sectionalized steel plates or reinforced with angle-iron frames. Cabinets must be constructed of not lighter than 18 gauge black steel. Provide each unit heater with a means of diffusing and distributing the air. Fans must be mounted on a common shaft, with one fan to each air outlet. Fan shaft must be equipped with self-aligning ball, roller, or sleeve bearings and accessible means of lubrication. Fan shaft may be either directly connected to the driving motor or indirectly connected by adjustable V-belt drive rated at 150 percent of motor capacity. All fans in any one unit heater must be the same size.

2.5.3 Heating Elements

Heating coils and radiating fins shall be of suitable nonferrous alloy with brazed fittings at each end for connecting to external piping. The heating elements shall be free to expand or contract without developing leaks and shall be properly pitched for drainage. The elements shall be tested under a hydrostatic pressure of 200 psig and a certified report of the test shall be submitted to the Contracting Officer. Coils shall be suitable for use with water up to 250 degrees F.

2.5.4 Motors

Motors shall be provided with NEMA 250 general purpose enclosure. Motors and motor controls shall otherwise be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.5.5 Motor Switches

Motors shall be provided with manual selection switches with "Off," and "Automatic" positions and shall be equipped with thermal overload protection.

2.5.6 Controls

Controls shall be provided as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

2.6 HEATING AND VENTILATING UNITS

Heating and ventilating units and associated equipment shall be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.7 AIR HANDLING UNITS

Air handling units and associated equipment shall be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.8 FITTINGS AND ACCESSORIES

Boiler fittings and accessories shall be installed with each boiler in accordance with ASME BPVC SEC IV, unless otherwise specified.

2.8.1 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.

2.8.1.1 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.

2.8.1.2 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.

2.8.2 Steel Sheets

2.8.2.1 Galvanized Steel

Galvanized steel shall be ASTM A653/A653M.

2.8.2.2 Uncoated Steel

Uncoated steel shall be composition, condition, and finish best suited to the intended use.

2.8.3 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.

2.8.4 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.

2.8.5 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.

2.8.6 Pipe Supports

Pipe supports shall conform to MSS SP-58.

2.8.7 Valves

Valves shall be Class 125 and shall be suitable for the application. 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. Valves are specified in Section 23 05 15 COMMON PIPING FOR HVAC.

2.8.7.1 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.

2.8.7.2 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.

2.8.8 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 brass sheet 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.

2.8.9 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)

2.8.10 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.

2.9 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.

2.9.1 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.

2.9.2 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.

2.10 INSULATION

Shop and field-applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.11 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.

2.11.1 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.

2.12 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.

2.12.1 MakeUp Water Analysis

Test makeup water conditions as prescribed in ASTM D596.

2.12.2 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 (CACO3)	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

2.12.3 Chemical Piping

The piping and fittings shall be constructed of steel.

2.12.4 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.

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 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.

3.2.1 Hot Water Piping and Fittings

Pipe shall be black steel or copper tubing. Fittings for steel piping shall be black malleable iron or cast iron to suit piping. Fittings adjacent to valves shall suit valve material. Grooved mechanical fittings will not be allowed

3.2.2 Thermometer Wells

Provide a thermometer well in each return line for each circuit in multicircuit systems.

3.2.3 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.

3.2.4 Strainer Blow-Down Piping

Strainer blow-down connections shall be fitted with a black steel blow-down pipeline routed to an accessible location and provided with a blow-down valve.

3.2.5 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.

3.3 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.

3.4 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.

3.5 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.

3.6 TEST OF BACKFLOW PREVENTION ASSEMBLIES

Backflow prevention assemblies shall be tested in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.7 HEATING SYSTEM TESTS

Submit the Qualifications of the firms in charge of installation and testing as specified. Submit a statement from the firms proposed to prepare submittals and perform installation and testing, demonstrating successful completion of similar services of at least five projects of similar size or scope, at least 2 weeks prior to the submittal of any other item required by this section. Before any covering is installed on pipe or heating equipment, the entire heating system's piping, fittings, and terminal heating units shall be hydrostatically tested and proved tight at a pressure of 1.5 times the design working pressure, but not less than 100 psi. Submit proposed test procedures for the heating system tests and fuel system tests, at least 2 weeks prior to the start of related testing.

a. Before pressurizing system for test, items or equipment (e.g., vessels, pumps, instruments, controls, relief valves) rated for pressures below the test pressure shall be blanked off or replaced with spool pieces.

b. Before balancing and final operating test, test blanks and spool pieces shall be removed; and protected instruments and equipment shall be reconnected. With equipment items protected, the system shall be pressurized to test pressure. Pressure shall be held for a period of time sufficient to inspect all welds, joints, and connections for leaks, but not less than 2 hours. No loss of pressure will be allowed. Leaks shall be repaired and repaired joints shall be retested.

c. Repair joints shall not be allowed under the floor for floor radiant heating systems. If a leak occurs in tubing located under the floor in radiant heating systems, the entire zone that is leaking shall be replaced. If any repair is made above the floor for floor radiant heating systems, access shall be provided for the installed joint. Caulking of joints shall not be permitted.

d. System shall be drained and after instruments and equipment are reconnected, the system shall be refilled with service medium and maximum operating pressure applied. The pressure shall be held while inspecting these joints and connections for leaks. The leaks shall be repaired and the repaired joints retested.

Upon completion of hydrostatic tests and before acceptance of the installation, submit test reports for the heating system tests. Upon completion of testing complete with results, balance the heating system in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS and operating tests required to demonstrate satisfactory functional and operational efficiency. The operating test shall cover a period of at least 24 hours for each system, and shall include, as a minimum, the following specific information in a report, together with conclusions as to the adequacy of the system:

a. Certification of balancing.

b. Time, date, and duration of test.

c. Outside and inside dry bulb temperatures.

d. Temperature of hot water supply leaving boiler.

e. Temperature of heating return water from system at boiler inlet.

f. Quantity of water feed to boiler.

g. Boiler make, type, serial number, design pressure, and rated capacity.

h. Fuel burner make, model, and rated capacity; ammeter and voltmeter readings for burner motor.

i. Circulating pump make, model, and rated capacity, and ammeter and voltmeter readings for pump motor during operation.

j. Flue-gas temperature at boiler outlet.

k. Percent carbon dioxide in flue-gas.

l. Grade or type and calorific value of fuel.

m. Draft at boiler flue-gas exit.

n. Draft or pressure in furnace.

o. Quantity of water circulated.

p. Quantity of fuel consumed.

q. Stack emission pollutants concentration.

Indicating instruments shall be read at half-hour intervals unless otherwise directed. Furnish all instruments, equipment, and personnel required for the tests and balancing. Operating tests shall demonstrate that fuel burners and combustion and safety controls meet the requirements of ASME CSD-1, ANSI Z21.13/CSA 4.9, and NFPA 85

3.7.1 Water Treatment Testing

The boiler water shall be analyzed prior to the acceptance of the facility by the water treatment company. Submit a water quality test report identifying the chemical composition of the boiler water. The report shall include a comparison of the condition of the boiler water with the manufacturer's recommended conditions. Any required corrective action shall be documented within the report. The test report shall identify the condition of the boiler at the completion of 1 year of service. The report shall include a comparison of the condition of the boiler with the manufacturer's recommended operating conditions. The analysis shall include the following information recorded in accordance with ASTM D596.

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 (C1)	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

If the boiler water is not in conformance with the boiler manufacturer's recommendations, the water treatment company shall take corrective action.

3.7.2 Boiler/Piping Test

At the conclusion of the 1 year period, the boiler and condensate piping shall be inspected 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, the water treatment company shall 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 shall be made by the water treatment company.

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.

3.8.2 Heating Units

Inside space heating equipment, ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for fans that are operated during construction, and new provide filters after construction dirt has been removed from the building, and the ducts, plenum, 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. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.9 FIELD TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests.

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.

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SECTION 23 80 20.00 10

GAS-FIRED HEATING 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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.66/CGA 6.14	(2015) Automatic Vent Damper Devices for Use with Gas-Fired Appliances
ANSI Z83.8/CSA 2.6	(2016; Errata 2017) Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters, and Gas-Fired Duct Furnaces

CSA GROUP (CSA)

CSA Directory	(updated continuously online) Product Index

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2018) National Fuel Gas Code
NFPA 211	(2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

UNDERWRITERS LABORATORIES (UL)

UL FLAMMABLE & COMBUSTIBLE	(2012) Flammable and Combustible Liquids and Gases Equipment Directory

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. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G
Installation

SD-03 Product Data

Spare Parts

SD-06 Test Reports

Testing, Adjusting, and Balancing; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions; G

1.3 QUALITY ASSURANCE

Submit detail drawings consisting of illustrations, schedules, performance charts, instructions, brochures, diagrams, and other information to illustrate the requirements and operation of the system. Detail drawings for space heating equipment, controls, associated equipment, and for piping and wiring. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from weather, humidity and temperature variations, dirt and dust, or 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 not later than 1 months prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 General

Provide materials and equipment which are standard products of a manufacturer regularly engaged in manufacturing of the products and that essentially duplicate equipment that has been in satisfactory use at least 2 years prior to bid opening. All gas fired appliances shall meet the requirements of NFPA 54.

2.1.2 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, affix an ENERGY STAR label as applicable.

2.1.3 Equipment Guards

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts so located that any person may come in close proximity thereto shall be completely enclosed or guarded. High-temperature equipment and piping so located as to endanger personnel or create a fire hazard shall be guarded or covered with insulation of type specified for service.

2.2 ELECTRICAL WORK

Electrical motor driven equipment shall be provided complete with motors, motor starters, and controls. Motors shall conform to NEMA MG 1. Electrical equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics shall be as specified or indicated. Integral size motors shall be premium efficiency type in accordance with NEMA MG 1. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control specified. Each motor shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.3 HEATERS

Heaters shall be equipped for and adjusted to burn natural gas. Each heater shall be provided with a gas pressure regulator that will satisfactorily limit the main gas burner supply pressure. Heaters shall have an intermittent or interrupted electrically ignited pilot or a direct electric ignition system. Safety controls shall conform to the ANSI standard specified for each heater. Mounting brackets and hardware shall be furnished by the heater manufacturer and shall be factory finished to match the supported equipment.

2.3.1 Indirect Fired Make-Up Heaters

Heaters shall be in accordance with ANSI and CSA Standards and be suitable for outdoor use mounted on a roof. Heaters shall be equipped with motorized inlet dampers, duct collar, and air filters. Gas control valve shall be modulating type. Maximum air temperature rise during minimum burner fire shall be 7 degrees F. Fan shall be two speed, with low speed approximately two-thirds of high speed. Motorized inlet dampers shall be closed when the unit is shut down. Dampers shall be interlocked to prevent burner operation when dampers are closed. Heaters shall be provided with a discharge air thermostat, a low limit air stream thermostat, and an ambient air thermostat. The discharge air thermostat shall control the modulating gas control valve. The low limit air stream thermostat shall shut down the entire unit if the discharge air temperature drops below the space thermostat setting. The ambient air thermostat shall shut down the burner if the outside air exceeds the space thermostat setting.

2.3.2 Unit Heaters

Heaters shall conform to requirements of ANSI Z83.8/CSA 2.6. Heat exchangers shall be aluminized steel. Air discharge section shall be equipped with adjustable horizontal louvers. Fan shafts shall be either directly connected to the driving motor, or indirectly connected by multiple V-belt drive. Fans in one unit shall be of the same size. Heaters shall be power-vented type, suitable for sidewall vent discharge and single-wall-thickness vent piping. Heaters shall have automatic ignition. Heaters shall employ metered combustion air with enclosed draft diverter (no open flue collar). Heaters shall be provided with a space thermostat which controls both unit's fan and burner.

2.4 VENT PIPING

Vent piping shall conform to the requirements of NFPA 54. Plastic material polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.5 ELECTRIC AUTOMATIC VENT DAMPERS

Electric automatic vent dampers shall conform to the requirements of ANSI Z21.66/CGA 6.14 and shall be provided in the vents of heaters using indoor air for combustion air.

2.6 INSULATION

Insulation for piping and equipment and application shall be in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.7 FACTORY FINISHES

Equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming thoroughly 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

install equipment as indicated and in accordance with the recommendations of the equipment manufacturer and the listing agency, except as otherwise specified.

3.2.1 Heating Equipment

Install heaters with clearance to combustibles, complying with minimum distances as determined by CSA Directory, UL FLAMMABLE & COMBUSTIBLE and as indicated on each heater approval and listing plate. Support heaters independently from the building structure, as indicated, but not relying on suspended ceiling systems for support.

3.2.2 Vents

Locate vent dampers, piping and structural penetrations as indicated. Vent damper installation shall conform to ANSI Z21.66/CGA 6.14. Vent pipes, where not connected to a masonry chimney conforming to NFPA 211, shall extend through the roof or an outside wall and shall terminate, in compliance with NFPA 54. Vents passing through waterproof membranes shall be provided with the necessary flashings to obtain waterproof installations.

3.2.3 Gas Piping

Connect gas piping as indicated, complying with the applicable requirements at Section 23 11 20 FACILITY GAS PIPING.

3.3 TRAINING

Conduct a training course for the maintenance and operating staff. The training period of 4 hours normal working time shall start after the system is functionally complete but before the final acceptance tests. Give the Contracting Officer at least two weeks advance notice of such training. The training shall include all of the items contained in the approved operation and maintenance instructions as well as demonstrations of routine maintenance operations. Submit 6 complete copies of operating instructions outlining the step-by-step procedures required for system startup, operation and shutdown. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and basic operating features. Submit 6 complete copies of maintenance instructions listing routine maintenance, possible breakdowns, repairs and troubleshooting guide. The instructions shall include simplified piping, wiring, and control diagrams for the system as installed.

3.4 TESTING, ADJUSTING, AND BALANCING

Perform testing, adjusting, and balancing as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. 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 shall indicate the final position of controls.

-- End of Section --

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SECTION 23 82 46.00 40

ELECTRIC UNIT HEATERS

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM 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.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)

UNDERWRITERS LABORATORIES (UL)

UL 1996	(2009; Reprint Aug 2020) UL Standard for Safety Electric Duct Heaters

1.2 ADMINISTRATIVE REQUIREMENTS

Provide the following for review and approval:

a. Submit fabrication drawings for electric heaters, indicating the fabrication and assembly details to be performed in the factory.

b. Submit manufacturer's instructions for electric heaters, stating the special provisions necessary to install equipment components and system packages. Detail the impedances, hazards and safety precautions within the special notices.

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

Fabrication Drawings

SD-03 Product Data

Performance Data; G

Electric Unit Heaters; G

Heating Element; G

Controls; G

Casings; G

Propellers and Motors; G

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide suspended electric unit heaters, and arrange for the discharge of air as indicated.

Provide electric unit heaters with at least the indicated capacity and ensure that they conform to the requirements specified herein. Ensure that the electric unit heaters are factory-prewired and ready for field terminal connections.

Ensure products conform to the requirements of UL 1996 for electric unit heaters.

Submit performance data for electric heaters, including use life, test, system functional flows, safety features, and mechanical automated details.

2.2 COMPONENTS

2.2.1 Heating Element

Provide a heating element constructed of a resistance wire insulated by highly compacted refractory insulation protected by a sealed metallic-finned sheath. Provide component materials as follows:

a. Provide a resistance wire of not less than 20-helix wound alloy of approximately 80-percent nickel and 20-percent chromium.

b. Provide a refractory insulation of magnesium oxide with a resistance of not less than 50,000 ohms after exposure to an ambient temperature and humidity of 90 degrees F and 85 plus or minus 5-percent relative humidity, respectively, for not less than 24 hours.

c. Provide a sheathing consisting of aluminum fins cast around an internal steel sheath containing refractory insulation and resistance wire or carbon-steel fins permanently attached to a tubular carbon-steel sheath containing refractory insulation and resistance wire and with external surfaces porcelainized.

Ensure that the maximum surface temperature of cast-aluminum sheathing is 500 degrees F.

2.2.2 Controls

Fit units up to and including 5 kilowatts with integral controls, including thermal overload cutout switches, necessary transformers, a liquid-vapor system, and low-mass bimetal thermostat as required. Provide a cutout switch that can be automatically reset.

2.2.3 Propellers and Motors

Provide propellers with mill-aluminized blades statically and dynamically balanced to within 0.5 percent. Provide units with fan-inlet safety guards.

Ensure that propellers and motors are AMCA-certified for air performance and noise level.

Protect motors against damage by the heating element and resilient mount.

Motors shall be provided with NEMA 250 general purpose enclosure. Motors and motor controls shall otherwise be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

Subfractional and fractional custom-designed or applied motors may deviate from the preceding motor requirements as follows:

a. Shaded-pole motors rated less than 1/6 horsepower may be used for direct-drive service.

b. Permanent split-capacitor, split-phase, and capacitor-start motors rated 1/4 horsepower or less may be used for direct-drive service.

c. Split-phase and capacitor-start motors, rated 1/4 horsepower or less, may be used for belt-drive service.

d. Motor bearings may be the manufacturer's standard prelubricated sleeve type but provide the motor with antifriction thrust bearings, when specified. Ensure that the lubricant provisions are for extended service, requiring replenishment not more than twice per year of continuous operation.

Provide the manufacturer's standard motor identification plate.

Provide the manufacturer's standard motor speed and control.

PART 3 EXECUTION

3.1 INSTALLATION

Install unit heaters in accordance with the manufacturer's instructions at the mounting heights indicated.

3.1.1 Casings

Provide casings with smoothly contoured propeller orifice rings of at least 20-gage cold-rolled carbon steel. Provide a casing surface finish with phosphate pretreatment, prime coating, and baked-enamel finish.

3.1.2 Air Distribution

Provide horizontal units with adjustable single- or double-deflection louvers.

3.2 FIELD QUALITY CONTROL

Demonstrate in the presence of the Contracting Officer that the unit heaters operate satisfactorily.

Cycle unit heaters five times, from start to operating thermal conditions to off, to verify adequacy of construction, system controls, and component performance.

Conduct an operational test for a minimum of 6 hours.

-- End of Section --

SECTION 25 05 11

CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS

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 are available online at the Information Assurance Support Environment (IASE) website at http://iase.disa.mil/stigs/Pages/index.aspx. Not all control system components have applicable STIGs or SRGs.

1.1 RELATED REQUIREMENTS

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.

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	(2016) 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

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

1.3 DEFINITIONS

1.3.1 Computer

As used in this Section, 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 OS, where Android is considered separate from Linux

e. a device running a version of Apple iOS

1.3.2 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 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).

Any device that supports wireless communication is network connected, regardless of whether the device is communicating using wireless.

1.3.3 User Account Support Levels

The support for user accounts is categorized in this Section as one of three levels:

1.3.3.1 FULLY Supported

Device supports configurable individual accounts. Accounts can be created, deleted, modified, etc. Privileges can be assigned to accounts.

1.3.3.2 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 "user name and password" structure).

1.3.3.3 NOT Supported

Device does not support any Access Enforcement therefore the whole concept of "account" is meaningless.

1.3.4 User Interface

Generally, a user interface is hardware on a device allowing user interaction with that device via input (buttons, switches, sliders, keyboard, touch screen, etc.) and a screen. There are three types of user interfaces defined in this Section: Limited Local User Interface, Full Local User Interface and Remote User Interface. In this Section, when the term "User Interface" is used without specifying which type, it refers only to Full Local User Interface and Remote User Interface (NOT to Limited Local User Interface).

1.3.4.1 Limited Local User Interface

A Limited Local User Interface is a user interface where the interaction is limited, fixed at the factory, and cannot be modified in the field. The user must be physically at the device to interact with it.

Examples of Limited Local User Interface include thermostats (Space Sensor Modules as defined in Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC).

1.3.4.2 Full Local User Interface

A Full Local User Interface is a user interface where the interaction and displays are field-configurable.

Examples of a Full Local User Interface include local applications on a computer and user interfaces to Variable Speed Drives.

1.3.4.3 Remote User Interface

A Remote User Interface is a user interface on a Client device allowing user interaction with a different Server device. The user need not be physically at the Server device to interact with it.

Examples of Remote User Interfaces include web browsers and Local Display Panels as defined in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.4 ADMINISTRATIVE REQUIREMENTS

1.4.1 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 communication, the Wireless Communication Request submittal must be approved prior to control system device selection and integration.

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 integration.

c. If requesting permission for the use of a device with multiple IP connections, the Multiple IP Connection Device Request must be approved prior to control system device selection and integration.

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. 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, HTTP web server certificates must be obtained from the indicated contact for the project site.

j. Contractor Computer Cybersecurity Compliance Statements for each contractor using contractor owned computers.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Wireless Communication Request; G

Multiple IP Connection Device Request; G

Contractor Computer Cybersecurity Compliance Statements; G

Contractor Temporary Network Cybersecurity Compliance Statements; G

SD-02 Shop Drawings

User Interface Banner Schedule; G

Network Communication Report; G

Cybersecurity Riser Diagram; G

Control System Inventory Report; G

Cybersecurity Interconnection Schedule; G

SD-03 Product Data

Control System Cybersecurity Documentation; G

SD-06 Test Reports

Wireless Communication Test Report; G

SD-07 Certificates

Software Licenses; G

SD-11 Closeout Submittals

Password Summary Report; G

Software Recovery And Reconstitution Images; G

Device Audit Record Upload Software; G

1.6 QUALITY CONTROL

1.7 CYBERSECURITY DOCUMENTATION

1.7.1 Cybersecurity Interconnection Schedule

{For Reference Only: This subpart (and its subparts) relates to CA-3(b), CCI-00258}

Provide a completed Cybersecurity Interconnection Schedule documenting connections between the installed system and other systems. Provide the following information for each device 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. 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 SUBMITTAL PROCEDURES, provide the Cybersecurity Interconnection Schedule as an editable Microsoft Excel file (a template Cybersecurity Interconnection Schedule in Excel format is available at
http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-

1.7.2 Network Communication Report

{For Reference Only: This subpart (and its subparts) relates to CA-9; CCI-002102, CCI-002103, CCI-002104, CCI-002105 and also the submittal requirements associated with CM-6, CM-7 and SC-41}

Provide a network communication report. For each networked controller, document the communication characteristics of the controller including communication protocols, services used, and a general description of what information is communicated over the network. For each controller using IP, document all TCP and UDP ports 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 SUBMITTAL PROCEDURES, provide the Network Communication Report as an editable Microsoft Excel file.

1.7.3 Control System Inventory Report

{For Reference Only: This subpart (and its subparts) relates to CM-8(a), CP-12, SI-17, IA-3; CCI-000389, CCI-000392, CCI-000398, CCI-002855, CCI-002856, CCI-002857, 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 http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-t documenting all networked devices, including network infrastructure devices. 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 SUBMITTAL PROCEDURES, provide the Control System Inventory Report as an editable Microsoft Excel file.

1.7.4 Software Recovery and Reconstitution Images

{For 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.

1.7.5 Cybersecurity Riser Diagram

{For Reference Only: This subpart (and its subparts) relates to PL-2(a); CCI-003051, CCI-003053}

Provide a cybersecurity riser diagram of the complete control system including all network and controller 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 overlayed on a facility schematic.

1.7.6 Control System Cybersecurity Documentation

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.

1.7.6.1 Software Applications

For all software applications running on computers provide:

a. administrator documentation that describes secure configuration of the software {relates to CCI-003124}

b. administrator documentation that describes secure installation of the software {relates to CCI-003125}

c. administrator documentation that describes secure operation of the software {relates to CCI-003124}

d. administrator documentation that describes effective use and maintenance of security functions or mechanisms for the software {relates to CCI-003127}

e. administrator documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the software {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 {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 {relates to CCI-003130}

h. user documentation that describes user responsibilities in maintaining the security of the software {relates to CCI-003131}

1.7.6.2 For HVAC Control System Devices

1.7.6.2.1 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 reference only: relates to CCI-003124}

b. Documentation that describes secure operation of the device {for reference only: relates to CCI-003124}

c. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {for 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 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 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 reference only: relates to CCI-003130}

1.7.6.2.2 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 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 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 reference only: relates to CCI-003130}

1.7.6.3 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 reference only: relates to CCI-003124}

b. Documentation that describes secure installation of the device {for reference only: relates to CCI-003125}

c. Documentation that describes secure operation of the device {for reference only: relates to CCI-003124}

d. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {for 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 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 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 reference only: relates to CCI-003130}

h. Documentation that describes user responsibilities in maintaining the security of the device {for reference only: relates to CCI-003131}

1.8 SOFTWARE UPDATE LICENSING

{For Reference Only: This subpart (and its subparts) relates to SI-2 (a),(c); CCI-001227, CCI-002605}

In addition to all other licensing requirements, all software licensing must include licensing of the following software updates for a period of no less than 5 years:

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 Reference Only: This subpart (and its subparts) relates to AC-18, SA-3, CCI-00258}

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. When used, contractor computers 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. All 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 all computers 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 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
http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-t
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 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 IP networks provided under this project or Government furnished IP networks provided for this purpose. Any and all network access 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 must not interfere with existing wireless network and must use WPA2 security. 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 http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-
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

(NOT USED)

PART 3 EXECUTION

3.1 ACCESS CONTROL REQUIREMENTS

3.1.1 User Accounts

{For Reference Only: This subpart (and its subparts) relate to AC-2(a)and AC-3; CCI-002110, CCI-000213.}

Any device supporting user accounts (either FULLY or MINIMALLY) must limit access to the device according to specified limitations for each account. Install and configure any device having a STIG or SRG in accordance with that STIG or SRG.

3.1.1.1 Computers

All computers must FULLY support user accounts.

3.1.1.2 For HVAC Control System Devices

Devices with web interfaces must either FULLY support user accounts or have their web interface disabled. Field devices with full local user interfaces allowing modification of data must at least MINIMALLY support user accounts.

3.1.1.3 Default Requirements for Control System Devices

For control system devices where User Account requirements are not otherwise indicated in this Section:

a. Devices with web interfaces must either at least MINIMALLY support user accounts or have their web interface disabled.

b. Field devices with full local user interfaces allowing modification of data must at least MINIMALLY support user accounts.

c. Field devices with read-only full local user interfaces must at least MINIMALLY support user accounts.

d. All devices must at least MINIMALLY support user accounts.

3.1.2 Unsuccessful Logon Attempts

{For Reference Only: This subpart (and its subparts) relate 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.

3.1.2.1 Devices MINIMALLY Supporting Accounts

Devices which MINIMALLY support accounts are not required to lock based on unsuccessful logon attempts.

3.1.3 System Use Notification

{For 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}

Web interfaces must display a warning banner meeting the requirements of DTM 08-060.

Devices which are connected to a network and have a user interface must display a warning banner meeting the requirements of DTM 08-060 if capable of doing so. Devices which are connected to a network and have a user interface but are not capable of displaying a banner must have a permanently affixed label displaying an approved banner from DTM 08-060.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 contract between font and background colors.

3.1.3.1 User Interface Banner Schedule

Provide a User Interface Schedule using the format indicated showing each user interface provided and how the information banner requirement has been implemented for each user interface.

User Interface Schedule Format (with sample entries)			
User Interface Description	**User Interface Location**	**Type of User Interface**	**Banner Implementation**
Sample 1	Room 1	Remote	DTM 08-060 Banner "A" Displayed at Logon
Sample 2	Room 2	Limited Local	DTM 08-060 Banner "B" on Affixed Label
Sample 3	Room 3	Full Local	DTM 08-060 Banner "B"

3.1.4 Permitted Actions Without Identification or Authentication

{For 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 by a user acting from a user interface which MINIMALLY or FULLY supports accounts.

3.1.5 Wireless Access

{For Reference Only: This subpart (and its subparts) relates to AC-18; CCI-001438, CCI-001439, CCI-002323, CCI-001441}

Unless explicitly authorized by the Government, do not use any wireless communication. Any device with wireless communication capability is considered to be using wireless communication, regardless of whether or not the device is actively communicating wirelessly, except when wireless communication has been physically permanently disabled (such as through the removal of the wireless transceiver).

3.1.5.1 Wireless IP Communications

Do not install wireless 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.

3.1.5.2 Non-IP Wireless Communication

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.

3.1.5.3 Wireless Communication Request

Provide a report documenting the proposed use of wireless communication prior to beginning construction using the Wireless Communication Request Schedule at
http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-

For each device proposed to use wireless 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, RF Frequency, Radiated Power in dBm (decibel with a milliwatt reference), free-space range, and the expected as-installed range.

3.1.5.4 Wireless Communication Testing

As part of Performance Verification Testing (PVT), conduct testing of wireless communication for all devices indicated on the approved Wireless 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 CYBERSECURITY AUDITING

3.2.1 Audit Events, Content of Audit Records, and Audit Generation

{For Reference Only: This subpart (and its subparts) relates to AU-2(a),(c),(d), AU-3, AU-12; CCI-000123, CCI-001571, CCI-000125, CCI-001485, CCI-000130, CCI-000131, CCI-000132, CCI-00133, CCI-000134, CCI-001487, CCI-000169, CCI-001459, CCI-000171, CCI-000172, CCI-001910}

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.

3.2.1.1 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

3.2.1.1.1 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)

a. Successful and unsuccessful logon attempts

b. Privileged activities or other system level access

c. Starting and ending time for user access to the system

d. Concurrent logons from different workstations

e. Successful and unsuccessful accesses to objects

f. All program initiations

g. All direct access to the information system

h. All account creations, modifications, disabling, and terminations

i. All kernel module load, unload, and restart

3.2.1.1.2 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

3.2.1.2 For HVAC Control System Devices

3.2.1.2.1 HVAC Control System Devices FULLY Supporting User Accounts

For devices FULLY supporting accounts, provide the capability to select audited events, and the contents of audit logs. Configure devices to audit the following events:

a. Successful and unsuccessful logon attempts to the device

b. Starting and ending time for user access to the device

c. All account creations, modifications, disabling, and terminations

d. All device shutdown and startup

Configure the device to record for each event the following information (as applicable): the type of event, when the event occurred and the identity of any individuals or subjects associated with the event

3.2.1.2.2 Other HVAC Control System Devices

There are no requirements to perform auditing at HVAC field devices that do not FULLY support accounts.

3.2.1.3 Default Requirements for Control System Devices

For control system devices where Audit Events, Content of Audit Records, and Audit Generation are not otherwise indicated in this Section:

3.2.1.3.1 Devices Which FULLY Support Accounts

For each device which FULLY supports accounts, provide the capability to select audited events and the content of audit logs. Configure devices to audit the indicated events, and to record the indicated information for each auditable event

3.2.1.3.1.1 Audited Events

Configure each device 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)

a. Successful and unsuccessful logon attempts

b. Privileged activities or other system level access

c. Starting and ending time for user access to the system

d. Concurrent logons from different workstations

e. All account creations, modifications, disabling, and terminations

f. All kernel module load, unload, and restart

3.2.1.3.1.2 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

3.2.1.3.2 Devices Which Do Not FULLY Support Accounts

For each Device which does not FULLY support accounts configure the device to audit all device shutdown and startup events and to record for each event the type of event and when the event occurred.

3.2.2 Audit Storage Capacity and Audit Upload

{For Reference Only: This subpart (and its subparts) relates to AU-4; CCI-001848, CCI-001849}

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 non-computer control system devices capable of generating audit records, provide 60 days worth of secure local storage, assuming 10 auditable events per day.

3.2.2.1 Device Audit Record Upload Software

For each non-computer device required to audit events, provide, and license to the Government, software implementing a secure mechanism of uploading audit records from the device to a computer and of exporting the uploaded audit records as a comma separated value text file. Where different devices use different software, provide software of each type required to upload audit logs from all devices.

Submit copies of device audit record upload software. If there are no non-computer devices requiring auditing, provide a document stating this in lieu of this submittal.

3.2.3 Response to Audit Processing Failures

{For Reference Only: This subpart (and its subparts) relates to AU-5; CCI-000139, CCI-000140, CCI-001490}.

In case of an audit failure, if possible, continue to collect audit records by overwriting existing audit records.

3.2.4 Time Stamps

{For Reference Only: This subpart (and its subparts) relates to AU-8; CCI-000159, CCI-001889, CCI-001890}

3.2.4.1 Computers

Computers generating audit records must have internal clocks capable of providing time with a resolution of 1 second. Clocks must not drift more than 10 seconds per day.

Configure the system so that each computer generating audit records maintains accurate time to within 1 second.

3.2.4.2 For HVAC Control System Devices

Time stamp requirements for HVAC Control Systems are as indicated in the HVAC Control System specifications.

3.2.4.3 Default Requirements for Control System Devices

For control system devices where Time Stamps requirements are not otherwise indicated in this Section: Devices generating audit records must have internal clocks capable of providing time with a resolution of 1 second. Clocks must not drift more than 10 seconds per day. Configure the system so that each device generating audit records maintains accurate time to within 1 second.

3.3 REQUIREMENTS FOR LEAST FUNCTIONALITY

{For Reference Only: This subpart (and its subparts), along with the network communication report submittal specified elsewhere in this section, relates to CM-6 (a), (c), CM-7, CM-7 (1)(b), SC-41; CCI-000363, CCI-000364, CCI-000365, CCI-001588, CCI-001755, CCI-000381, CCI-000380, CCI-00382, 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.

For HVAC Control Systems: Do not provide devices with 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: Do not provide devices with user interfaces where one was not required.

3.3.1 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, or use any protocol on ports other than those specified.

When control system specifications do not indicate requirements for communication protocols, use only those protocols required for operation of the system as specified.

3.3.2 IP Control Networks

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.

3.4 SAFE MODE AND FAIL SAFE OPERATION

{For Reference Only: This subpart (and its subparts) relates to CP-12, SI-17; CCI-002855, CCI-002856, CCI-002857, 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.

3.5 IDENTIFICATION AND AUTHENTICATION

3.5.1 User Identification and Authentication

{For Reference Only: This subpart (and its subparts) relates to IA-2,(1),(12); CCI-000764, CCI-000765, CCI-001953, CCI-001954}

a. Devices that FULLY support accounts must uniquely identify and authenticate organizational users.

b. Devices which allow network access to privileged accounts must implement multifactor authentication for network access to privileged accounts.

3.5.1.1 HVAC Control Systems Devices

Identification and Authentication for network access to privileged accounts must be implemented by either accepting and electronically verify Personal Identity Verification (PIV) credentials or inheriting identification and authentication from the operating system.

3.5.1.2 Default Requirements for Control System Devices

For control system devices where User Identification and Authentication requirements are not otherwise indicated in this Section, User Identification and Authentication for network access to privileged accounts must be implemented by accepting and electronically verify Personal Identity Verification (PIV) credentialsorinheriting identification and authentication from the operating system.

3.5.2 Authenticator Management

{For Reference Only: This subpart (and its subparts) relates to IA-5 (b),(c),(e),(g),(1),(11); CCI-000176, 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}

3.5.2.1 Authentication Type

3.5.2.1.1 For HVAC Control System Devices

Unless otherwise indicated:

a. Software which FULLY supports accounts and which runs on a computer must use password-based authentication or hardware token-based authentication.

b. Other devices which FULLY support accounts must use password-based authentication.

c. Devices MINIMALLY supporting accounts must use password-based authentication.

3.5.2.1.2 Default Requirements for Control System Devices

For control system devices where Authentication Type requirements are not otherwise indicated in this Section:

a. Software which FULLY supports accounts and which runs on a computer must use password-based authentication or hardware token-based authentication.

b. Other devices which FULLY support accounts must use either password-based authentication or hardware token-based authentication.

c. Devices MINIMALLY supporting accounts must use either password-based authentication or hardware token-based authentication.

3.5.2.2 Password-Based Authentication Requirements

3.5.2.2.1 Passwords for Computers

All 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.

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 no 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.

i. Passwords must be cryptographically protected during storage and transmission.

3.5.2.2.2 Passwords for Non-Computer Devices FULLY Supporting Accounts

All non-computer devices 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.

f. Password must have a maximum lifetime of sixty (60) days. When passwords expire, prompt users to change passwords. Do no 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.

3.5.2.2.3 Passwords for Web Interfaces

Passwords for connecting to a web interface 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.

f. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do no 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.

h. Passwords must be cryptographically protected during storage and transmission.

3.5.2.2.4 Passwords for Devices Minimally Supporting Accounts

Devices minimally supporting accounts must support passwords with a minimum length of four characters.

3.5.2.2.5 Password Configuration and Reporting

For all devices with a password, change the password from the default password. Do not use the same password for more than one device unless specifically instructed to do so. Provide a Password Summary Report documenting the password for each device and describing the procedure to change the password for each device.

Do not provide the Password Summary Report in electronic format. Provide two hardcopies of the Password Summary Report, each copy in its own sealed envelope.

3.5.2.3 Hardware Token-Based Authentication Requirements

Devices supporting hardware token-based authentication must use Personal Identity Verification (PIV) credentials for the hardware token.

3.5.3 Authenticator Feedback

{For 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.

3.5.4 Device Identification and Authentication

{For Reference Only: This subpart (and its subparts) relates to IA-3; CCI-000777, CCI-000778, CCI-001958}

All computers must use IEEE 802.1x for authentication to the network. All web servers running on computers must use HTTPS.

3.5.4.1 For HVAC Control System Devices

Devices using Fox Protocol must use HTTPS. Devices using Fox Protocol must support IEEE 802.1x. Devices using Ethernet must support IEEE 802.1x. Devices using BACnet must support Network Security as specified in Clause 24 of ASHRAE 135.

3.5.4.2 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.

3.5.5 Cryptographic Module Authentication

{For Reference Only: This subpart (and its subparts) relates to IA-7; CCI-000803}

For devices that have STIG/SRGs related to cryptographic module authentication (CCI-000803), comply with the requirements of those STIG/SRGs.

3.6 EMERGENCY POWER

{For Reference Only: This subpart (and its subparts) relates to PE-11,(1); CCI-02955, CCI-000961}

Any emergency power requirements are specified in the control system and equipment specifications.

3.7 DURABILITY TO VULNERABILITY SCANNING

{For Reference Only: This subpart (and its subparts) relates to RA-5 (a),(b),(c),(d); CCI-001054, CCI-001055, CCI-0010156, 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.

For control system devices other than computers:

3.7.1 HVAC Control System Devices Other Than Computers

HVAC control system devices other than computers are not required to respond to scans.

3.7.2 Default Requirements for Control System Devices

Non-computer control system devices where Durability to Vulnerability

Scanning requirements are not otherwise indicated in this Section are not required to respond to scans.

3.8 DEVICES WITH CONNECTION TO MULTIPLE IP NETWORKS

Except for Ethernet switches, do not use more than one physical connection to IP networks on the same device unless doing so is both required by the project specifications and the specific application is approved. If a device with multiple IP connections is required, provide a Multiple IP Connection Device Request using the Multiple IP Connection Device Request Schedule at http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-t to request approval for each device.

3.9 SYSTEM AND COMMUNICATION PROTECTION

3.9.1 Denial of Service Protection, Process Isolation and Boundary Protection

{For Reference Only: This subpart (and its subparts) 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 in non-computer hardware and without reliance on the network.

3.10 SYSTEM AND INTEGRATION INTEGRITY

3.10.1 Malicious Code Protection

{For Reference Only: This subpart (and its subparts) relates to SI-3(c); CCI-001241, CCI-002623}

For all computers installed under this project, install and configure malware protection software in accordance with the relevant STIGs.

3.11 FIELD QUALITY CONTROL

3.11.1 Tests

In addition to testing and testing support required by other Sections, provide a minimum of 40 hours of technical support for cybersecurity testing of control systems.

-- End of Section --

SECTION 25 08 10

UTILITY MONITORING AND CONTROL SYSTEM TESTING

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.

CONSUMER TECHNOLOGY ASSOCIATION (CTA)

CTA CTA-709.1-D	(2014) Control Network Protocol Specification
CTA CTA-709.3	(1999; R 2015) Free-Topology Twisted-Pair Channel Specification
CTA CTA-852-C	(2014) Tunneling Device Area Network Protocols Over Internet Protocol Channels

1.2 DEFINITIONS

1.2.1 Algorithm

A set of well-defined rules or procedures for solving a problem or providing an output from a specific set of inputs.

1.2.2 Analog

A continuously varying signal value (temperature current, velocity, etc.).

1.2.3 Analog to Digital (A/D) Converter

An A/D converter is a circuit or device whose input is information in analog form and whose output is the same information in digital form.

1.2.4 CTA CTA-709.1-D

"Control Network Protocol Specification", Standard communication protocol for networked control systems that provides peer-to-peer communications.

1.2.5 Application Specific Controller

A device that is furnished with a pre-established built in application that is configurable but not re-programmable.

1.2.6 Architecture

Architecture is the general organization and structure of hardware and software.

1.2.7 Binary

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.

1.2.8 Building Point of Connection (BPOC)

The point of connection between the UMCS network backbone and the building network backbone. The hardware at this location, which performs/provides the connection is referred to as the BPOC Hardware.

1.2.9 Control Wiring

This includes conduit, wire, and wiring devices to install complete HVAC control systems, including motor control circuits, interlocks, sensors, PE and EP switches, and like devices. This also includes all wiring from node to node, and nodes to all sensors and points defined in the I/O summary shown on drawings or specified herein, and required to execute the sequence of operation. Does not include line voltage power wiring.

1.2.10 Demand

The maximum rate of use of electrical energy averaged over a specific interval of time, usually expressed in kW.

1.2.11 Diagnostic Program

Machine-executable instructions used to detect and isolate system and component malfunctions.

1.2.12 Distributed Control

A system whereby all control processing is decentralized and independent of a central computer. In regards to a LonWorks based system, it also means where the control logic for a single piece of building level control resides in more than one controller (node).

1.2.13 Graphical User Interface (GUI)

Human-machine interfacing allows the operator to manage, command, monitor, and program the system.

1.2.14 Integration

Establishing communication between two or more systems to create a single system.

1.2.15 Interoperable

Two devices are interoperable if installed into the same system and they communicate with each other without the use of another device (such as a gateway).

1.2.16 LonTalk(r)

Open communication protocol developed by the Echelon(r) Corporation.

1.2.17 LONWORKS(r)

The communication technology developed by Echelon(r) Corporation for control systems developed. The technology is based on the CTA CTA-709.1-D protocol and employs interoperable devices along with the capability to openly manage these devices using a network configuration tool.

1.2.18 LONMARK(r) International (LONMARK(r) Interoperability Assoc.)

Standards committee consisting of numerous independent product developers and systems integrators dedicated to determining and maintaining the interoperability guidelines for the LONWORKS(r) industry.

1.2.19 LonMarked(r)

A device that has been certified for compliance with LonMark(r) standards by the LonMark(r) International.

1.2.20 LONWORKS(r) Application Specific Controller (ASC)

A networked device or node that contains a complete, configurable application that is specific to a particular task.

1.2.21 LONWORKS(r) General Purpose Programmable Controller

A programmable control product, that unlike an ASC, is not installed with a fixed factory-installed application program. The application in the controller is custom software produced by the integrator specifically for the project.

1.2.22 LONWORKS(r) Network Services (LNS)

The database format for addressing nodes and variable bindings node-to-node.

1.2.23 Network

A system of distributed control units that are linked together on a communication bus. A network allows sharing of point information between all control units. Additionally, a network provides central monitoring and control of the entire system from any distributed control unit location.

1.2.24 Network Configuration Tool

Software used to create and modify the control network database and configure controllers.

1.2.25 Node ID

A unique 48-bit node identification (ID) tag given to each node by Echelon Corporation.

1.2.26 Node

An intelligent LONWORKS(r) device with a node ID and communicates via CTA CTA-709.1-D and is connected to an CTA CTA-709.1-D network.

1.2.27 Operating System (OS)

Software which controls the execution of computer programs and which provides scheduling, debugging, input/output controls, accounting, compilation, storage assignment, data management, and related services.

1.2.28 Operator Workstation (OWS)

The OWS consists of a high-level processing desktop or laptop computer that provides a graphic user interface to network.

1.2.29 Peripheral

Input/Output (I/O) equipment used to communicate to and from the computer and make hard copies of system outputs and magnetic files.

1.2.30 Router

A device which routes messages destined for a node on another segment subnet or domain of the control network. The device controls message traffic based on node address and priority. Routers may also serve as communication links between powerline, twisted pair, fiber, coax, and RF media.

1.2.31 Standard Network Variable Type (SNVT)

A network variable of a standard format type used to define data information transmitted and receive by the individual nodes.

1.2.32 UMCS Network Media

Transmission equipment including cables and interface modules (excluding MODEMs) permitting transmission of digital information.

1.2.33 XIF

"External Interface File" contains the contents of the manufacturer's product documentation.

1.2.34 Gateway

A device that translates from one protocol to another. Gateways are also called Communications Bridges or Protocol Translators.

1.3 SYSTEM DESCRIPTION

a. The purpose of this Specification is to define generic Factory, Performance Verification, and Endurance Test procedures for Utility Monitoring and Control Systems (UMCS) and building level DDC. These tests are to be used to assure that the physical and performance requirements of UMCS and building level DDC are tested, and that the test results are adequately documented. The Government will base certain contractual decisions on the results of these tests.

b. This document covers the factory, performance verification, and endurance test procedures for the Utility Monitoring and Control System (UMCS) and Direct Digital Control for HVAC. It has been written for a host based system where the LONWORKS(r) LNS database resides on the main computer (server) and communicates over the Ethernet (TCP/IP) connection to the field level controller nodes. The system shall be comprised of the server hardware and software, IP network hardware and software, and building point of connection (BPOC) hardware and software.

c. The contractor who provided building level DDC under Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC is responsible for testing the building level DDC. All control testing and controller tuning required under Section 23 09 00 shall be completed and approved before performing Performance Verification and Endurance Tests under this section.

d. The following UFGS: Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION and Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC shall be part of the contract documents.

1.3.1 Factory Test

Conduct a factory test at a company site. Perform some of the basic functions of the UMCS and building level DDC, to assure that the performance requirements of the specifications are met.

1.3.2 Performance Verification and Endurance Test

a. Shall be conducted on hardware and software installed at the jobsite to assure that the physical and performance requirements of specifications are met. Tests on network media shall include all contractor furnished media and shall include at least one type of each device installed.

b. Shall be conducted under normal mode operation, unless otherwise indicated in the initial conditions description for each test. System normal mode describes a condition in which the system is performing its assigned tasks in accordance with the contract requirements.

c. Shall utilize the operator workstation (OWS) to issue commands or verify status data.

1.3.3 Test Equipment and Setup

All test equipment calibrations shall be traceable to NIST. The accuracy of the test equipment and overall test method shall be at least twice the maximum accuracy required for the test. For example, if a temperature sensor has an accuracy of +1 degree F over the executed range, the test instrument used shall have an accuracy of at least +0.5 degree F or better. Provide all test equipment unless otherwise noted in the contract documents.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Factory Test; G

SD-06 Test Reports

UMCS and Building Level DDC Testing Sequence
Performance Verification Test; G
Endurance Testing

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 UMCS AND BUILDING LEVEL DDC TESTING SEQUENCE

Perform a successful factory test prior to start of installation work, as described in this section. During the installation phase, perform all required field testing requirements on the UMCS and building level DDC as specified in Sections 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION and 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC, to verify that systems are functioning and installed in accordance with specifications. Submit field test report prior to start of PVT and endurance testing. After completing all required field testing, perform a successful PVT and endurance test. All tests shall be successfully completed, and test reports received, prior to final acceptance of the UMCS and building level DDC. Perform and document Contractor field test on UMCS and building level DDC.

3.2 COORDINATION

Coordinate the testing schedule with the Government. Coordination shall include controls specified in other sections or divisions which include controls and control devices that are to be part of or interfaced to the UMCS specified in this section.

3.3 PROTECTION

Protect all work and material from damage by the work or workers. The Contractor is liable for any damage caused and responsible for the work and equipment until finally inspected, tested, and accepted. Protect the work against theft, and carefully store material and equipment received onsite that is not immediately installed.

3.4 FACTORY TEST

3.4.1 Factory Test Plan

Prior to the scheduling of the factory tests, provide the Government with a Factory Test Plan for approval, and wait to receive notification of approval of the Test Plan and Procedures before performing the tests. The plan shall include the following, as a minimum:

a. System one-line block diagram of equipment used in the factory test model, indicating servers, workstations, peripherals, network equipment, controllers, and instrumentation.

b. System hardware description used in the factory test.

c. System software description used in the factory test.

d. Listing of control and status points in the factory test model; plus a table with the following information:

(1) Input and output variables.
(2) SNVTs for each variable.
(3) Expected engineering units for each variable.
(4) Node ID.
(5) Domain & subnet addressing.

e. Required passwords for each operator access level.

f. List of other test equipment.

3.4.2 Test Procedures

Develop the factory test procedures from the generic test procedures in ATTACHMENT A. The test procedures shall consist of detailed instructions for test setup, execution, and evaluation of test results. Edit the generic test procedure for the provided UMCS and building level DDC. Perform a factory test on a model of the UMCS and building level DDC for the Government to verify the system will function to the requirements of the contract documents. The test architecture shall mimic a two building arrangement. There shall be a TCP/IP layer with two Internet Protocol (IP) to Lon routers. Below each of the routers shall be both programmable (GPPC) and application-specific controllers (ASC). One server and one workstation with printers shall be connected to the IP layer. There shall be simulated input devices connected to controllers to enable the creation of changing variables. If, during testing, the system fails a portion of a test, the Government will inform the Contractor if the entire test or only the portion that failed shall be re-performed. Give the Government a written report of those items which failed, what the problem was, and what was done to correct it. Provide onsite technical support to perform the PVT. ATTACHMENT A presents the generic Test Procedures with the following information:

a. Test identification number.

b. Test title.

c. Objective.

d. Initial conditions (if applicable).

e. Test equipment (if required).

f. Sequence of events.

g. Expected results.

3.4.3 Test Report

Submit a factory final, complete test report after completing the test, consisting of the following, as a minimum:

a. Section one of the submittal shall be a short summary of the factory test.

b. Section two of the submittal shall be a copy of the test plans.

c. Section three shall be the executed test procedure and shall be divided using tabs. Each tab section shall include all pertinent information pertaining to the executed and approved test, showing date and Government representative who witnessed/approved the test.

3.5 FIELD TEST REQUIREMENTS

The UMCS contractor shall perform and document contractor start-up and field tests as required by Sections 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION and 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. The field test validates that the UMCS and building level DDC are in operation without any problems or system errors prior to starting a PVT. Validate that all software along with all hardware is installed to meet or exceed the contract document requirements. This includes all LONWORKS(r) networking and monitoring hardware and all peripherals associated with the network and hardware. Start-up and field testing shall include:

3.5.1 Start-up Testing

All testing listed in Sections 25 10 10 and 23 09 00 shall be completed.

3.5.2 Point-to-Point Testing

All point-to-point testing of end field devices through proper input/output to graphic and operator interface shall be completed and approved.

3.5.3 Field Calibration

All field calibration shall be completed and approved.

3.5.4 Detailed Functional Testing

Detailed functional tests, verified by the Government that the system operation adheres to the Sequences of Operation.

3.5.5 Alarms and InterlocksAll alarm limits and testing shall be completed.

3.5.6 System Schedules and Setpoints

All schedule start/stops and system setpoints shall be entered, operating, and approved.

3.6 PERFORMANCE VERIFICATION TEST

3.6.1 Test Plan

Prior to the scheduling of the performance verification tests, provide the Government with a Performance Verification and Endurance Test Plan and Procedures for approval, and receive notification of approval of the Test Plan and Procedures. The plan shall include the following, as a minimum:

a. Installed system one-line block diagram, indicating servers, workstations, peripherals, network equipment, controllers, and instrumentation.

b. Installed system hardware description.

c. Installed system software description, including any software revisions made since the factory test.

d. Listing of control and status points installed in the system; plus a table with the following information:

(1) Input and output variables.
(2) SNVTs for each variable.
(3) Expected engineering units for each variable.
(4) Node ID.
(5) Domain & subnet addressing.

e. Required passwords for each operator access level.

f. List of other test equipment.

3.6.2 Test Procedures

Develop the performance verification test procedures from the generic test procedures in ATTACHMENT A. The test procedures shall consist of detailed instructions for test setup, execution, and evaluation of test results. Edit the generic test procedure for the provided UMCS and building level DDC. Perform a performance verification test (PVT) on the completed UMCS and building level DDC for the Government to verify the system is completely functional. If, during testing, the system fails a portion of a test, the Government will inform the Contractor if the entire test or only the portion that failed shall be re-performed. Give the Government a written report of those items which failed, what the problem was, and what was done to correct it. Provide on-site technical support to perform the PVT. ATTACHMENT A presents the generic UMCS Performance Verification Test Procedures with the following information:

a. Test identification number.

b. Test title.

c. Objective.

d. Initial conditions (if applicable).

e. Test equipment (if required).

f. Sequence of events.

g. Expected results.

3.6.3 Test Report

Submit a final, complete PVT test report, after completing the test, consisting of the following, as a minimum:

a. Section one of the submittal shall be a short summary of the performance verification test.

b. Section two of the submittal shall be a copy of the test plans.

c. Section three shall be the executed test procedure and shall be divided using tabs. Each tab section shall include all pertinent information pertaining to the executed and approved test, showing date and Government representative who witnessed/approved the test.

3.7 ENDURANCE TESTING

3.7.1 General

Endurance Test shall be designed to demonstrate the specified overall system reliability requirement of the completed system. Conduct the Endurance Test in four phases as described below. The Endurance Test shall not be started until the Government notifies the Contractor, in writing, that the Performance Verification Tests have been satisfactorily completed, training as specified has been completed, correction of all outstanding deficiencies has been satisfactorily completed, and that the Contractor has permission to start the Endurance Test. Provide an operator to man the system eight hours per day during first shift operations, including weekends and holidays, during Phase I and Phase III Endurance testing, in addition to any Government personnel that may be made available. The Government may terminate testing at any time if the system fails to perform as specified. Upon termination of testing by the Government or by the Contractor, commence an assessment period as described for Phase II and Phase IV. Upon successful completion of the Endurance Test, submit test reports to the Government explaining in detail the nature of any failures, corrective action taken, and results of tests performed, prior to acceptance of the system. Keep a record of the time and cause of each outage that takes place during the test period.

3.7.2 Phase I

During the Phase I testing, operate the system as specified for 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays. Do not make repairs during this phase of testing unless authorized by the Government, in writing. If the system experiences no failures during the Phase I test, proceed directly to Phase III testing, after receiving written permission from the Government.

3.7.3 Phase II

In Phase II, which occurs after the conclusion of Phase I, identify all failures, determine the causes of all failures, repair all failures, and submit a test failure report to the Government. After submitting the written report, convene a test review meeting at the job site to present the results and recommendations to the Government. The meeting shall be scheduled no earlier than five business days after receipt of the report by the Government. As a part of this test review meeting, demonstrate that all failures have been corrected by performing appropriate Performance Verification Tests. Based on the Contractor's report, the test review meeting, and the Contractor's recommendation, the Government will independently determine the restart point and may require that the Phase I test be totally or partially rerun. Do not commence any required retesting until after receipt of written notification by the Government.

3.7.4 Phase III

After the conclusion of any retesting which the Government may require, repeat the Phase II assessment as if Phase I had just been completed. If the retest is completed without any failures, proceed directly to Phase III testing, after receiving written permission from the Government. During Phase III testing, operate the system as specified for 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays. Do not make repairs during this phase of testing unless authorized by the Government, in writing.

3.7.5 Phase IV

In Phase IV, which occurs after the conclusion of Phase III, identify all failures, determine the causes of all failures, repair all failures, and submit a test failure report to the Government. After submitting the written report, convene a test review meeting at the job site to present the results and recommendations to the Government. The meeting shall not be scheduled earlier than five business days after receipt of the report by the Government. As a part of this test review meeting, demonstrate that all failures have been corrected by performing appropriate Performance Verification Tests. Based on the Contractor's report, the test review meeting, and the Contractor's recommendation, the Government will independently determine the restart point and may require that the Phase III test be totally or partially rerun. Do not commence any required retesting until after receipt of written notification by the Government. After the conclusion of any retesting which the Government may require, the Phase IV assessment shall be repeated as if Phase III had just been completed. The Contractor will not be held responsible for failures resulting from the following:

a. An outage of the main power supply in excess of the capability of any backup power source, provided that the automatic initiation of all backup sources was accomplished and that automatic shutdown and restart of the UMCS performed as specified.

b. Failure of a Government-furnished communications link, provided that the LON nodes and LON routers automatically and correctly operate in the stand-alone mode as specified, and that the failure was not due to contractor furnished equipment, installation, or software.

c. Failure of existing Government-owned equipment, provided that the failure was not due to contractor-furnished equipment, installation, or software.

3.7.6 Failure Reports

Provide UMCS Endurance Test Failure Reports. UMCS Test Failure Reports shall explain in detail the nature of each failure, corrective action taken, results of tests performed. If any failures occur during Phase I or Phase III testing, recommend the point at which the Phase I or Phase III testing, as applicable, should be resumed.

3.8 ATTACHMENT A

TEST PROCEDURES

TITLE: Test Index
OBJECTIVE: The following is an index of tests.

NOTES: Tests one through twenty contain specific "item(s)" that apply to Sections 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION) and 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. The following index of tests provides a summary of which "items numbers" apply to which specification.

Test No.	Test Title	Section 23 09 00, Section 25 10 10	DDC for HVAC
One	Initial System Equipment Verification	Items 1 through 15	Items 16 through 32
Two	System Start-up	Items 1 through 4	Items 5 and 6
Three	Monitor and Control Software	Items 1 through 5	Not Applicable
Four	Graphic Display of Data	Items 1 through 18	Not Applicable
Five	Graphic Navigation Scheme	Items 1 and 2	Not Applicable
Six	Command Functions	Items 1 through 6	Not Applicable
Seven	Command Input Errors	Items 1 through 6	Items 1 through 6
Eight	Special Functions	Item 1	Not Applicable
Nine	Software Editing Tools	Items 1 through 42	Items 1 through 42
Ten	Scheduling	Items 1 through 7	Items 8 through 10
Eleven	Alarm function	Items 1 through 15	item 16
Twelve	Trending	Items 1 through 8	Not Applicable
Thirteen	Demand Limiting	Items 1 through 8	Not Applicable
Fourteen	Report Generation	Items 1 through 6	Not Applicable
Fifteen	UPS Test	Items 1 through 5	Not Applicable
Sixteen	CTA CTA-709.1-D to IP Router Test	Items 1 through 3	Not Applicable
Seventeen	CTA CTA-709.1-D Router and Repeater	Not Applicable	Items 1 through 4

Test No.	Test Title	Section 23 09 00, Section 25 10 10	DDC for HVAC
Eighteen	CTA CTA-709.1-D Gateway Test	Items 1 through 5	Items 1 through 5
Nineteen	Local Display Panel	Not Applicable	Items 1 through 5
Twenty	Network Configuration Tool	Items 1 through 8	Items 1 through 8
Twenty-One	Custom Tests	Item 1 and 2	Item 1 and 2

PVT Checklist

OBJECTIVE:

1. Inspect/test/verify that building-level DDC system is compliant with Section 23 09 00 and capable of integration with UMCS

INITIAL REQUIREMENTS/CONDITIONS

1. The following tests shall be completed and documentation shall be submitted to the Government.

2. Date of Checklist: ___________
3. Time of Checklist: ___________
4. Contractor's Representative: ______________________
5. Government's Representative: ______________________

CHECKLIST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Draft or Final As-Built Drawings	Drawings submitted and approved	___________
		Point schedule(s) showing all required UMCS SNVTs submitted	___________
		Point schedules(s) showing device network addresses submitted	___________
		Local display panel (LDP) locations indicated on drawings submitted	___________
	Notes: ______________________		
2	Network Bandwidth Test Report	Test completed, accepted, and a report documenting results submitted	___________
	Notes: ______________________		
3	Programming software	Most recent version of the programming software for each type of GPPC has been submitted	___________
	Notes: ______________________		

Item	Action Item	Expected Results	Approved
4	XIF Files	External interface files (XIF) files for each model of LONWORKS®-based DDC hardware has been submitted	___________
	Notes: ___________		
5	LNS Database	Copies of the LNS database for the completed control network has been submitted	___________
	Notes: ___________		
6	LNS Plug-in	LNS Plug-ins for each application specific controller has been submitted	___________
	Notes: ___________		
7	Start-up testing report	Start-up has been successfully completed and testing report submitted	___________
		Controller tuning has been completed and document on point schedule	___________
		Calibration accuracy check completed and documented in test report	___________
		Actuator range check completed and documented in test report	___________
		Functional test to demonstrate control sequence completed and documented in test report	___________
	Notes: ___________		
8	Software License	Software licenses received for all software on the project	___________
	Notes: ___________		

Item	Action Item	Expected Results	Approved

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: One
TITLE: Initial System Equipment Verification

OBJECTIVE:

1. To verify that the hardware and software components of the system provided by the Contractor are in accordance with the contract plans and specifications and all approved submittals.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Submit a detailed list of all approved hardware with Manufacturer, model number and location. This list is based on the contract plans, specifications, change orders (if any) and approved submittals which shall be available for reference purposes during the test.

b. Submit a detailed list of all approved software with revision number and purpose of software. This list is based on the contract plans, specifications, change orders (if any) and approved submittals which shall be available for reference purposes during the test.

2. Equipment

a. Verify all equipment is functional.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	The workstation hardware is installed and complies with specification paragraph titled "Workstation Hardware".	__________________	___________
	Notes: ____		
2	The Server hardware is installed and complies with specification paragraph titled "Server Hardware".	__________________	___________
	Notes: ____		

Item	Action Item	Expected Results	Approved
3	The fiber optic patch panel is installed and complies with specification paragraph titled "Fiber Optic Patch Panel".	________	________
	Notes: ________		
4	The fiber optic media converter is installed and complies with specification paragraph titled "Fiber Optic Media Converter".	________	________
	Notes: ________		
5	The Ethernet switch is installed and complies with specification paragraph titled "Ethernet Switch".	________	________
	Notes: ________		
6	The IP router is installed and complies with specification paragraph titled "IP Router".	________	________
	Notes: ________		
7	The CTA CTA-709.1-D to IP router is installed and complies with specification paragraph titled "CTA CTA-709.1-D to IP Router".	________	________
	Notes: ________		
8	The CTA CTA-709.1-D gateway is installed and complies with specification paragraph titled "CTA CTA-709.1-D Gateway".	________	________
	Notes: ________		

Item	Action Item	Expected Results	Approved
9	The alarm printer is installed and complies with specification paragraphs titled "PRINTERS" and "Alarm Printer".	________	________
	Notes: ________		
10	The laser printer is installed and complies with specification paragraphs titled "PRINTERS" and "Laser Printer".	________	________
	Notes: ________		
11	The color printer is installed and complies with specification paragraphs titled "PRINTERS" and "Color Printer".	________	________
	Notes: ________		
12	The operating system is installed and complies with specification paragraph titled "Operating System (OS)".	________	________
	Notes: ________		
13	The office automation software is installed and complies with specification paragraph titled "Office Automation Software".	________	________
	Notes: ________		
14	The virus protection software is installed and complies with specification paragraph titled "Virus Protection Software".	________	________
	Notes: ________		
15	The configuration server is installed and complies with specification paragraph titled		

Item	Action Item	Expected Results	Approved
	"CTA CTA-852-C Configuration Server".	___________	___________

Notes: ____________________

____

DDC FOR HVAC

Item	Action Item	Expected Results	Approved
16	The CTA CTA-709.1-D Router is installed and complies with specification paragraph titled "CTA CTA-709.1-D Router".	___________	___________

Notes: ____________________

____

Item	Action Item	Expected Results	Approved
17	The CTA CTA-709.3 Repeater is installed and complies with specification paragraph titled "CTA CTA-709.3 Repeater".	___________	___________

Notes: ____________________

____

Item	Action Item	Expected Results	Approved
18	The TP/FT-10 network is installed in accordance with CTA CTA-709.3, with double-terminated bus topology.	___________	___________

Notes: ____________________

____

Item	Action Item	Expected Results	Approved
19	Network wiring extends to the location of UMCS BPOC.	___________	___________

Notes: ____________________

____

Item	Action Item	Expected Results	Approved
20	The Gateway is installed and complies with specification paragraph titled "Gateway".	___________	___________

Notes: ____________________

____

Item	Action Item	Expected Results	Approved
21	All control valves are installed and comply with their associated specification paragraph under the section titled "Control Valves".	___________	___________

Notes: ____________________

____

Item	Action Item	Expected Results	Approved
22	All dampers are installed and comply with their associated specification paragraph under the section titled "Dampers".	______	______
	Notes: ______		
23	All sensors are installed and comply with their associated specification paragraph under the section titled "Sensors".	______	______
	Notes: ______		
24	All indicating devices are installed and comply with their associated specification paragraph under the section titled "Indicating Devices".	______	______
	Notes: ______		
25	All user input devices are installed and comply with their associated specification paragraph under the section titled "User Input Devices".	______	______
	Notes: ______		
26	All output devices are installed and comply with their associated specification paragraph under the section titled "Output Devices".	______	______
	Notes: ______		
27	All multifunction devices are installed and comply with their associated specification paragraph under the section titled "Multifunction Devices".	______	______
	Notes: ______		

Item	Action Item	Expected Results	Approved
28	All compressed air equipment is installed and complies with their associated specification paragraph under the section titled "Compressed Air".	______	______
	Notes: ______		
29	All ASCs are installed and comply with the specification paragraph titled "Application Specific Controller".	______	______
	Notes: ______		
30	All LDPs and laptop computers are provided and comply with the specification paragraph titled "Local Display Panel".	______	______
	Notes: ______		
31	All GPPCs are installed and comply with the specification paragraph titled "General Purpose Programmable Controller".	______	______
	Notes: ______		
32	LNS-based system used to address nodes, bind variables, and LNS database of network exists on system.	______	______
	Notes: ______		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Two
TITLE: System Start-up

OBJECTIVE:

1. To validate that the system properly initializes and that the GUI properly reconnects to all communicating devices.
2. To validate that both application specific and programmable devices retain all vital information upon a power cycle.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide a list of all software that will be used to verify point connection at field level controllers and user interface.

b. Provide a list of all software need to verify application specific and programmable controller start-up.

2. Equipment

a. All peripherals and cables shall be connected in accordance with manufacturer's requirements.

b. The workstation shall be in the off mode.

c. All controls shall be fully functional and tested.

d. A programmable and application specific controller shall be randomly selected for the test.

3. Date of Test: __________
4. Time of Test: __________
5. Contractor's Representative: ____________________
6. Government's Representative: ____________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Energize the workstation.	The workstation will power-up and perform its start-up procedure without generating any errors or problems.	__________
	a) Operating system	Operating system shall be latest version of windows.	__________
	b) Start Network Configuration Tool.	The Network Configuration Tool drawing will open.	__________
	c) Start the System Plug-in.	The System plug-in will open.	__________
	d) Start the Server.	The Server will start.	__________
	e) Start the Workstation.	The Workstation will start. The operator shall now have the ability to view data from any device on the	

Item	Action Item	Expected Results	Approved
		network.	___

Notes: ______________________________

Item	Action Item	Expected Results	Approved
2	Check the communication from the server to the controllers.	Within the workstation software, when a device is selected, dynamic points lists become visible. Dynamic data represents success. A completion event failure message represents failure.	___

Notes: ______________________________

Item	Action Item	Expected Results	Approved
3	Verify on-line status.	All devices shall have on-line status indicated by the workstation software (green indicator).	___

Notes: ______________________________

Item	Action Item	Expected Results	Approved
4	View data from the graphical environment.	When a graphics page is opened, the points on the page should update. Question marks in lieu of data reflect failure.	___

Notes: ______________________________

DDC FOR HVAC

Item	Action Item	Expected Results	Approved
5	Verify that configuration data in application specific controllers is written to EEPROM.	All configuration parameters should be accessible.	___
	a) Open the LONWORKS® plug-in.	Software should open without errors.	___
	b) Note several parameters such as temperature setpoints and flow settings.	Operator is able to view a sample of parameters (data values and setpoints).	___
	c) Remove power from the controller for a minimum of 3 minutes.	Device should go off-line in Network Configuration Tool and workstation/server.	___
	d) Replace power to the controller.	Device should return to on-line status.	___
	e) Using the plug-in, verify that the parameters have not	Parameters shall not have changed.	___

Item	Action Item	Expected Results	Approved
	changes.		
	Notes: ____________		
6	Verify that configuration data in programmable controllers is retained after a power cycle.	____________	____________
	a) From the Workstation view several configuration parameters and note the values.	Values of the parameters can be viewed from the tree structure.	____________
	b) Remove power for a minimum of 3 minutes.	Controller will go offline in workstation software.	____________
	c) Replace power to the controller.	Controller will return to online status.	____________
	d) From the Workstation view the same configuration parameters and note the values.	Parameters values shall not have changed.	____________
	Notes: ____________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Three
TITLE: Monitor and Control (M&C) Software Passwords

OBJECTIVE:

1. To validate that the system utilizes four basic password levels
2. To validate that each password level has the specified authority

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation of M&C user password capacity in comparison with specification.

b. Provide a complete list of all users along with their passwords and user level prior to testing.

2. Equipment

a. Server and Workstation

3. Reference Documentation

a. Provide user manual documentation for setting up passwords

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Create password for new users.	New users shall exist in the server Database.	___________
	a) Set-up 4 users.	_________________	___________
	b) Assign different levels to each.	_________________	___________
	Notes: ___________________________________		
	___________________________________		
2	Demonstrate level 1 authority.	_________________	___________
	a) Sign in as the level 1 user.	Sign in shall be successful.	___________
	b) Attempt to view a system graphic.	Action shall be possible.	___________
	c) Attempt to acknowledge an alarm.	Action shall be denied.	___________
	d) Attempt to configure a trend.	Action shall be denied.	___________
	e) Attempt to configure a report.	Action shall be denied.	___________

Item	Action Item		Expected Results	Approved
	f)	Attempt to override a point.	Action shall be denied.	________
	g)	Attempt to configure an alarm.	Action shall be denied.	________
	h)	Attempt to configure a schedule.	Action shall be denied.	________
	i)	Attempt to configure a demand limiting parameter.	Action shall be denied.	________
	j)	Attempt to modify a graphic page.	Action shall be denied.	________
	k)	Attempt to create a custom program.	Action shall be denied.	________

Notes: ____

____

Item	Action Item		Expected Results	Approved
3	Demonstrate level 2 authority.		________	________
	a)	Sign in as the level 2 user.	Sign in shall be successful.	________
	b)	Attempt to view a system graphic.	Action shall be possible.	________
	c)	Attempt to acknowledge an alarm.	Action shall be possible.	________
	d)	Attempt to configure a trend.	Action shall be possible.	________
	e)	Attempt to configure a report.	Action shall be possible.	________
	f)	Attempt to override a point.	Action shall be denied.	________
	g)	Attempt to configure an alarm.	Action shall be denied.	________
	h)	Attempt to configure a schedule.	Action shall be denied.	________
	i)	Attempt to configure a demand limiting parameter.	Action shall be denied.	________
	j)	Attempt to modify a graphic page.	Action shall be denied.	________
	k)	Attempt to create a custom program.	Action shall be denied.	________

Notes: ____

____

Item	Action Item		Expected Results	Approved
4	Demonstrate level 3 authority.		________	________
	a)	Sign in as the level 3 user.	Sign in shall be successful.	________
	b)	Attempt to view a system graphic.	Action shall be possible.	________
	c)	Attempt to acknowledge an alarm.	Action shall be possible.	________
	d)	Attempt to configure a	Action shall be possible.	

Item	Action Item		Expected Results	Approved
		trend.		___
	e)	Attempt to configure a report.	Action shall be possible.	___
	f)	Attempt to override a point.	Action shall be possible.	___
	g)	Attempt to configure an alarm.	Action shall be possible.	___
	h)	Attempt to configure a schedule.	Action shall be possible.	___
	i)	Attempt to configure a demand limiting parameter.	Action shall be possible.	___
	j)	Attempt to modify a graphic page.	Action shall be denied.	___
	k)	Attempt to create a custom program.	Action shall be denied.	___

Notes: ______________________________

____

Item	Action Item		Expected Results	Approved
5	Demonstrate level 4 authority.		___	___
	a)	Sign in as the level 3 user.	Sign in shall be successful.	___
	b)	Attempt to view a system graphic.	Action shall be possible.	___
	c)	Attempt to acknowledge an alarm.	Action shall be possible.	___
	d)	Attempt to configure a trend.	Action shall be possible.	___
	e)	Attempt to configure a report.	Action shall be possible.	___
	f)	Attempt to override a point.	Action shall be possible.	___
	g)	Attempt to configure an alarm.	Action shall be possible.	___
	h)	Attempt to configure a schedule.	Action shall be possible.	___
	i)	Attempt to configure a demand limiting parameter.	Action shall be possible.	___
	j)	Attempt to modify a graphic page program.	Action shall be possible.	___
	k)	Attempt to create a custom program.	Action shall be possible.	___

Notes: ______________________________

____

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Four
TITLE: Graphic Display of Data

OBJECTIVE:

1. To validate that floor plans and equipment can be graphically displayed through GUI.
2. To validate the proper display of alarms on GUI.
3. To validate the proper display of trend data on GUI.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide hard copies of "snap shots" of sample graphics pages prior to testing.

2. Equipment

a. Complete all graphics.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Notes

a. Different types of data and states should be clearly distinguishable from each other.

5. Date of Test: __________
6. Time of Test: __________
7. Contractor's Representative: ____________________
8. Government's Representative: ____________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
1	Demonstrate the use of a three dimensional representation of a mechanical system.	Equipment shall be represented in a three dimensional manner.	__________
	Notes: ______________________________		
2	Demonstrate the presentation of real time data.	Dynamic real time data shall be presented on a graphics page.	__________
	Notes: ______________________________		
3	Demonstrate the presentation of user	A user defined parameter such as a setpoint shall be	

Item	Action Item	Expected Results	Approved
	entered data.	presented on a graphics page. Different types of data and states should be clearly distinguishable from each other.	__________
	Notes: __________		
4	Demonstrate the presentation of a point in override.	An indication of override condition shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	__________
	Notes: __________		
5	Demonstrate the presentation of a device in the alarm state.	An indication of the alarm state shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	__________
	Notes: __________		
6	Demonstrate the presentation of data that is out of range.	An indication of out of range condition shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	__________
	Notes: __________		
7	Demonstrate the presentation of missing data (controller is offline).	An indication of missing data shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	__________
	Notes: __________		

Item	Action Item	Expected Results	Approved
8	Demonstrate an error message when the operator attempts to execute in improper command.	An error message shall be displayed.	___________
	Notes: ___________		
9	Demonstrate point and click access to context sensitive help.	Operator shall be able to easily access context sensitive help using the mouse.	___________
	Notes: ___________		
10	Demonstrate point and click access to an engineering diagram.	Operator shall be able to access an engineering diagram using the mouse.	___________
	Notes: ___________		
11	Demonstrate the creation of an engineering diagram.	Operator shall be able to create an engineering diagram.	___________
	Notes: ___________		
12	Demonstrate the printing of a prepared report.	Operator shall be able to print a report using the mouse.	___________
	Notes: ___________		
13	Demonstrate the display of one or more points.	Operator shall be able to request the display of one or more points.	___________
	Notes: ___________		
14	Demonstrate the operator override of a point.	Operator shall be able to override a point.	___________
	Notes: ___________		

Item	Action Item	Expected Results	Approved
15	Demonstrate the modification of a time schedule.	Operator shall be able to modify a time schedule.	______
	Notes: ______		
16	Demonstrate the execution of a report.	Operator shall be able to initiate a report.	______
	Notes: ______		
17	Demonstrate the presentation of an alarm to include:	Operator shall be able to view an alarm with all of the required data.	______
	a) Identification	______	______
	b) Date and time	______	______
	c) Alarm Type	______	______
	d) Set Points	______	______
	e) Units	______	______
	f) Current Value	______	______
	g) Priority	______	______
	h) Associated message & Secondary message	______	______
	Notes: ______		
18	Demonstrate the presentation of real time trend data.	Operator shall be able to view real time trend data as a function of time.	______
	Notes: ______		

End of Test

Specific Abbreviations:
- Y = Yes
- N = No
- NA = Not Applicable

TEST NUMBER: Five
TITLE: Graphic Navigation Scheme

OBJECTIVE:

1. To validate hierarchical graphic displays from main screen to end devices.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide a hierarchical block diagram of the system network prior to testing.

2. Equipment

a. Have all programming completed to demonstrate graphic display.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Demonstrate the creation of a hierarchical tree structure for the presentation of point data with at least five levels.	Operator shall be able to organize point data graphic display in a hierarchical tree structure based on any organization desired. A typical organization could be: - Installation - Building - Building sub area - Main System-Unit - Terminal Unit	___________
	Notes: ____		
2	Demonstrate the creation of a hierarchical navigation structure for the graphic pages.	Operator shall be able or organize the graphical navigation from page to page using any hierarchical structure desired.	

Item	Action Item	Expected Results	Approved
		Examples: Home page to building 1 Building 1 to AHU 1 Building 1 back to Home Page Building 1 to 1st Floor Plan AHU 1 back to Building 1 AHU 1 back to Home Page AHU 1 to Terminal Unit Summary 1st Floor Plan back to Building 1 1st Floor Plan back to Home Page 1st Floor Plan to Any Terminal Device Terminal Unit Summary back to AHU 1 Terminal Unit Summary back to Building 1 Terminal Unit Summary back to Home Page Terminal Unit Summary to Individual Device	________

Notes: ______________________________

____

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Six
TITLE: Command Functions

OBJECTIVE:

1. To demonstrate the functionality and ability to execute command to the end devices.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

    a. Provide documentation of all command functions prior to testing.

2. Equipment

    a. Have all command functions programmed and functional.

3. Reference Documentation

    a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	From the tree structure, modify a parameter such as a set point.	The modified value shall be downloaded to the controller without delay and the controller performance shall be viewable by the monitoring of other dynamic points.	___________
	Notes: ____________________		
2	From a graphic page, modify a parameter such as a set point.	The modified value shall be downloaded to the controller without delay and the controller performance shall be viewable by the monitoring of dynamic points.	___________
	Notes: ____________________		
3	From the tree structure, place an analog output point under operator	The analog output point shall accept the assigned value and ignore changes	

Item	Action Item	Expected Results	Approved
	override and assign a fixed value.	from application logic until the point is taken out of override.	______
	Notes: ______		
4	From a graphic page, place an analog output point under operator override and assign a fixed value.	The analog output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	______
	Notes: ______		
5	From the tree structure, place a digital output point under operator override and assign a fixed value.	The digital output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	______
	Notes: ______		
6	From a graphic page, place a digital output point under operator override and assign a fixed value.	The digital output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	______
	Notes: ______		

End of Test

Specific Abbreviations:
- Y = Yes
- N = No
- NA = Not Applicable

TEST NUMBER: Seven
TITLE: Command Input Errors

OBJECTIVE:

1. To validate that the system ensures the necessary authority for command inputs
2. To validate that the system can control the range of command input values

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

   a. Provide all command input error messages prior to testing.

2. Equipment

   a. UMCS and DDC hardware and software

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Login using a password with point command.	Login occurs.	__________
	Notes: ____________________		
2	Request a display of a SNVT.	The system displays the controllers SNVT value.	__________
	Notes: ____________________		
3	Override the SNVT point to a selected value.	The SNVT value override changes the value in the controller.	__________
	Notes: ____________________		
4	Release the override of	The SNVT value returns to	

Item	Action Item	Expected Results	Approved
	a SNVT.	normal.	___________
	Notes: ___________		
5	For an nvi to a controller with a limit of 50 to 80, command the nvi to a value of 90.	The value will go the maximum of 80.	___________
	Notes: ___________		
6	For an nvi to a controller for which the operator only has read privileges, command the nvi to a value of 90.	The operator will be denied the ability to command the nvi to any value.	___________
	Notes: ___________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Eight
TITLE: Special Functions

OBJECTIVE:

1. Verify system has special integration as defined.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

    a. Provide documentation of all integrations prior to testing.

2. Equipment

    a. Have all UMCS and DDC hardware and software programmed, integrated, and completed.

3. Reference Documentation

    a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Verify that a building that uses controls from a vendor other than the one being installed can be integrated into the GUI without any loss of functionality. (A simulated building will be set up using an IP-L router and controllers from Honeywell, TAC, Trane, etc.)	Data from the other vendors controllers shall be integrated into the GUI and the same functionality that would exist if the controllers were from the same manufacture shall exist.	__________

Notes: ____

____

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Nine
TITLE: Software editing tools

OBJECTIVE:

1. To validate the performance of the M & C application programming tool for the GPPC.
2. To validate the performance of the display editing tool.
3. To validate the performance of the report generation display tool.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation and a backup softcopy of the editing tool prior to testing.

b. Provide documentation of any future software upgrade versions that pertain to the software-editing tool.

2. Equipment

a. Have working knowledge of the full capability of the software-editing tool.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS and DDC for HVAC			
1	Demonstrate the programming of an override function in a GPPC.	Operator shall be able to use the programmed function to override an output point in a GPPC.	___________
	Notes: ______________________________		
2	Demonstrate software that enables the monitoring of data from a GPPC.	Operator shall be able to monitor points from a GPPC.	___________
	Notes: ______________________________		
3	Demonstrate timer	Control logic shall honor	

Item	Action Item	Expected Results	Approved
	functions within applications of GPPC.	the built in timers.	________
	a) delay on	____________	________
	b) delay off	____________	________
	c) one second delays	____________	________
	d) interval timers	____________	________
	Notes:		
4	Demonstrate logic loops ("for" and "while") in GPPC.	Control logic shall honor the criteria.	________
	Notes:		
5	Demonstrate if-then-else logic in GPPC.	Control logic shall properly follow the if, then, else requirements.	________
	Notes:		
6	Demonstrate basic math functions in GPPC.	Control logic shall properly execute math functions.	________
	Notes:		
7	Demonstrate Boolean math functions in GPPC.	Control logic shall properly execute the functions.	________
	Notes:		
8	Demonstrate exponential math functions in GPPC.	Control logic shall properly execute the functions.	________
	Notes:		
9	Demonstrate trigonometric math functions in GPPC.	Control logic shall properly execute the functions.	________
	Notes:		
10	Demonstrate bitwise math functions in GPPC.	Control logic shall properly execute the functions.	________

Item	Action Item	Expected Results	Approved
	Notes: ____________		
11	Create a user defined subroutine/function in GPPC.	Subroutine/function shall work correctly and be easily reused.	____
	Notes: ____________		
12	Create alarm conditions in GPPC.	Alarm variables shall be created according to the criteria.	____
	Notes: ____________		
13	Create and save a graphic symbol at the server.	Symbol shall be reusable on a new graphic.	____
	Notes: ____________		
14	Modify a graphic symbol at the server.	Operator shall be able to open an existing symbol and make changes.	____
	Notes: ____________		
15	Save a graphic symbol to a library at the server.	Symbol shall be available from the library for reuse.	____
	Notes: ____________		
16	Delete a graphic symbol at the server.	Symbol shall no longer exist for use.	____
	Notes: ____________		
17	Place a graphic symbol on a new graphic page at server.	When the new page is opened, the symbol shall be there.	____
	Notes: ____________		

Item	Action Item	Expected Results	Approved
18	Associate particular conditions with particular displays at the server.	When the conditional variable changes, the display should change.	___________
	Notes: ___________		
19	Overlay alphanumeric text on a graphic at the server.	Text shall properly display.	___________
	Notes: ___________		
20	Create a new graphic from an old one at the server.	New graphic shall properly display.	___________
	Notes: ___________		
21	Place dynamic data on a graphic at the server.	The dynamic data shall be viewable on the graphic.	___________
	Notes: ___________		
22	Define the background color of a new graphic at the server.	The new graphic shall show the selected background color.	___________
	Notes: ___________		
23	Define a foreground color for an element on a graphic to distinguish it from the background color at the server.	The color of the dynamic data that uses the foreground color shall display in the foreground color.	___________
	Notes: ___________		
24	Position a symbol on a graphic at the server.	The operator shall be able to place a symbol at any location on a graphic.	___________
	Notes: ___________		

Item	Action Item	Expected Results	Approved
25	Position and edit alphanumeric descriptors at the server.	The alphanumeric display shall be as designed.	___________
	Notes: ___________		
26	Draw lines on a graphic at the server.	Lines shall display as drawn.	___________
	Notes: ___________		
27	Associate source of dynamic data for presentation on a graphic at the server.	Correct data shall be displayed.	___________
	Notes: ___________		
28	Display analog data on a graphic page at the server.	Correct data shall be displayed.	___________
	Notes: ___________		
29	Demonstrate the movement of the curser (crosshairs) by the use of the mouse at the server.	Crosshairs shall follow the commands from the mouse.	___________
	Notes: ___________		
30	Demonstrate the simultaneous use of multiple graphics (coincident graphics)at the server.	Operator shall see the use of the tile function and the use of the tab function to manage multiple graphics.	___________
	Notes: ___________		
31	Associate graphic properties such as color with the values from dynamic variables at	Graphic properties shall change as the value of the dynamic variable changes.	

Item	Action Item	Expected Results	Approved
	the server.		________
	Notes: ________		
32	Create conditional displays based on the value of a dynamic variable at the server.	The graphic display shall change as the dynamic variable changes.	________
	Notes: ________		
33	Review the standard symbol library at the	Operator shall see how to access symbols from the standard symbol library.	________
	Notes: ________		
34	Demonstrate how to move data from the database to a report at the server.	The executed report shall contain data from the database.	________
	Notes: ________		
35	Add comments and headers to a report at the server.	The executed report shall contain the comments and headers.	________
	Notes: ________		
36	Demonstrate the time stamping of data in a report at the server.	Data presented in a report shall include the date and time the data was sampled.	________
	Notes: ________		
37	Demonstrate the time stamping of the report generation at the server.	A report shall include the date and time it executed.	________
	Notes: ________		
38	Demonstrate basic mathematical manipulation	Report shall display the results of the mathematical	

Item	Action Item	Expected Results	Approved
	of data within a report (daily averages, highs, lows, etc.) at the server.	manipulations.	___________
	Notes: ___________		
39	Demonstrate the operator's ability to select either automatic or manual generation of a report.	Reports shall execute per the operator's instructions. Report one shall execute per the operator's instructions. Report two shall execute automatically on a time basis per operator's instructions.	___________
	Notes: ___________		
40	Demonstrate the selection of either display, print to printer or print to file.	Reports shall execute per the operator's instructions. Report one is printed to printer. Report two is printed to file.	___________
	Notes: ___________		
41	Demonstrate how a modified application program is imported into the server database for presentation to the workstations.	Modified list of variables shall be available from a workstation.	___________
	Notes: ___________		
42	Demonstrate how a new device is added to the server database for presentation to the workstations.	New list of variables from the new device shall be available from a workstation.	___________
	Notes: ___________		

End of Test

Item	Action Item	Expected Results	Approved

Specific Abbreviations:

Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Ten
TITLE: Scheduling

OBJECTIVE:

1. Verify that M&C software has ability to operate end devices off a time of day schedule utilizing defined parameters.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation of the minimum programmable schedules in comparison to the specification requirement prior to testing.

b. Provide documentation of all schedules programmed in the UMCS prior to testing.

c. Provide a trend or report log of all equipment on a schedule prior to testing.

2. Equipment

a. Have GPPC and ASC with all scheduling completed for testing.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Demonstrate the basic functionality of a time schedule by monitoring the value of SNVT_occupancy as the time changes through a start time or a stop time.	The value of SNVT_occupancy shall properly track the time schedule.	__________
	Notes: ______________________________		
2	Setup a weekly time schedule for a demo system with independent times for each day of the week and with up to 6 events per day.	Scheduling software shall accommodate the described requirements.	__________

Item	Action Item	Expected Results	Approved
	Notes: ______		
3	Setup a special event or date specific time schedule and verify that this schedule takes precedence over the weekly schedule.	The special event schedule shall take precedence.	______
	Notes: ______		
4	Setup a group time schedule for a collection of systems. This group schedule shall take precedence over the individual time schedules.	The group schedule shall take precedence.	______
	Notes: ______		
5	Demonstrate operator access to a time schedule from a graphic page.	Operator shall be able to access the time scheduling editor from a graphic page.	______
	Notes: ______		
6	Display the current date and time on a graphic page.	Operator shall be able to view the current date and time from a graphic page.	______
	Notes: ______		
7	Demonstrate automatic daylight savings time adjustment.	Time of day shifts automatically.	______
	Notes: ______		
HVAC			
8	Demonstrate the ability of GPPC to accept an occupied, unoccupied and standby command from the UMCS.	Equipment shall change modes based on the UMCS or from "system scheduler" SNVT schedule data.	______

Item	Action Item	Expected Results	Approved
	Notes: ______		
9	Demonstrate the ability of ASC to accept an occupied, unoccupied and standby command from the UMCS.	Equipment shall change modes based on the UMCS SVNT schedule data.	______
	Notes: ______		
10	Demonstrate use of the default schedule when communication is lost to the UMCS.	Equipment should use the default schedule until communication is reestablished.	______
	Notes: ______		

End of Test

Specific Abbreviations:
- Y = Yes
- N = No
- NA = Not Applicable

TEST NUMBER: Eleven
TITLE: Alarm Function

OBJECTIVE:

1. Verify M&C software is capable of alarm notification and routing.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation of alarm managing capacity in caparison with specification.

b. Provide documentation of all alarm types and priorities utilized in the M&C prior to testing.

c. Provide documentation of the alarm routing in this particular M&C.

2. Equipment

a. Provide GPPC and ASC will alarms programmed.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Initiate a basic binary alarm condition such as a fan fail to start.	The nvo (SNVT) displayed on designated server/workstation shall change from a value of 0 to a value of 1. The alarm shall be presented in the alarm window. The alarm shall define the source of the alarm. The alarm shall define the time of the alarm. The alarm shall present its assigned priority. The alarm shall display a text message.	___________

Item	Action Item	Expected Results	Approved
	Notes: ______		
2	Demonstrate the capability of associating a secondary text message with the alarm.	With a simple point and click, the operator shall have access to the secondary text message.	______
	Notes: ______		
3	Acknowledge the alarm.	The status of the alarm shall changed to acknowledged. The user that acknowledged the alarm shall be recorded along with the date and time of the action.	______
	Notes: ______		
4	Demonstrate the "pop up" of the alarm window when an alarm occurs.	When the alarm occurs, the alarm window shall automatically open.	______
	Notes: ______		
5	Demonstrate the capability to send a numeric page when an alarm occurs.	The numeric page is received.	______
	Notes: ______		
6	Demonstrate the capability to send an e-mail when an alarm occurs.	The e-mail shall be received.	______
	Notes: ______		
7	Demonstrate the printing of an alarm on the alarm printer.	The printer shall print the alarm.	______
	Notes: ______		

Item	Action Item	Expected Results	Approved
8	Identify the file on the hard disk that contains all of the alarms.	Opening the file shall display a list of all of the alarms.	___________
	Notes: ___________		
9	Execute a user sort on the alarm file.	The presentation shall follow the defined sort.	___________
	Notes: ___________		
10	Print the alarm file.	Paper copy shall be printed.	___________
	Notes: ___________		
11	Take an application specific controller off-line.	An alarm should be generated.	___________
	Notes: ___________		
12	Take a programmable controller off line.	An alarm should be generated.	___________
	Notes: ___________		
13	Simulate a data circuit going off line.	An alarm should be generated.	___________
	Notes: ___________		
14	Simulate a point not responding to a command.	An alarm should be generated.	___________
	Notes: ___________		
15	Simulate a change of state without command.	An alarm should be generated.	___________
	Notes: ___________		

Item	Action Item	Expected Results	Approved
DDC FOR HVAC			
16	Initiate an alarm condition such as a fan fail to start.	DDC system shall dial a pager and send a numerical alarm. DDC system shall dial an e-mail server. The node shall be able to dial and connect to a remote server and send an e-mail via Simple Mail Transfer Protocol (SMTP). DDC system shall send an e-mail over IP Network. The alarm handling node shall be capable of connecting to an IP network and sending e-mail via Simple Mail Transfer Protocol (SMTP).	________

Notes: ____

____

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Twelve
TITLE: Trending

OBJECTIVE:

1. To validate the capability for historical trend data collection and presentation

2. To validate the capability for real time trend data collection and presentation

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation of trending capability in comparison with specification.

2. Equipment

a. Provide GPPC or ASC and workstation/server programmed with trend data.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Set up a trend with a 1 second sample rate.	It shall be possible to collect data on a 1 second sample rate.	___________

Notes: ____

____

Item	Action Item	Expected Results	Approved
2	Set up a trend to start and stop at specific times.	It shall be possible to start and stop a trend based on time.	___________

Notes: ____

____

Item	Action Item	Expected Results	Approved
3	Open a trend data display that has 8 values trended versus time.	Trend plots shall show all 8 variables as a function of time.	___________
	a) historical data	__________________	___________

Item	Action Item	Expected Results	Approved
	b) instantaneous data	__________	__________
	Notes:		
4	Open a pre-programmed trend data presentation.	Trend plot shall open without operator programming.	__________
	Notes:		
5	Open the trend configuration dialog box and set up a trend.	Operator shall be able to configure a trend plot.	__________
	Notes:		
6	Set up a trend for a randomly selected binary value and a randomly selected analog value.	Any binary or analog variable shall be trendable.	__________
	Notes:		
7	Verify that historical trend data is stored on the hard drive.	With the controller offline, historical trend data from that controller shall be presented in a graphical form.	__________
	Notes:		
8	Export trend log data to Microsoft Excel for manipulation and printing by the operator.	Data shall be presented in a ****.xls form.	__________
	Notes:		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Thirteen
TITLE: Demand Limiting

OBJECTIVE:

1. Verify M&C software has the capability of performing demand-limiting strategies

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation of the specific equipment being monitored.

b. Provide documentation of the load shed priority and the equipment associated with the priorities.

2. Equipment

a. Provide GPPC and ASC programmed for demand-limit strategies.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	From the home page of the M&C go to or click on the graphical demand-limiting page.	The demand-limiting page will open without any errors.	___________
	Notes: ____________________		
2	Document the present kW load__________.	The M&C will display the actual kW.	___________
	Notes: ____________________		
3	Set kW limit setpoint to cause program to shed load.	__________________	___________
	Notes: ____________________		

Item	Action Item	Expected Results	Approved
4	Turn off 25% of the mechanical equipment being monitored.	The kW usage will decrease.	___________
	Notes: ___________		
5	Allow the building(s) to remain at 75% for a given time as to generate a temperature load.	The building(s) will warm-up/cool down.	___________
	Notes: ___________		
6	After time period has expired, turn all equipment on at the same time.	The kW usage will greatly increase. The M&C will stop other pieces of equipment as to shed the load. The equipment shut down will be priority based. After the building(s) come under temperature control the M&C will start all of the equipment. The equipment start up will be priority based.	___________
	Notes: ___________		
7	Verify the building(s) remain under temperature control and go back to the home page.	The building(s) will come under control. The home page will be displayed.	___________
	Notes: ___________		
8	Reset kW setpoint to normal limits.	The UMCS goes back to normal control.	___________
	Notes: ___________		

Item	Action Item	Expected Results	Approved

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Fourteen
TITLE: Report Generation

OBJECTIVE:

1. To demonstrate that M&C software has ability to generate reports in a fixed format initialized by operator request

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide documentation of all report logs set-up and the equipment associated with the report logs.

2. Equipment

a. Provide server/workstation, GPPC, ASC and I/O to create reports.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Manually generate a report for viewing on the workstation.	Report shall present itself for viewing without disrupting the operation of the control system.	___________
	Notes: ____		
2	Manually generate a report and direct it to a specific printer.	Report shall print on the specified printer.	___________
	Notes: ____		
3	Verify that the report contains the date and time associated with the raw data.	Data samples listed in the report shall have the associated date and time the samples were collected.	___________
	Notes: ____		

Item	Action Item	Expected Results	Approved
4	Verify that the report has the date and time the report was generated.	The report shall include the date and time of the report generation.	___
	Notes: ___		
5	Save a report to a file that is compatible with Microsoft Office products.	The report shall be saved in a ***.xls format.	___
	Notes: ___		
6	Generate a comma delimited file with trend log data.	The comma delimited data shall be produced.	___
	Notes: ___		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Fifteen
TITLE: UPS Test

OBJECTIVE:

1. Validate UPS requirements

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

   a. The Contractor provides documentation on UPS.

2. Equipment

   a. The server/workstation and the UPS needs to be on and operating for a minimum of one week.

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	The UMCS home graphic page is called up.	The home page is displayed.	___________
	Notes: ______________________		
2	Unplug the UPS from the wall outlet.	The UMCS home page remains displayed. UPS LED-warning lights if applicable. UPS sound audible warning alarm if applicable.	___________
	Notes: ______________________		
3	Log out of the home page of the M&C and then log back into it.	The UPS will not affect the UMCS hardware and all associated software.	___________
	Notes: ______________________		

Item	Action Item	Expected Results	Approved
4	Allow the UPS to be unplugged for 20 minutes.	The UPS will not affect the UMCS hardware and all associated software.	________
	Notes: ________		
5	Return the UPS plug to the wall outlet.	The UPS will not affect the UMCS hardware and all associated software.	________
	Notes: ________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Sixteen
TITLE: CTA CTA-709.1-D to IP Router Test

OBJECTIVE:

1. Validate CTA CTA-709.1-D to IP Router requirements

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Submittal information on router and O&M manual on network analysis tool.

2. Equipment

a. The router needs to be on and operating.

b. Provide a LONWORKS® network analysis tool and router configuration tool.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Connect and open network analysis tool and verify router.	Tool shall identify function, network address, and identifier of the device.	___________
	Notes: ______________________		
2	Using router configuration tool, open network properties dialog box.	Router shall be utilizing a static IP address and shall not be configured for DHCP.	___________
	Notes: ______________________		
3	Confirm LON data is transmitted to/from LON bus to IP network.	All LONWORKS® network data is being transmitted to/from the IP network.	___________
	Notes: ______________________		

Item	Action Item	Expected Results	Approved

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Seventeen
TITLE: CTA CTA-709.1-D Router and Repeater

OBJECTIVE:

1. Validate EIA-709.1B Router and Repeater requirements

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

   a. Submittal information on router/repeater and O&M Manual on network analysis tool.

2. Equipment

   a. The router needs to be on and operating for a minimum of one week.

   b. The repeater needs to be on and operating for a minimum of one week.

   c. Provide a LONWORKS® network analysis tool and router/repeater configuration tool.

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: __________
5. Time of Test: __________
6. Contractor's Representative: ____________________
7. Government's Representative: ____________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
DDC FOR HVAC			
1	Connect and open network analysis tool and verify router and repeater.	Tool shall identify function, network address, and identifier of the devices.	__________
	Notes: ____________________		
2	Using router configuration tool, open the properties dialog box. Verify what data is configured to pass through router.	Only the data that is configured to pass through the router is being sent.	__________
	Notes: ____________________		
3	Using repeater	Dialog box opens.	

Item	Action Item	Expected Results	Approved
	configuration tool, open the properties dialog box.		___________
	Notes: ___________		
4	Verify that repeater is configured as a repeater and that all data is being sent.	Verify that all data is being sent through the repeater.	___________
	Notes: ___________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Eighteen
TITLE: CTA CTA-709.1-D Gateway Test

OBJECTIVE:

1. Validate CTA CTA-709.1-D Gateway requirements.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Provide a list of all software that will be used to verify CTA CTA-709.1-D Gateway configuration.

b. Provide a LonMark external interface file (XIF) for the gateway.

2. Equipment

a. The gateway needs to be on and operating.

b. Provide a LonWorks® network analysis tool and gateway configuration tool.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS and DDC FOR HVAC			
1	Connect a LONWORKS® Network Analysis Tool to the network.	a. Tool shall identify function, network address, and identifier of the device.	
		b. All network traffic from gateway shall be utilizing the CTA CTA-709.1-D protocol.	___________

Notes: ____

____

Item	Action Item	Expected Results	Approved
2	Use gateway configuration tool to verify or create a binding from gateway to a LONWORKS® controller on the network.	a. Gateway allows binding of the Standard Network Variable Types from the gateway to a LONWORKS® controller.	
		b. Information from gateway should be bounded and	

Item	Action Item	Expected Results	Approved
		LONWORKS® controller should be receiving data.	________
	Notes: ________		
3	Using gateway or network configuration tool verify the following:		
	Open the properties dialog box for one of the configured SNVTs.	Gateway should allow the SNVT to be transmitted on "min", "max" and "delta".	________
	Rename one of the SNVTs from the gateway.	Gateway should allow all variable names to be customized.	________
	Check total capacity of Gateway.	Gateway shall have 50% extra capacity to map over additional points.	________
	Notes: ________		
4	Press service pin on gateway.	Gateway should broadcast the neuron ID and Program ID over the network.	________
	Notes: ________		
5	Remove power source from gateway for two hours. Then return power to gateway.	Gateway should retain all configuration data.	________
	Notes: ________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Nineteen
TITLE: Local Display Panel (LDP)

OBJECTIVE:

1. To demonstrate capability of the Local display panel to view and override control points

INITIAL REQUIREMENTS/CONDITIONS

1. Submittal

   a. O & M Manual for LDP

2. Equipment

   a. Hardware and software to connect and demo LDP configuration tool

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
DDC FOR HVAC			
1	Connect LDP to LON bus. Push service pin button on LDP.	LDP Controller should broadcast its neuron ID.	___________
	Notes: ______________________________		
2	Use navigation buttons on LDP to display a status point such as a temperature or fan status.	LCP should allow user to read all status points.	___________
	Notes: ______________________________		
3	Use navigation buttons to display a control point such as a discharge air temperature setpoint.	LCP should allow user to read all control points.	___________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
4	Use LDP to override setpoint.	System accepts new setpoint. Verify system reacts to new setpoint.	________
	Notes: ________		
5	Use LDP to release local control override.	Verify system returns to normal control.	________
	Notes: ________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Twenty
TITLE: Network Configuration Tool

OBJECTIVE:

1. To validate the performance of the network configuration tool

INITIAL REQUIREMENTS/CONDITIONS

1. Submittal

   a. Network configuration tool manuals

2. Equipment

   a. Hardware, network connection, LNS database, and network configuration tool

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: ___________
5. Time of Test: ___________
6. Contractor's Representative: ______________________
7. Government's Representative: ______________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Open network configuration tool and verify LNS data for project opens is being used.	The Network Configuration Tool is being used and entire LNS database for project is exposed.	___________
	Notes: ______________________________		
2	Open a typical LNS plug-in.	Plug-in shall open and enable configuration of the device.	___________
	Notes: ______________________________		
3	Reconstruct a database by connecting to an existing network and uploading the data.	The database and drawing shall be created.	___________
	Notes: ______________________________		

Item	Action Item	Expected Results	Approved
4	Verify that a graphical interface is use.	Note that Network Configuration Tool uses Visio (type) as a graphical interface.	___________
	Notes: ___________		
5	Print the graphical representation.	Printing shall be successful.	___________
	Notes: ___________		
6	Merge two LNS databases into a single database.	The merge shall be successful.	___________
	Notes: ___________		
7	Print reports from network configuration tool.	Address table, SNVT I/O table, and SCPT/UCPT table reports shall be successfully printed.	___________
	Notes: ___________		
8	Randomly select a sample of network variable and confirm they are using correct SNVT types.	Correct SNVT types were used.	___________
	Notes: ___________		

End of Test

Specific Abbreviations:
- Y = Yes
- N = No
- NA = Not Applicable

TEST NUMBER: Twenty one
TITLE: Custom Tests

OBJECTIVE:

1. To test custom applications for UMCS and/or DDC for HVAC, that are specific to a project

INITIAL REQUIREMENTS/CONDITIONS

1. Submittal

   a. Documents related to custom application - to be identified

2. Equipment

   a. Equipment to be provided related to custom application - to be identified

3. Date of Test: __________
4. Time of Test: __________
5. Contractor's Representative: ____________________
6. Government's Representative: ____________________

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Identify special tests for the UMCS that relate to a custom application for a specific project - to be completed by designer.	To be completed by designer.	__________
	Notes: ____________________		
2	Identify special tests for the DDC for HVAC systems that relate to a custom application for a specific project - to be completed by designer.	To be completed by designer.	__________
	Notes: ____________________		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

-- End of Section --

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SECTION 25 10 10

UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION

PART 1 GENERAL

1.1 SUMMARY

Integrate into the existing Base-wide Utility Monitoring and Control System (UMCS) which performs supervisory monitoring and supervisory control of base-wide building control systems and utility control systems using ASHRAE 135 (BACnet) 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

The existing UMCS is manufactured and provided by Automated Logic Corporation (ALC). All components provided and installed with this section and as referenced by this section to be compatible with the base-wide system. In general, requirements for a UMCS are 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 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.

1.1.2 General Cybersecurity Requirements

Address cybersecurity in accordance with AF ETL 11-1.

1.1.3 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 Stds Dictionary and the ASHRAE FUN IP, as applicable.

1.1.4 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.

1.1.5 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 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	(2016) BACnet—A Data Communication Protocol for Building Automation and Control Networks
ASHRAE FUN IP	(2017) Fundamentals Handbook, I-P Edition

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 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

INTERNET ENGINEERING TASK FORCE (IETF)

IETF RFC 7465	(2015) Prohibiting RC4 Cipher Suites
RFC 821	(2001) Simple Mail Transfer Protocol (SMTP)

LONMARK INTERNATIONAL (LonMark)

LonMark Interoperability Guide	(2005) LonMark Application-Layer Interoperability Guide and LonMark Layer 1-6 Interoperability Guide; Version 3.4

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 ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment

	(1000 Volts Maximum)

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 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-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-606	(2017c) Administration Standard for the Telecommunications Infrastructure
TIA-607	(2015c; Addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. AIR FORCE (USAF)

AF ETL 11-1	(2011) Civil Engineer Industrial Control System Information Assurance Compliance

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

1.3 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.

1.3.1 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.

1.3.2 Alarm Handling

see Alarm Routing

1.3.3 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.

1.3.4 Application Generic Controller (AGC)(LonWorks)

A device that is furnished with a (limited) pre-established application that also has the capability of being programmed. Further, the ProgramID and XIF file of the device are fixed. The programming capability of an AGC may be less flexible than that of a General Purpose Programmable Controller (GPPC).

1.3.5 Application Specific Controller (ASC)(LonWorks)

A device that is furnished with a pre-established built in application that is configurable but not re-programmable. An ASC has a fixed factory-installed application program (i.e Program ID) with configurable settings.

1.3.6 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.

1.3.7 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.

1.3.8 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.

1.3.9 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.

1.3.10 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.

1.3.11 BACnet Internetwork (BACnet)

Two or more BACnet networks connected with BACnet routers. In a BACnet Internetwork, there exists only one message path between devices.

1.3.12 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.

1.3.13 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.

1.3.14 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.

1.3.15 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.

1.3.16 BACnet Smart Sensor (B-SS)(BACnet)

A hardware device BTL Listed as a B-SS. A simple sensing device with very limited resources.

1.3.17 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.

1.3.18 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".

1.3.19 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'.

1.3.20 Binding (LonWorks)

The act of establishing communications between CEA-709.1-D devices by associating the output of a device to the input of another so that information is automatically (and regularly) sent without being requested by the recipient.

1.3.21 Broadcast

Unlike most messages, which are intended for a specific recipient device, a broadcast message is intended for all devices on the network.

1.3.22 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.

1.3.23 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.

1.3.24 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)

1.3.25 Channel (LonWorks)

A portion of the control network consisting of one or more segments connected by repeaters. Channels are separated by routers. The device quantity limitation is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to

128 devices per channel.

1.3.26 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.

1.3.27 Configuration Property (LonWorks)

Controller parameter used by the application which is usually set during installation/testing and seldom changed. For example, the P and I settings of a P-I control loop. Also see 'Standard Configuration Property Type (SCPT)'

1.3.28 Control Logic Diagram

A graphical representation of control logic for multiple processes that make up a system.

1.3.29 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.

1.3.30 Explicit Messaging (LonWorks)

A non-standard and often vendor (application) specific method of communication between devices.

1.3.31 External Interface File (XIF) (LonWorks)

A file which documents a device's external interface, specifically the number and types of LonMark objects, the number, types, directions, and connection attributes of network variables, and the number of message tags.

1.3.32 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.)

1.3.33 Field Control Network

The network used by a field control system.

1.3.34 Field Control System (FCS)

A building control system or utility control system.

1.3.35 Fox Protocol (Niagara Framework)

The protocol used for communication between components in the Niagara Framework. By default, Fox uses TCP port 1911

1.3.36 Functional Profile (LonWorks)

A standard description, defined by LonMark International, of a LonMark Object used to classify and certify devices.

1.3.37 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.

1.3.38 General Purpose Programmable Controller (GPPC) (LonWorks)

Unlike an ASC or AGC, a GPPC is not furnished with a fixed application program and does not have a fixed ProgramID or XIF file. A GPPC can be (re-)programmed, usually using vendor-supplied software. When a change to the program affects the external interface (and the XIF file) the ProgramID will change.

1.3.39 Internetwork (BACnet)

See BACnet Internetwork.

1.3.40 JACE (Niagara Framework)

Java Application Control Engine. See Niagara Framework Supervisory Gateway

1.3.41 LonMark Object (LonWorks)

A collection of network variables, configuration properties, and associated behavior defined by LonMark International and described by a Functional Profile. It defines how information is exchanged between devices on a network (inputs from and outputs to the network).

1.3.42 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.

1.3.43 LonMark (LonWorks)

See LonMark International. Also, a certification issued by LonMark International to CEA-709.1-D devices.

1.3.44 LonMark International (LonWorks)

Standards committee consisting of independent product developers, system integrators and end users dedicated to determining and maintaining the interoperability guidelines for LonWorks. Maintains guidelines for the interoperability of CEA-709.1-D devices and issues the LonMark Certification for CEA-709.1-D devices.

1.3.45 LonWorks (LonWorks)

The term used to refer to the overall technology related to the CEA-709.1-D protocol (sometimes called "LonTalk"), including the protocol itself, network management, interoperability guidelines and products.

1.3.46 LonWorks Network Services (LNS) (LonWorks)

A network management and database standard for CEA-709.1-D devices.

1.3.47 LonWorks Network Services (LNS) Database (LonWorks)

The standard database created and used by LonWorks Network Services (LNS) compatible tools, such as LNS Network Configuration tools.

1.3.48 Modbus

A basic protocol for control network communications generally used in utility control systems. The Modbus protocol standard is maintained by The Modbus Organization.

1.3.49 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.

1.3.50 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.

1.3.51 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.

1.3.52 Network Variable (LonWorks)

See 'Standard Network Variable Type (SNVT)'.

1.3.53 Network Configuration Tool (LonWorks)

The software used to configure the control network and set device configuration properties. This software creates and modifies the control network database (LNS Database).

1.3.54 Niagara Framework

A set of hardware and software specifications for building and utility control owned by Tridium Inc. and licensed to multiple vendors. The Framework consists of front end (M&C) software, web based clients, field level control hardware, and engineering tools. While the Niagara Framework is not adopted by a recognized standards body and does not use an open licensing model, it is sufficiently well-supported by multiple HVAC vendors to be considered a de-facto Open Standard.

1.3.55 Niagara Framework Supervisory Gateway (Niagara Framework)

DDC Hardware component of the Niagara Framework. A typical Niagara architecture has Niagara specific supervisory gateways at the IP level and other (non-Niagara specific) controllers on field networks (TP/FT-10, MS/TP, etc.) beneath the Niagara supervisory gateways. The Niagara specific controllers function as a gateway between the Niagara framework protocol (Fox) and the field network beneath. These supervisory gateways may also be used as general purpose controllers and also have the capability to provide a web-browser based user interface.

Note that different vendors refer to this component by different names. The most common name is "JACE"; other names include "EC-BOS", "FX-40", and "UNC".

1.3.56 Node (LonWorks)

A device that communicates using the CEA-709.1-D protocol and is connected to a CEA-709.1-D network.

1.3.57 Node Address (LonWorks)

The logical address of a node on the network, consisting of a Domain number, Subnet number and Node number. Note that the "Node number" portion of the address is the number assigned to the device during installation and is unique within a subnet. This is not the factory-set unique Node ID (see Node ID).

1.3.58 Node ID (LonWorks)

A unique 48-bit identifier assigned (at the factory) to each CEA-709.1-D device. Sometimes called the Neuron ID.

1.3.59 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.

1.3.60 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.

1.3.61 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.

1.3.62 Point, Network

A value that the M&C Software reads from or writes to a field control network.

1.3.63 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.

1.3.64 Program ID (LonWorks)

An identifier (number) stored in the device (usually EEPROM) that identifies the node manufacturer, functionality of device (application & sequence), transceiver used, and intended device usage.

1.3.65 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.

1.3.66 Protocol Implementation Conformance Statement (PICS)(BACnet)

A document, created by the manufacturer of a device, which describes which potions of the BACnet standard are implemented by a given device.

1.3.67 Repeater

A device that connects two control network segments and retransmits all information received on one side onto the other.

1.3.68 Router (LonWorks)

A device that connects two channels and controls traffic between the channels by retransmitting signals received from one subnet onto the other based on the signal destination. Routers are used to subdivide a control network and to control bandwidth usage.

1.3.69 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.

1.3.70 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.

1.3.71 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).

1.3.72 Service Pin (LonWorks)

A hardware push-button on a device which causes the device to broadcast a message containing its Node ID and Program ID. This broadcast can also be initiated via software.

1.3.73 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.

1.3.74 Standard Configuration Property Type (SCPT) (LonWorks)

Pronounced 'skip-it'. A standard format type (maintained by LonMark International) for Configuration Properties.

1.3.75 Standard Network Variable Type (SNVT) (LonWorks)

Pronounced 'snivet'. A standard format type (maintained by LonMark International) used to define data information transmitted and received by the individual nodes. The term SNVT is used in two ways. Technically it is the acronym for Standard Network Variable Type, and is sometimes used in this manner. However, it is often used to indicate the network variable itself (i.e. it can mean "a network variable of a standard network variable type"). In general, the intended meaning should be clear from the context.

1.3.76 Subnet (LonWorks)

Consists of a logical grouping of up to 127 nodes, where the logical grouping is defined by node addressing. Each subnet is assigned a number which is unique within the Domain. See also Node Address.

1.3.77 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.

1.3.78 Supervisory Gateway

A device that is both a supervisory controller and a gateway.

1.3.79 TP/FT-10 (LonWorks)

A Free Topology Twisted Pair network (at 78 kbps) defined by CEA-709.3. This is the most common media type for a CEA-709.1-D control network.

1.3.80 TP/XF-1250 (LonWorks)

A high speed (1.25 Mbps) twisted pair, doubly-terminated bus network defined by the LonMark Interoperability Guidelines. This media is typically used only as a backbone media to connect multiple TP/FT-10 networks.

1.3.81 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.

1.3.82 User-defined Configuration Property Type (UCPT) (LonWorks)

Pronounced 'u-keep-it'. A Configuration Property format type that is defined by the device manufacturer.

1.3.83 User-defined Network Variable Type (UNVT) (LonWorks)

A network variable format defined by the device manufacturer. Note that UNVTs create non-standard communications (other vendor's devices may not correctly interpret it) and may close the system and therefore are not permitted by this specification.

1.3.84 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.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. 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: 4 hard copies and 2 copies on CDROM. Submit hardcopy drawings on ISO A1 34 by 22 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: 4 hard copies and 2 copies on CDROM. Submit hardcopy drawings must on ISO A1 34 by 22 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: 4 hard copies and 2 copies on CDROM. Submit hardcopy drawings on ISO A1 34 by 22 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.

Enclosure Keys

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.
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. Index and tab bound instructions. 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 two additional copies delivered for archival at the project site. Submit two 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 two additional copies delivered for archival at the project site. Submit two 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 two additional copies delivered for archival at the project site. Submit two 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.

1.5 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).

1.5.1 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.

1.5.2 Sequencing for Activities

The sequencing specified for activities indicates the earliest the activity may begin.

1.5.3 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	days after #1
3	S	Design Drawings	days after #1
4	S	Product Data Sheets	days after #1
5	S	UMCS IP Network Bandwidth Usage Estimate	days after #1
6	S	Pre-construction QC Checklist	days after #1
7	E	Install UMCS	AAO #2 thru #6
8	E	Start-Up and Start-Up Testing	ACO #7
9	S	Post-Construction QC Checklist	days ACO #8
10	S	Computer Software	days ACO #8
11	S	Start-Up and Start-Up Testing Report	days ACO #8
12	S	Draft As-Built Drawings	days ACO #8
13	S	PVT Phase I Procedures	days before scheduled start of #14 and AAO #11
14	E	PVT Phase I	AAO #13 and #12

TABLE I. PROJECT SEQUENCING

ITEM	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
15	S	PVT Phase I Report	days ACO #14
16	S	Preventive Maintenance Work Plan	AAO #11
17	S	O&M Instructions	AAO #11
18	S	Basic Training Documentation	AAO #11 and days before scheduled start of #19
19	E	Basic Training (PVT Phase II)	AAO #16, #17 and #18
20	S	PVT Phase II Report	days ACO #19
21	S	Final As-Built Drawings	days AAO #20
22	S	Advanced Training Documentation	days before schedule start of #23 and AAO #18
23	E	Advanced Training	ACO #19, days AAO #22, and no later than days ACO #19
24	S	Refresher Training Documentation	days before #25 and AAO #18 and #22
25	E	Refresher Training	between and days ACO #19 and AAO #24
26	S	Closeout QC Checklist	ACO #23

1.6 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.

1.7 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.

2.2.2 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. ASHRAE 135 in accordance with ASHRAE 135 Annex J and using only Standard ASHRAE 135 services.

Monitoring and Control (M&C) Controller Hardware must 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 10 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 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

2.3 COMPUTER HARDWARE

For computer hardware furnished under this specification provide standard products of a single manufacturer which advertises service in all 48 contiguous states, and provide only model currently in production. Except for PCI-E cards installed into expansion slots provided in a desktop or server computer in order to meet the requirements of this specification, do not modify computer hardware from the manufacturer configuration.

2.3.1 Server Hardware

Computer Server Hardware (server) will be furnished by the Government

2.3.2 Workstation Hardware (Desktop and Laptop)

The Government will provide the Computer Workstation Hardware (workstation) as indicated.

2.4 COMPUTER SOFTWARE

2.4.1 Operating System (OS)

Provide the latest version of the DISAGold Master Windows Operating System. The Operating System media will be furnished by the Government. The Government will provide the Operating System license.

2.4.2 Office Automation Software

Office Automation Software will be furnished by the Government.

2.4.3 Virus Protection Software

Virus Protection Software will be furnished by the Government.

2.4.4 Disk Imaging (Backup) Software

Disk imaging (backup) software will be furnished by the Government.

2.4.5 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.

2.4.6 BACnet Network Browser

Provide a BACnet Network Browser software that:

a. Can perform full discovery of a ASHRAE 135 system including but not limited to discovery of all ASHRAE 135 devices, the ASHRAE 135 Objects and Properties of each device, and the standard ASHRAE 135 services supported by each device.

b. Can read any ASHRAE 135 Property of any Object in any device. Proprietary Properties may be presented as read without further interpretation.

c. Can write any Standard ASHRAE 135 Property of any Object in any device.

d. Supports segmentation.

e. Supports all of the following BIBBs:

(1) DM-ANM-A (Device Management-Automatic Network Management-A)

(2) DM-ADM-A (Device Management-Automatic Device Management-A)

(3) DM-DDB-A (Device Management-Dynamic Device Binding-A)

(4) DM-DOB-A (Device Management-Dynamic Object Binding-A)

(5) DS-RP-A (Data Sharing-Read Property-A)

(6) DS-RPM-A (Data Sharing-Read Property Multiple-A)

(7) DS-WP-A (Data Sharing-Write Property-A)

2.4.7 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 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.

2.4.7.1 M&C Software License

License the M&C Software as specified. Use of multiple copies of M&C Server software working in coordination and sharing data between them such that they function as, and appear to an operator as, a single M&C Server is permitted to meet these requirements.

2.4.7.1.1 Network Points

Provide M&C Software and licensing to support no less than than 15% extra network points, and to be capable of expansion to support no less than 50,000 network points.

2.4.7.1.2 Web Clients

Provide M&C Software and licensing to support no less than 10 simultaneous web clients with no limit on the total number of web clients. M&C Software must be capable of expansion to support no less than 30 simultaneous web clients.

2.4.7.1.3 Calculations

Provide M&C Software and licensing to support no less than one calculated point for every ten network points (see "Network Points" above).

2.4.7.1.4 Other Points

For installations using M&C Software installed on M&C Controller Hardware (as opposed to Server hardware), provide additional licensing to support additional network points for the communications between portions of the M&C Software installed on different hardware. For example, if the Calculations requirement is performed by M&C Software installed on Controller hardware, the M&C Software must be licensed for additional network points to cover the network points required for communication between the Controller hardware and the Server hardware.

2.4.7.1.5 Alarming

Provide M&C Software and licensing to support the handling (routing) of alarms for no less than 10,000 ASHRAE 135 Alarm Event Notifications.

2.4.7.1.6 Trending

Provide M&C Software and licensing to support a minimum of 8,000 simultaneous trends.

2.4.7.2 M&C Software Update Licensing

In addition to all other licensing requirements, provide M&C Software licensing which includes licensing of the following software updates for a period of no less than 5 years:

a. Security and bug-fix patches issued by the M&C 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.

2.4.7.3 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 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.

2.4.7.4 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 he interface such that any system capable of communicating with that protocol can be used to read and write data from the M&C Software.

2.4.7.5 Point Information

Every point, both network and internal, in the M&C Software must contain the following fields:

2.4.7.5.1 Name

A configurable name used for identification of the point within the M&C Software.

2.4.7.5.2 Description

A configurable description of no less than 80 alpha-numeric characters.

2.4.7.5.3 Value

A field containing the current point value.

2.4.7.5.4 Units

A field containing the engineering units.

2.4.7.5.5 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).

2.4.7.6 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.

2.4.7.7 Browser-Based Graphical User Interface (GUI)

Provide M&C Software which includes a web-browser based (client-server) graphical user interface through which all M&C Software functionality, except for the Graphics Editor, System Display Editor, report configuration, point calculation configuration, and enterprise protocol configuration, is accessible.

Provide graphical user interface web server and web clients meeting the following requirements:

a. The web server must use HTTPS based on the Transport Layer Security (TLS) Protocol in accordance with IETF RFC 7465 using a

Government-furnished certificate.

b. The graphical user interface must be Common Access Card (CAC) enabled: It must support web client authentication using certificates obtained from a Department of Defense Common Access Card (CAC) Smart Card.

c. The web client must operate on any version of Windows currently supported by Microsoft.

d. The web client must function in the most recent three version of Internet Explorer and the most recent three versions of Firefox.

e. The web client must not require a connection to any server other than the M&C Server.

f. The web client must function in a browser with Java, Shockwave, Silverlight, and Flash installed. The client may require a download of mobile code from the M&C Server, but must not require the download of additional browser plug-ins or add-ins and there must be no limit on the number of downloads. The client must not require ActiveX.

2.4.7.8 Passwords

Provide M&C software with user-based access control to M&C functionality. The M&C Software must recognize at least 100 separate users and have at least 4 levels of user permissions. User permission levels (from most restrictive to most permissive) must include:

a. Permission Level 1: View-only access to the graphical user interface.

b. Permission Level 2: Permission Level 1 plus acknowledge alarms and set up (configure) trends and reports.

c. Permission Level 3: Permission Level 2 plus override points and set up (configure) alarms, schedules and demand limiting.

d. Permission Level 4: Permission Level 3 plus create and modify Graphical System Displays using the System Display Editor.

Passwords must not be displayed and must not be logged. The system must maintain a disk file on the server hardware logging all activity of the system. This file must maintain, as a minimum, a record of all operators logged onto the system, alarm acknowledgments, commands issued and all database modifications. If the file format is not plain ASCII text, provide a means to export or convert the file to plain ASCII text. Provide a mechanism for archiving the log files for long term record storage.

2.4.7.9 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.

2.4.7.9.1 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 foot print 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.

2.4.7.9.2 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.

2.4.7.10 Graphic Editor

Provide a fully featured graphics editor and capable of creating custom graphics and graphic symbols for use by the System Display Editor.

2.4.7.11 System Display Editor

Provide a system display editor which allows the user to create, modify, and delete graphic displays. The display editor may have a separate user interface and is not required to be accessible via the web browser interface. Provide a display editor which includes the following functions:

a. Create and save displays. Save an existing or modified display as a new display (i.e. "save as")

b. Group and ungroup graphics, where graphics include both alphanumeric and graphic symbols, and where a grouped graphic is manipulated as a single graphic.

c. Place, locate, resize, move, remove, reposition, rotate and mirror a graphic on a display.

d. Overlay graphics over other graphics and assign depths such that when there are coincident graphics the one on top is visible.

e. Modify graphic properties based on the value of network points and create conditions governing the display of a graphics such that different graphics are visible based on the value of network points or calculated points

f. Integrate real-time data with the display.

g. Establish connecting lines.

h. Establish sources of latest data and location of readouts.

i. Display analog values as specified.

j. Assign conditions which automatically initiate a system display.

k. Include library of display symbols which include: Pump, Motor, Two- and Three-way Valves, Flow Sensing Element, Point and Averaging Temperature Sensors, Pressure Sensor, Humidity Sensor, Single and Double Deck Air Handling Unit, Fan, Chiller, Boiler, Air Compressor, Chilled Water Piping, Steam Piping, Hot Water Piping, Ductwork, Unit Heater, Pressure Reducing Valve, Damper, Electric Meter, Limit Switch, Flow Switch, High- and Low- Point and Averaging Temperature Switches, High- and Low-Pressure Switches, Coil, Solenoid Valve, Filter, Condensing Unit, Cooling Tower, Variable Frequency Drive (VFD), Heat Exchanger, Current Sensing Relays, Generator, Circuit Breaker, Transformer, Tank. Symbols must at a minimum conform to ASHRAE FUN IP where applicable.

2.4.7.12 Scheduling

a. The M&C software must be capable of performing time synchronization and configuring Schedule Objects in ASHRAE 135 field devices in accordance with the DM-MTS-A (Device Management-Manual Time Synchronization-A).

b. The M&C Software must include a scheduling graphic display, accessible via the graphical user interface, with the following fields and functions:

(1) Current date and time.

(2) System identifier(s) and name(s), including location information such as Building name(s) and number(s).

(3) System group. Systems grouped by the user to perform according to a common schedule.

(4) Weekly schedules. For each system, a weekly schedule based on a seven day per week schedule with independent schedules for each day of the week including no less than 6 value changes per day.

(5) Holiday and special event schedules. Support for holiday and special event calendar schedules independent of the daily schedule. Special event schedules include one-time events and recurring events. Scheduling of one-time events include the

beginning and ending dates and times of the event. Holiday and special event schedules must have precedence over device weekly schedules.

2.4.7.13 Alarms

Provide M&C Software meeting the following minimum requirements for alarms:

a. The M&C software must be capable of configuring alarms in ASHRAE 135 field devices in accordance with the B-AWS BIBBs

b. The M&C software must be capable of handling (routing) alarms received as an ASHRAE 135 Alarm Event Notifications.

c. The M&C software must support at least two alarm priority levels: critical and informational. Critical alarms must remain in alarm until acknowledged by an operator and the alarm condition no longer exists; informational alarms must remain in alarm until the alarm condition no longer exists or until the alarm is acknowledged.

d. The creation, modification, and handling (routing) of alarms must be fully accessible and fully adjustable from the graphical user interface.

e. 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.

f. Alarm Notification and Routing: The M&C software must be capable of performing alarm notification and routing functions. Upon receipt of ASHRAE 135 event notification, the M&C software must immediately perform alarm notification and routing according to an assigned routing for that alarm. The M&C software must support at least 100 alarm routes, where an alarm route is a unique combination of any of the following activities:

(1) Generate a pop-up up active clients. The pop-up display must include the Alarm Data. Alarms must be capable of being acknowledged from the pop-up display by operators with sufficient permissions. Pop-up must be displayed until acknowledged.

(2) Send an e-mail message via simple mail transfer protocol (SMTP; RFC 821). The e-mail must contain a configurable message and all alarm data. The e-mail recipient and scripted message must be user configurable for each alarm route.

(3) Print alarms to designated alarm printers. The printed message must be the same as the pop-up message.

g. Alarm Display and Acknowledgement. The M&C software must include an alarm display. Alarms must be available for display at each workstation as shown, along with all associated alarm data. Alarms must be capable of being acknowledged from this display. Multiple alarms must be capable of being acknowledged using a single command. Operator acknowledgment of one alarm must not automatically be considered as acknowledgment of any other alarm nor may it inhibit reporting of subsequent alarms.

h. Alarm Storage and Reports: The M&C software must store each alarm and its associated alarm data to hard disk and retain this information after the alarm no longer exists. The stored data must be sortable, searchable, and printable.

2.4.7.14 Trending

Provide M&C software capable of creating, modifying, uploading and archiving ASHRAE 135 Trend Objects in field devices in accordance with the B-AWS BIBBs .

a. The M&C Software must include a graphical display for trend configuration, creation and deletion accessible through the graphical user interface. Each trend must be user-configurable for:

(1) Point to trend.

(2) Sampling interval: adjustable between 1 second and 1 hour.

(3) Start and Stop Time of Trend: Start and stop times determined by one or more of the following methods:

(a) Start time and stop time

(b) Start time and duration

(c) Start time and number of samples

b. The M&C software must be capable of displaying and printing a graphical representation of each trend, and of multiple trended points on the same graph. The software must be capable of saving trend logs to a file. If the file format is not plain ASCII text in a Comma-Separated-Value (CSV) format, provide a means to export or convert the file to plain ASCII text in a CSV format.

2.4.7.15 Electrical Power Demand Limiting

Provide M&C software which includes demand limiting functionality capable of performing electrical demand limiting such that it can change the occupancy mode or setpoint of field control system hardware via a network point based on a projected demand in order to maintain demand below a configured target. The demand limiting algorithm must incorporate priority levels such that low priority equipment is adjusted before high-priority equipment. The demand limiting algorithm must generate a critical alarm when it begins to impact the system and a critical alarm if the demand target is exceeded.

2.4.7.16 Report Generation

Provide M&C Software capable of generating, saving and printing reports. Dynamic operation of the system must not be interrupted to generate a report. The report must contain the time and date when the samples were taken, and the time and date when the report was generated. The software must be capable of saving reports to a PDF file and to a file compatible with the provided Office Automation Software.

The software must allow for automatic and manual generation of reports. For automatic reports an operator must be able to specify the time the initial report is to be generated, the time interval between reports, end of period, and the output format for the report. Manual report generation must allow for the operator to request at any time the output of any report.

2.4.7.17 Custom Report Generation

Provide M&C software capable of generating custom reports, including but not limited to the following standard reports:

2.4.7.17.1 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.

2.4.7.17.2 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.

2.4.7.17.3 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.

2.4.7.17.4 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.

2.4.7.17.5 Alarm Report

Outstanding alarms by building or unit, including time of occurrence.

2.4.7.17.6 M&C Software Override Report

Points overridden by the M&C Software, including time overridden, and identification of operator overriding the point.

2.4.7.17.7 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.

2.4.7.17.8 Device Offline Report

A report listing all offline devices in all ASHRAE 135 building control systems integrated to the M&C Software.

2.5 RACKS AND ENCLOSURES

2.5.1 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:

2.5.1.1 Outdoors

For enclosures located outdoors, provide enclosures meeting NEMA 250 Type 3 requirements.

2.5.1.2 Mechanical and Electrical Rooms

For enclosures located in mechanical or electrical rooms, provide enclosures meeting NEMA 250 Type 2 requirements.

2.5.1.3 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.

2.5.2 Equipment Racks

Provide standard 19 inch equipment racks compatible with the electronic equipment provided. Racks must be either aluminum or steel with bolted or welded construction. Steel equipment racks must be painted with a flame-retardant paint. Guard rails must be included with each equipment rack and have a copper grounding bar installed and grounded to the earth.

PART 3 EXECUTION

3.1 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.

3.2 DRAWINGS AND CALCULATIONS

3.2.1 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.

3.2.2 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:

a. 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).

b. Manufacturer and model number for each piece of Computer Hardware and Control Hardware.

c. Physical location for each piece of Computer Hardware and Control Hardware.

d. Version and service pack number for all software and for all Control Hardware firmware.

3.2.3 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.

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.

3.3 INSTALLATION REQUIREMENTS

3.3.1 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.

3.3.2 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.

3.3.3 Nameplates

Provide Nameplates for all Control Hardware and all Computer Hardware. Attach Nameplates to the device in a conspicuous location.

3.4 INSTALLATION OF EQUIPMENT

3.4.1 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-C.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.

3.4.2 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.

3.4.3 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.

3.4.4 IP Addresses

For all Control Hardware requiring an IP address on the UMCS IP Network, coordinate with the Government to obtain IP addresses.

3.4.5 Computer Hardware and Software

3.4.5.1 Software Installation

Install software as follows:

a. BACnet Network Browser: Install the BACnet Network Browser software as indicated. Install the BACnet Network Browser on workstation hardware.

b. Monitoring and Control Software: Install the monitoring and control (M&C)software as shown. Except for M&C Software performing Point Calculations or Electrical Peak Demand Limiting, install M&C Software on server hardware. Install M&C Software performing Point Calculations or Electrical Peak Demand Limiting on either server hardware or Monitoring and Control (M&C) Controller Hardware. Install M&C Software in a manner consistent with its B-AWS listing such that it provides all functionality of a B-AWS.

   Provide sufficient computer hardware and M&C Controller Hardware and install M&C Software to support the number of points required in PART 2 (PRODUCTS), regardless of the number of points integrated under this project specification. Note that meeting this requirement may entail the installation of unused hardware or spare point licenses to accommodate the full number of required points in order to allow for integration of future field control systems.

c. M&C Controller Hardware Configuration Software: Install the M&C Controller Hardware Configuration Software on server hardware.

Where software requires connection to an IP device outside of the UMCS, coordinate with Government to obtain access to a Government-furnished server to provide the needed functionality. Do not connect to any device outside of the UMCS without explicit permission from Government.

3.4.5.2 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 and passwords. Coordinate user accounts, passwords and permissions with the Controls 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 Governmentfor 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. Obtain certificate from Government.

3.4.5.3 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 Controls shop supervisor.

3.5 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.

3.5.1 Integration Step 1: Install Control Hardware

Install Control Hardware as specified at the FPOC location 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 Government. 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.

3.5.1.1 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. 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 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.

3.5.1.2 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 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.

3.5.1.3 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.

3.5.2 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.

3.5.2.1 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.

3.5.2.2 Integration of Field Control Systems Via Other (non-ASHRAE 135) Protocols

Perform all actions necessary to make all points as shown on the Points Schedule from the field control system available in the M&C Software.

3.5.3 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.

3.5.3.1 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.

3.5.3.2 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 including overrides, as shown on the Points Schedule and as specified. Label all points on displays with full English language descriptions. Configure user permissions for access to and executions of action using graphic pages. Coordinate user permissions with the Controls shop supervisor

b. Configure 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. Create and configure Schedule Objects in BACnet Supervisory Controllers or in the field control system.

   Create and configure displays for configuration of 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 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 15 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.

3.6 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.

3.7 PERFORMANCE VERIFICATION TEST (PVT)

3.7.1 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.

3.7.2 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.

3.7.3 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.

3.8 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.

3.8.1 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.

3.8.2 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.

3.8.3 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.

3.8.4 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.

3.8.5 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.

3.8.6 Preventive Maintenance Requirements

Prepare a Preventive Maintenance Work Plan as specified.

3.8.6.1 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.

3.8.7 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.

3.8.8 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.

3.8.9 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.

3.9 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.

3.9.1 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:

3.9.1.1 Course Attendance List

Course Attendance List developed in coordination with and signed by the Controls shop supervisor.

3.9.1.2 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.

3.9.2 Basic Training

Conduct a Basic Training course at the project site on the installed system for a period of no less than 5 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.

3.9.3 Advanced Training

Conduct an Advanced Operator Training course at the project site for a period of not less then five 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.

3.9.4 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

QC CHECKLIST		
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 . 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.	|____|

QC CHECKLIST			
4	Connections to non-ASHRAE 135field control systems are via a Gateway from the field control system to ASHRAE 135 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.		|____|

QC CHECKLIST			
14	Basic Operator and Advanced Training courses have been completed.		|____|
______________________________		______________	
	(QC Representative Signature)	(Date)	

-- End of Section --

SECTION 26 00 00.00 20

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

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
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)

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

1.2 RELATED REQUIREMENTS

This section applies to certain sections of Division 02, EXISTING CONDITIONS Divisions 22 and 23, PLUMBING and HEATING VENTILATING AND AIR CONDITIONING. This section applies to all sections of Division 26 and 33, ELECTRICAL and UTILITIES, of this project specification unless specified otherwise in the individual sections. This section has been incorporated into, and thus, does not apply to, and is not referenced in the following sections.

Section 26 12 19.00 40 THREE-PHASE PAD MOUNTED TRANSFORMERS
Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM
Section 26 24 13 SWITCHBOARDS
Section 26 51 00 INTERIOR LIGHTING
Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM

Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION
Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP)

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

c. The technical paragraphs referred to herein are those paragraphs in PART 2 - PRODUCTS and PART 3 - EXECUTION of the technical sections that describe products, systems, installation procedures, equipment, and test methods.

1.4 ELECTRICAL CHARACTERISTICS

Electrical characteristics for this project shall be 7.2 kV primary, three phase, four wire, 60 Hz, and 480Y/277-and 208Y/208- volts secondary, three phase, four wire. Final connections to the power distribution system at the existing pad mounted switch shall be made by the Contractor as directed by the Contracting Officer.

1.5 ADDITIONAL SUBMITTALS INFORMATION

Submittals required in other sections that refer to this section must conform to the following additional requirements as applicable.

1.5.1 Shop Drawings (SD-02)

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.5.2 Product Data (SD-03)

Submittal shall include performance and characteristic curves.

1.6 QUALITY ASSURANCE

1.6.1 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.

1.6.2 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. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

1.6.2.1 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.

1.6.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 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.

1.8 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

a. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.

b. Start up, proper adjustment, operating, lubrication, and shutdown procedures.

c. Safety precautions.

d. The procedure in the event of equipment failure.

e. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.9 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.

1.10 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified in the technical sections or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

1.11 WARNING SIGNS

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28 or IEEE C57.12.29, such as for pad-mounted transformers, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

1.12 ELECTRICAL REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.13 INSTRUCTION TO GOVERNMENT PERSONNEL

Where specified in the technical sections, furnish the services of competent instructors to give full instruction to designated Government personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. 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 equipment or system. When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instructions to acquaint the operating personnel with the changes or modifications.

PART 2 PRODUCTS

2.1 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.1 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 .

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, but space the signs a maximum of 30 feet apart.

-- End of Section --

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SECTION 26 05 00.00 40

COMMON WORK RESULTS FOR ELECTRICAL

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 INDUSTRIES ALLIANCE (EIA)

EIA 480	(1981) Toggle Switches

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL CODE COUNCIL (ICC)

ICC/ANSI A117.1	(2009) Accessible and Usable Buildings and Facilities

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2015) American National Standard for Electrical Metallic Tubing (EMT)
ANSI Z535.1	(2017) Safety Colors
ANSI/NEMA OS 1	(2013) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA 250	(2018) Enclosures for Electrical Equipment

	(1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
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 PB 1	(2011) Panelboards
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	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2016) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2015) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2016) Wiring Devices Dimensions Specifications

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 70E	(2018; TIA 18-1; TIA 81-2) Standard for Electrical Safety in the Workplace

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jan 2020) UL Standard for Safety Flexible Metal Conduit
UL 5	(2016) UL Standard for Safety Surface

	Metal Raceways and Fittings
UL 5A	(2015) Nonmetallic Surface Raceways and Fittings
UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 44	(2018) 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 Oct 2019) UL Standard for Safety Panelboards
UL 83	(2017) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 198M	(2018) UL Standard for Mine-Duty Fuses
UL 360	(2013; Reprint Nov 2018) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 486A-486B	(2018) UL Standard for Safety Wire Connectors
UL 486C	(2019) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Jan 2020) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017) UL Standard for Safety Specialty Transformers
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint Nov 2014) 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 Nov 2018) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings

UL 797	(2007; Reprint Mar 2017) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 817	(2015; Reprint May 2017) UL Standard for Safety Cord Sets and Power-Supply Cords
UL 869A	(2006) 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 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2014; Reprint Jul 2017) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 4248-1	(2017) 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

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Marking Strips; G

SD-03 Product Data

Conduits and Raceways; G

Wire and Cable; G

Splices and Connectors; G

Switches; G

Receptacles; G

Outlet Boxes, Pull Boxes and Junction Boxes; G

Circuit Breakers; G

Panelboards; G

Dry-Type Distribution Transformers; G

Device Plates; G

SD-06 Test Reports

Continuity Test; G

Phase-Rotation Tests; G

Insulation Resistance Test; G

600-Volt Wiring Test; G

Transformer Tests; G

Ground-Fault Receptacle Test; G

Insulation-Resistance Test; G

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

1.4 QUALITY CONTROL

1.4.1 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. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

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 which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product 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.

PART 2 PRODUCTS

2.1 EQUIPMENT

Provide the standard cataloged materials and equipment of manufacturers regularly engaged in the manufacture of the products. For material, equipment, and fixture lists submittals, show manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

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.

2.1.1 Conduits and Raceways

2.1.1.1 Rigid Steel Conduit

Provide hot dipped galvanized rigid steel conduit complying with NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable. Except where installed underground, or in corrosive areas, provide polyvinylchloride (PVC), or protect from corrosion by painting with bitumastic coating or wrapping with corrosion inhibiting tape..

Use threaded fittings for rigid steel conduit.

Use solid gaskets. Ensure conduit fittings with blank covers have gaskets, except in clean, dry areas or at the lowest point of a conduit run where drainage is required.

Provide covers with captive screws and are accessible after the work has been completed.

2.1.1.2 Electrical Metallic Tubing (EMT)

Ensure EMT is in accordance with UL 797, UL 5, and ANSI C80.3 and is zinc coated steel. Provide zinc-coated couplings and connectors that are raintight, gland compression type with insulated throat. Crimp, spring, or setscrew type fittings are not acceptable.

2.1.1.3 Flexible Metallic Conduit

Ensure flexible metallic conduit is galvanized steel and complies with UL 1 and UL 360.

Ensure fittings for flexible metallic conduit are specifically designed for such conduit.

Provide liquidtight flexible metallic conduit with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosive fumes.

Ensure fittings for liquidtight flexible metallic conduit are specifically designed for such conduit.

2.1.1.4 Intermediate Metal Conduit

Ensure intermediate metal conduit is galvanized steel and complies with UL 1242, NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable.

2.1.1.5 Rigid Nonmetallic Conduit

Ensure rigid nonmetallic conduit complies with NEMA TC 2, NEMA TC 3, and UL 651 as applicable with a wall thickness not less than Schedule 40.

2.1.1.6 Surface Metal Raceway

Ensure surface metal raceways and multi-outlet assemblies conform to NFPA 70, and have receptacles conforming to NEMA WD 1, Type 5-20R.

UL 5, two-piece painted steel, totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Provide receptacles as specified herein, spaced a minimum of one every 18 inches.

2.1.1.7 Surface Nonmetallic Raceway

UL 5A, nonmetallic totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Provide receptacles as specified herein, spaced a minimum of one every 18 inches.

2.1.2 Wireways

Ensure wireways and auxiliary gutters are a minimum 4 by 4-inch trade size conforming to UL 870.

UL 870. Material: steel galvanized 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- or screw-cover NEMA 1 or 3R enclosure as required per NEMA ICS 6.

2.1.3 Cable Trays

NEMA VE 1. Provide the following:

a. Cable trays: form a wireway system, with a nominal depth as indicated.

b. Cable trays: constructed of aluminum.

c. Cable trays: include splice and end plates, dropouts, and miscellaneous hardware.

d. Edges, fittings, and hardware: finished free from burrs and sharp edges.

e. Fittings: ensure not less than load-carrying ability of straight tray sections and have manufacturer's minimum standard radius.

f. Radius of bends 12 inches.

Provide basket-type cable trays size as indicated with maximum wire mesh spacing of 2 by 4 inch.

Provide ladder-type cable trays size as indicated with maximum rung spacing of 12 inches.

2.1.4 Outlet Boxes, Pull Boxes and Junction Boxes

Ensure outlet boxes for use with conduit systems are in accordance with NEMA FB 1 UL 514A, UL 514B, UL 514C and ANSI/NEMA OS 1 and are not less than 1-1/2 inches deep. Furnish all pull and junction boxes with screw-fastened covers.

2.1.5 Panelboards

Provide panelboards in accordance with NEMA PB 1, UL 67, and UL 50. Ensure panelboards for use as service equipment are also in accordance with UL 869A. Ensure panelboards have current rating, number of phases, and number of wires as indicated or specified herein. Ensure panelboards are rated for the voltages and phases indicated on the plans, 60- or 400-hertz. Ensure each panelboard, as a complete unit, has a short-circuit current rating equal to or greater than the integrated equipment rating indicated, but in no case less than 10,000 amperes symmetrical.

Provide panelboards with bolt-on circuit breakers only. Use of plug-in style breaker is not permitted. Ensure panelboards are designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining required clearance. Provide main lugs or main circuit breakers mounted "above" or "below" branch breakers with current ratings as indicated. Use of sub-feed breakers is not acceptable unless specifically indicated otherwise. Where "space only" is indicated, make provisions for future installation of breakers.

Submit detail drawings and manufacturer's standard product data for panelboards. Detail drawings consist of fabrication and assembly drawings for all parts of the work in sufficient detail to verify conformity with all requirements. Ensure drawings for panelboards indicate details of bus layout, overall physical features, dimensions, ratings, service requirements, and weights of equipment.

Providetinned copper buses of the rating indicated, with main lugs or main circuit breaker. Provide all panelboards for use on grounded ac systems with a separate grounding bus in accordance with UL 67 bonded to the panelboard enclosure. Ensure grounding bus is a solid bus bar of rectangular cross section equipped with binding screws for the connection of equipment grounding conductors. Provide three-phase, four-wire and single-phase, three-wire panelboards with an isolated full-capacity bus providing spaces for single-pole circuit breaker switches and spaces indicated as spare.

Provide bus bar connections to the branch circuit breakers that are the "distributed phase" or "phase sequence" type. Ensure single-phase, three-wire panelboard busing is such that when any two adjacent single-pole breakers are connected to opposite phases, two-pole breakers can be installed in any location. Ensure that three-phase, four-wire panelboard busing is such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two- or three-pole breakers can be installed at any location. Ensure current-carrying parts of the bus assembly are plated.

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.

2.1.5.1 Circuit Breakers

Provide circuit breakers that conform to UL 489 and NEMA AB 3 with frame a trip ratings as indicated.

Provide bolt-on type, molded-case, manually operated, trip-free circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection. Completely enclose circuit breakers in a molded case, with a factory-sealed, calibrated sensing element to prevent tampering. Plug-in type, tandem, and half-size circuit breakers are not permitted.

Provide inverse-time-delay thermal-overload protection and instantaneous magnetic short-circuit protection. Provide an instantaneous electronic tripping element that is adjustable and accessible from the front of the breaker on frame sizes larger than 250 ampere. Provide circuit breakers with frame sizes 250 ampere and larger with solid-state trip units equipped with adjustable long-time, short-timeandground-fault settings in addition to instantaneous.

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 A and that conform to NEMA AB 3. Series rating of circuit breakers or overcurrent protective devices to achieve indicated interrupt rating is not permitted.

Provide the common-trip-type multipole circuit breakers having a single operating handle and a two-position on/off indication. Provide circuit breakers with temperature compensation for operation in an ambient temperature of 104 degrees F. Provide circuit breakers that have root mean square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied. Interrupting ratings may have selective-type tripping (time delay, magnetic, thermal, or ground fault).

Provide a phenolic-composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required to meet lock-out/tag-out requirements of NFPA 70E.

2.1.6 Dry-Type Distribution Transformers

2.1.6.1 General Requirements

Ensure that general purpose dry-type transformers with windings 600 volts or less are two-winding, 60 hertz, and self-cooled in accordance with UL 506 and UL 1561. Ensure windings have a minimum of two 2-1/2-percent taps above and below nominal voltage.

Provide transformers in NEMA 1 enclosure.

Transformer insulation system:

a. 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 150 degrees C under full-rated load in maximum ambient of 40 degrees C.

b. 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 150 degrees C under full-rated load in maximum ambient of 40 degrees C.

2.1.6.2 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.

2.2 MATERIALS

2.2.1 Wire And Cable

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.

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.

Ensure connectors used in wire systems comply with UL 486A-486B and UL 486C as applicable.

Ensure conductors installed in plenums are marked plenum rated.

2.2.1.1 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 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 lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.2.1.2 Wire and Cable for 400 Hertz (Hz) Circuits

Insulated copper conductors.

2.2.1.3 Cord Sets and Power-Supply Cords

UL 817.

2.2.2 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: satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.

e. Screws: machine-type with countersunk heads in color to match finish of plate.

f. Sectional type device plates are not be permitted.

g. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.2.3 Switches

2.2.3.1 Safety Switches

Ensure safety switches comply with NEMA KS 1, and are the heavy-duty type with enclosure, voltage, current rating, number of poles, and fusing as indicated on the drawings. Ensure fused switch fuse holders comply with UL 4248-1. Ensure switch construction is such that, when the switch handle in the "ON" position, the cover or door cannot be opened. Cover release device is coinproof and so constructed that an external tool is used to open the cover. Make provisions to lock the handle in the "OFF" position. Ensure the switch is not capable of being locked in the "ON" position.

Provide switches of the quick-make, quick-break type and terminal lugs for use with copper conductors.

Ensure safety color coding for identification of safety switches conforms to ANSI Z535.1.

2.2.3.2 Toggle Switches

Ensure toggle switches comply with EIA 480, NEMA WD 1, and UL 20 control Light Emitting Diode (LED), and fluorescent lighting fixtures and are the heavy duty, general purpose, noninterchangeable flush-type.

Provide commercial grade toggle switches, single -pole, three or four-way two-position devices rated 20 amperes at 120/277 volts, 60 hertz alternating current (ac) only.

Ensure all toggle switches are products of the same manufacturer.

2.2.4 Fuses

NEMA FU 1. Provide complete set of fuses for each fusible switch. Coordinate time-current characteristics curves of fuses serving motors or connected in series with circuit breakers for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

2.2.4.1 Fuseholders

Provide in accordance with UL 4248-1.

2.2.4.2 Cartridge, Current Limiting Type (Class R)

UL 198M, Class RK-1. Provide only Class R associated fuseholders in accordance with UL 4248-12.

2.2.4.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 198M, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.2.4.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 198M, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.2.5 Receptacles

Provide the following:

a. UL 498, hard use (also designated heavy-duty), grounding-type.

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.

2.2.5.1 Switched Duplex Receptacles

Provide separate terminals for each ungrounded pole. Top receptacle: switched when installed.

2.2.5.2 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations." Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, polycarbonate, UV resistant/stabilized cover plate.

2.2.5.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak of 6 milliamperes or greater 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.

2.2.5.4 Special Purpose Receptacles

Receptacles serving indicated equipment are special purpose. Provide in ratings indicated. Furnish one matching plug with each receptacle.

2.2.5.5 Plugs

Provide heavy-duty, rubber-covered three-, four-, or five-wire cord of required size, install plugs thereon, and attach to equipment. Provide UL listed plugs with receptacles, complete with grounding blades. Where equipment is not available, turn over plugs and cord assemblies to the Government.

2.2.6 Manufacturer's Nameplate

Ensure each item of equipment has 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 is not acceptable.

2.2.7 Warning Signs

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. Enclosure integrity to conform with IEEE C57.12.28, such as for pad-mounted transformers. Provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Provide decal signs with nominal dimensions of 7 by 10 inches. Print the legend "DANGER HIGH VOLTAGE" in two lines of nominal 2 inch high letters. Show the word "DANGER" in white letters on a red background and the words "HIGH VOLTAGE" in black letters on a white background.

2.2.8 Firestopping Materials

Provide firestopping around electrical penetrations in accordance with Section 07 84 00, FIRESTOPPING.

2.2.9 Surge Protective Devices

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entranceswitchboard and any other indicated panelboards. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker.

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)
- Phase to ground (L-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, L-G, and N-G Voltage Protection Rating:

600V 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
1,200V for 480Y/277V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120% of nominal voltage for 240 volts and below; 115% of nominal voltage above 240 volts to 480 volts.

PART 3 EXECUTION

3.1 PREPARATION

Submit manufacturer's instructions including special provisions required to install equipment components and system packages. Special provisions include impedances, hazards and safety precautions.

Clean and paint conduit, supports, fittings, cabinets, pull boxes, and racks as specified in Section 09 90 00 PAINTS AND COATINGS.

Protect metallic materials against corrosion. Provide equipment enclosures with the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and abrasive action), and all outdoor installations, refer to

Section 09 90 00 PAINTS AND COATINGS. Do not use aluminum when in contact with earth or concrete and, where connected to dissimilar metal, protect by using approved fittings and treatment. Except where other equivalent protective treatment is specifically approved in writing, provide hot-dip galvanized ferrous metals for items such as, anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous items not made of corrosion-resistant steel.

3.2 INSTALLATION

3.2.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.2.2 Hazardous Locations

Perform work in hazardous locations, as defined by NFPA 70, in strict accordance with NFPA 70 for particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by NFPA 70. Provide conduit with tapered threads.

3.2.3 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.2.4 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.

3.2.5 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.

3.2.5.1 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.

3.2.5.2 Metal Clad Cable

Install in accordance with NFPA 70, Type MC cable.

3.2.5.3 Armored Cable

Install in accordance with NFPA 70, Type AC cable.

3.2.6 Conduits, Raceways and Fittings

Ensure that conduit runs between outlet and outlet, between fitting and fitting, or between outlet and fitting does not contain more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting.

Do not install crushed or deformed conduit. Avoid trapped conduit runs where possible. Take care to prevent the lodgment of foreign material in the conduit, boxes, fittings, and equipment during the course of construction. Clear any clogged conduit of obstructions or replace conduit.

Conduit and raceway runs concealed in or behind walls, above ceilings, or exposed on walls and ceilings 5 feet or more above finished floors and not subject to mechanical damage may be electrical metallic tubing (EMT).

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.3.2.6.1 Rigid Steel Conduit

Make field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use long radius conduit for elbows larger than 2-1/2 inches.

Provide a flush coupling for all conduit stubbed-up through concrete floors for connections to free-standing equipment with the exception of motor-control centers, cubicles, and other such items of equipment, when the floor slab is of sufficient thickness. Otherwise, provide a floor box set flush with the finished floor. For conduits installed for future use, terminate with a coupling and plug; set flush with the floor.

3.2.6.2 Electrical Metallic Tubing (EMT)

Ground EMT in accordance with NFPA 70, using pressure grounding connectors especially designed for EMT.

3.2.6.3 Flexible Metallic Conduit

Use flexible metallic conduit to connect recessed fixtures from outlet boxes in ceilings, transformers, and other approved assemblies.

Use bonding wires in flexible conduit as specified in NFPA 70, for all circuits. Flexible conduit is not considered a ground conductor.

Make electrical connections to vibration-isolated equipment with flexible metallic conduit.

Use liquidtight flexible metallic conduit in wet and oily locations and to complete the connection to motor-driven equipment.

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 liquidtight flexible conduit in wet and damp locations and in fire pump rooms for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.2.6.4 Intermediate Conduit

Make all field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use intermediate metal conduit only for indoor installations.

3.2.6.5 Rigid Nonmetallic Conduit

Install a green insulated copper grounding conductor in conduit with conductors and solidly connect to ground at each end. Size grounding wires in accordance with NFPA 70.

3.2.6.6 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40; or fiberglass. Convert nonmetallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before rising through floor slab. Plastic coating: extend minimum 6 inches above floor.

3.2.6.7 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.2.6.8 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.

3.2.6.9 Conduit Installed Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab.

3.2.6.10 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. 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 and/or 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.

3.2.6.11 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.

3.2.6.12 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. 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. Where conduit crosses building expansion joints, provide suitable 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.

3.2.6.13 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.

3.2.6.14 Wireway and Auxiliary Gutter

Bolt together straight sections and fittings to provide a rigid, mechanical connection and electrical continuity. Close dead ends of wireways and auxiliary gutters. Plug all unused conduit openings.

Support wireways for overhead distribution and control circuits at maximum 5 -foot intervals.

Ensure auxiliary gutters used to supplement wiring spaces for equipment not contained in a single enclosure contains no switches, overcurrent devices, appliances, or apparatus and is not more than 30 feet long.

3.2.6.15 Surface Raceways and Assemblies

Mount surface raceways plumb and level, with the base and cover secured. Minimum circuit run is three-wire, with one wire designated as ground.

3.2.6.16 Cable Trays

Support cable trays from ceiling hangers, equipment bays, or floor or wall supports. Cable trays may be mounted on equipment racks. Provide support when the free end extends beyond 3 feet. Maximum support spacing is 6 feet. Support trays 10-inches wide or less by two hangers. Support trays greater than 10 inches wide by two hangers. Bond cable trays at splices.

3.2.7 Wiring

Color code feeder and branch circuit conductors as follows:

CONDUCTOR	COLOR AC
Phase A	Black (208VAC); Brown (480VAC)
Phase B	Red (208VAC); Orange (480VAC)
Phase C	Blue (208VAC); Yellow (480VAC)
Neutral	White (208VAC); Natural Gray (480VAC)
Equipment Grounds	Green

Use conductors up to and including AWG No. 2 that are manufactured with colored insulating materials. For conductors larger than AWG No. 2, have ends identified with color plastic tape in outlet, pull, or junction boxes.

Splice in accordance with the NFPA 70. Provide conductor identification within each enclosure where a tap, splice, or termination is made and at the equipment terminal of each conductor. Match terminal and conductor identification as indicated.

Where several feeders pass through a common pullbox, tag the feeders to clearly indicate the electrical characteristics, circuit number, and panel designation.

3.2.8 Wiring Devices

3.2.8.1 Wall Switches and Receptacles

Install wall switches and receptacles so that when device plates are applied, the plates are aligned vertically to within 1/16 inch.

Bond ground terminal of each flush-mounted receptacle to the outlet box with an approved green bonding jumper when used with dry wall type construction.

3.2.8.2 Device Plates

Ensure device plates for switches are suitably engraved with a description of the loads when not within sight of the loads controlled.

Mark device plates and receptacle cover plates for receptacles other than 125-volt, single-phase, duplex, convenience outlets. Show the circuit number, voltage, frequency, phasing, and amperage available at the receptacle. Use self-adhesive labels having 1/4 inch embossed letters.

Similarly mark device plates for convenience outlets indicating the supply panel and circuit number.

3.2.9 Splices and Connectors

Make all splices in AWG No. 8 and smaller with approved insulated electrical type indentor crimp-type connectors and compression tools.

Make all splices in AWG No. 6 and larger with indentor crimp-type connectors and compression tools. Wrap joints with an insulating tape that has an insulation and temperature rating equivalent to that of the conductor.

3.2.10 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.

3.2.10.1 Marking Strips

Provide marking strips 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.

3.2.11 Safety Switches

Securely fasten switches to the supporting structure or wall, utilizing a minimum of four 1/4 inch bolts. Do not use sheet metal screws and small machine screws for mounting. Do not mount switches in an inaccessible location or where the passageway to the switch may become obstructed. Mounting height 5 feet above floor level, when possible.

3.2.12 Boxes and Fittings

Provide pullboxes where necessary in the conduit system to facilitate conductor installation. For conduit runs longer than 100 feet or with more than three right-angle bends, install a pullbox at a convenient intermediate location.

Securely mount boxes and enclosures to the building structure using supports that are independent of the conduit entering or leaving the boxes.

Select the mounting height of wall-mounted outlet and switch boxes, as measured between the bottom of the box and the finished floor, in accordance with ICC/ANSI A117.1 and as follows, unless otherwise indicated:

LOCATION	MOUNTING HEIGHT (inches)
Receptacles in offices	30
Receptacles in corridors	30
Receptacles in shops and laboratories	48
Receptacles in rest rooms	48
Switches for light control	48

3.2.13 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.

3.2.14 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.2.15 Panelboards

Securely mount panelboards so that the top operating handle does not exceed 72-inches above the finished floor. Do not mount equipment within 36-inches of the front of the panel. Ensure directory card information is complete and legible.

3.2.16 Dry-Type Distribution Transformers

Connect dry-type transformers with flexible metallic conduit.

3.2.17 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.

3.2.18 Field Fabricated Nameplates

Ensure nameplates conform to 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 identifies the function and, when applicable, the position. Provide nameplates that are melamine plastic, 0.125-inch thick, white with black center core and a matte finish surface . Accurately align lettering and engrave into the core. Minimum size of nameplates is 1 by 2.5 inches. Lettering is a minimum of 0.25-inch high normal block style.

3.2.19 Identification Plates and Warnings

Provide identification plates for lighting and power panelboards, motor control centers, all line voltage heating and ventilating control panels, fire detector and sprinkler alarms, door bells, pilot lights, disconnect switches, manual starting switches, and magnetic starters. Attach identification plates to process control devices and pilot lights.

Install identification plates for all line voltage enclosed circuit breakers, identifying the equipment served, voltage, phase(s) and power source. For circuits 480 volts and above, install conspicuously located warning signs in accordance with OSHA requirements.

3.3 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.

3.4 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.5 FIELD APPLIED MOUNTING

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.

3.6 FIELD QUALITY CONTROL

After completion of the installation and splicing, and prior to energizing the conductors, perform wire and cable continuity and insulation tests as herein specified before the conductors are energized.

Provide all necessary test equipment, labor, and personnel to perform the tests, as herein specified.

Isolate completely all wire and cable from all extraneous electrical connections at cable terminations and joints. Use substation and switchboard feeder breakers, disconnects in combination motor starters, circuit breakers in panel boards, and other disconnecting devices to isolate the circuits under test.

Perform insulation-resistance test on each field-installed conductor with respect to ground and adjacent conductors. Applied potential is 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Take readings after 1 minute and until the reading is constant for 15 seconds. Minimum insulation-resistance values is not less than 25 Megohms for 300 volt rated cable and 100 Megohms for 600 volt rated cable. For circuits with conductor sizes AWG No. 8 and smaller insulation resistance testing is not required.

Perform continuity test to insure correct cable connection end-to-end (i.e correct phase conductor, grounded conductor, and grounding conductor wiring). Repair and verify any damages to existing or new electrical equipment resulting from mis-wiring. Receive approval for all repairs prior to commencement of the repair.

Conduct phase-rotation tests on all three-phase circuits using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment in a clockwise direction, facing the source.

Perform 600-volt wiring test on 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 approximately 500 volts to provide direct reading of resistance. Minimum resistance: 250,000 ohms.

Perform the standard, not optional, transformer 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.

Perform ground-fault receptacle test for ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed.

Submit test reports in accordance with referenced standards in this section.

Final acceptance requires the successful performance of wire and cable under test. Do not energize any conductor until the final test reports are reviewed and approved.

-- End of Section --

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SECTION 26 05 13.00 40

MEDIUM-VOLTAGE CABLES

PART 1 GENERAL

Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION 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.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS1 (2012) Impregnated-Paper-Insulated, Metallic Sheathed Cable, Solid Type

AEIC CS8 (2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM B3 (2013) Standard Specification for Soft or Annealed Copper Wire

ASTM B8 (2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM D746 (2014) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 48 (2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV

IEEE 400.2 (2013) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)

IEEE 404 (2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2016) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
ANSI/NEMA WC 71/ICEA S-96-659	(2014) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA WC 70	(2009) Power Cable Rated 2000 V or Less for the Distribution of Electrical Energy--S95-658
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

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 70B	(2019) Recommended Practice for Electrical Equipment Maintenance
NFPA 70E	(2018; TIA 18-1; TIA 81-2) Standard for Electrical Safety in the Workplace

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-228	(2014; Rev A; Notice 1) Test Methods for Cable and Wire, Insulated

1.2 DEFINITIONS

Medium-voltage power cables include all cables rated above 600 volts up to 35,000 volts.

1.3 ADMINISTRATIVE REQUIREMENTS

1.3.1 Pre-Installation Meetings

No later than 30 days of Contract Award, coordinate with the Contracting Officer to schedule a pre-installation meeting. Submit the following for review and approval prior to the meeting:

a. Pulling Plan including calculations of pulling tension and side wall pressure anticipated, and the maximum allowable pulling tension for each pull. Do not perform any pull until Government reviews and approves the pulling plan.

b. Splicer/Terminator Certifications

c. List of Splices and Terminations to be Installed by Splicer/Terminator

d. Manufacturer's catalog data for all cables, cable supports and fittings, cable tags, fireproof tape, splice kits, terminations, and any other product data required to complete the work.

e. Certificates showing that the cable manufacturer has made factory-conducted tests on each shipping length (reel) of cable. Include certified copies of test data showing conformance with the referenced standards and approval prior to delivery of cable.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

List of Splices and Terminations to be Installed by Splicer/Terminator; G

SD-02 Shop Drawings

Pulling Plan; G

SD-03 Product Data

Single-Conductor Shielded Cables; G

Single-Conductor Nonshielded Cables; G

Cable Supports and Fittings; G

Polyethylene Cable Tags; G

Fireproof Tape; G

Terminations; G

Polyethylene Cable Tags; G

SD-06 Test Reports

Field Testing; G

Qualification Test Reports; G

Radiographic Tests; G

SD-07 Certificates

Splicer/Terminator Certifications; G

SD-08 Manufacturer's Instructions

Medium-Voltage Power Cables; G

Terminations; G

1.5 QUALITY CONTROL

1.5.1 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. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.5.2 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 which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product 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.

Qualifications`

Verify personnel performing Medium Voltage (MV) splicing or terminations have 5 years minimum experience in cable splicing and terminations of the type used in this project. Submit splicer/terminator certifications issued by the cable splice and termination manufacturer who has examined and tested a test splice or termination of each type required by this contract for each cable splicer. Ensure the certification identifies which splices and terminations it applies to. Submit each splice or termination performed by individuals without manufacturer's certification to the manufacturer for testing and subsequent certification.

Once a splice or termination has been started by a splicer, ensure the same splicer completes that particular splice, and that each termination and splice is started and completed in one continuous work period.

Maintain and submit a list of splices and terminations to be installed by splicer/terminator. Ensure the list includes the following for each splice or termination completed.

a. Name of splicer/terminator.

b. Date splice or termination was performed.

c. Location of splice or termination. For terminations at equipment indicate equipment number as required to completely define the location.

1.6 DELIVERY, STORAGE, AND HANDLING

Ship cables on reels in a way that protects the cable from mechanical injury. Hermetically seal end of each cable length using heat-shrinkable molded cable end caps to exclude moisture and securely attached to the reel..

Make the minimum reel drum diameter 14 times the overall diameter of the cable. Ensure that each cable length is installed with a pulling eye installed by the manufacturer, for installation in ducts, manholes, and utility tunnels.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide medium-voltage power cables including multiple- and single-conductor cables rated 15,000 volts, ungrounded neutral, on 4,800 -volt three-phase, 60-hertz, phase-to-phase, for grounded and ungrounded neutral systems.

Provide conductor cable assemblies consisting of:

a. Conductor core with an extruded semiconductor shield over the conductors

b. Insulation

c. A polyethylene (PE) jacket.

2.2 EQUIPMENT

Ensure that ethylene-propylene rubber and cross-linked polyethylene-insulated conductors are lead-free.

2.2.1 Single-Conductor Shielded Cables

2.2.1.1 Cross-Linked Polyethylene with PVC Jacket

Provide single-conductor, polyethylene-insulated, PVC-jacketed, shielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC CS8.

2.2.2 Single-Conductor Nonshielded Cables

2.2.2.1 Cross-Linked Polyethylene

Provide single-conductor, cross-linked polyethylene-insulated, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, and NEMA WC 74/ICEA S-93-639.

2.2.3 Terminations

Provide Class 1 terminations per IEEE 48.

2.2.4 Cable Supports and Fittings

Provide cable supports, related fittings, and accessories for use in corrosive underground locations, such as manholes and utility tunnels, with a factory-applied coating of PVC of at least 20 mils thick. Provide PVC coated items that have a uniform thickness and are free of blisters, breaks, and holidays. Provide PVC compound that conforms to ASTM D746.

Provide cable racks, cable tray supports and related fittings that are UL-listed heavy-duty nonmetallic polycarbonate.

2.2.5 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 4500 pounds per square inch, and are 0.035-inch thick, non-corrosive non-conductive. Ensure tags are resistive to acids, alkalis, organic solvents, salt water, and are distortion resistant to 300 degrees F. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ensure ties have a minimum loop tensile strength of 175 pounds. Provide cable tags with block letters, numbers, and symbols 1 inch high on a yellow background. Ensure letters, numbers, and symbols do not fall off or change positions regardless of the cable tags orientation.

2.2.6 Fireproof Tape

Provide fireproof tape approximately 30 mils thick by 3 inches wide, consisting of a flexible, unsupported elastomer that expands in fire to provide a thick char buildup between the flame and the cable. Ensure the tape does not give off a smoke when subjected to flames or support combustion. Also, ensure tape does not deteriorate when subjected to oil, water, gases, salt water, sewage and fungus.

2.3 MATERIALS

2.3.1 Conductors

Ensure that conductors conform to the applicable requirements of NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639.

Ensure that conductors are solid copper core conforming to ASTM B3 and ASTM B8 and that they are bare, or tin-alloy-coated, according to the type of insulation used. Do not intermix copper and aluminum conductors in the same raceway.

Provide Class B stranded conductors.

2.3.2 Insulation

Ensure the provided cables are rated for minimum 221 degrees F continuous conductor temperature and 266 degrees F emergency overload.

Provide cables with 133 percent insulation. Ensure insulation thickness is in accordance with the following:

Voltage Rating (kV)	Insulation Level (%)	Typical Insulation Thickness	
		mm	mils
15	100	4.45	175
	133	5.59	220
	173	6.6	260

2.3.3 Cable Identification

Provide cables with printing on the outer jacket showing the cable type, name of the manufacturer, the year in which the cable was manufactured, sequential cable reel length markings and a unique number for identification purposes. Closely group the information on the tape at 6 foot maximum intervals to permit complete identification.

2.3.4 Non-metallic Insulation Shield

Provide extruded insulation shield made of an extruded thermoset material compatible with the insulation and jacket. Ensure insulation shield is applied directly over and bonded to the insulation, and complies with AEIC CS8.

2.3.5 Concentric Neutral Shield

Provide copper wires helically applied over the insulation shield, where the minimum total cross sectional area (of the shield wires) is full core conductor for the cable. Minimum size of an individual shield wire is No. 14 AWG.

2.3.6 Jacket

Provide polyvinyl-chloride (PVC) jacketed cable extruded over the cable to a minimum thickness of 80 mils.

2.4 TESTS, INSPECTIONS, AND VERIFICATIONS

2.4.1 FACTORY TESTING

Submit certified evidence that the cable manufacturer has made factory-conducted tests on each shipping length (reel) of cable. Submit certified copies of test data in accordance with applicable provisions of the referenced standard. Include in tests on each length of cable to include:

(1) Conductor Resistance

(2) Accelerated Water Absorption Test

(3) Water Immersion Test

(4) Ionization

(5) High-Voltage

(6) Partial Discharge Test

Contracting Officer or designee has the option of witnessing required factory testing at no additional cost. Provide a schedule of manufacturing and testing in advance to permit such witnessing, if requested.

Submit certified qualification test reports in accordance with AEIC CS8 made in accordance with the applicable referenced standards. Ensure certified copies of test data show conformance to the requirements of referenced standards and submit for approval prior to shipment of the cable.

Prior to manufacturing, provide data regarding degradation of proposed insulating material and cable performance due to water immersion test as specified in this specification to the Contracting Officer or designee. Indicate in information AC breakdown stress in kV/mm or V/mil versus immersion time. Ensure a complete description and condition under which cable was tested accompanies the test information. Submit an accelerated water absorption test.

For cables not to be enclosed in metallic conduit, test for flammability in accordance with FED-STD-228, Method 5221 vertical, .

PART 3 EXECUTION

3.1 DEMOLITION OR CABLE CUTTING

Notify the Contracting Officer 14 working days prior to an outage for demolition or cable cutting of medium voltage electrical system.

The Government has established a mandatory inspection point prior to Contractor performing any medium voltage cable cuts or demolition. Notify the Contracting Officer 48 hours in advance of this mandatory inspection point.

As part of the mandatory inspection point, positively identify and label the medium voltage cable to be worked utilizing an electronic cable identifier. Ensure the process of identifying and labeling the cable to be worked is witnessed by the Government. Cable cutting and demolition of any medium voltage cable can occur only after approval by the Contracting Officer.

Cut medium voltage cables and conductors by indirect means using cable cutters specifically designed to be operated remotely only. Cutting of medium voltage cables and conductors by direct means is not permitted.

3.2 INSTALLATION

Install medium-voltage cables in accordance with NFPA 70, NFPA 70E; and IEEE C2.

Refer to contract provisions for safety submittals and requirements associated with working in the vicinity of energized cables and equipment. The use of arc-flash and shock prevention equipment and personal protective equipment is mandatory.

Notify the Contracting Officer 14 working days prior to an outage that requires testing for phasing and phase rotation of medium voltage electrical systems. The Government will identify and tag the phasing of equipment and provide to the Contractor, in writing, the results of phasing and phase rotation tests. The Contractor is responsible for maintaining the phasing and phase rotation tests, and is responsible for maintaining the phasing, and matching the existing phase rotation and phasing when installing conductors in existing electrical systems.

Install the cables in the following locations:

Exterior:

a. In underground duct banks

b. In conduit above and below grade

c. In manholes

Secure cables with heavy-duty cable ties in existing or new trays mounted horizontally, where the cable rests on the tray bottom. Install cable ties at a minimum of 10 foot intervals.

Secure cables with PVC-coated metallic cable clamps, straps, hangers, or other approved supporting devices to tunnel walls, ceilings, and in new or existing cable trays mounted vertically, where the tray bottom is in a vertical plane.

When field cuts or other damage occurs to the PVC coating, apply a liquid PVC patch to maintain the integrity of the coating. After the installation is complete, perform an inspection to ensure that the coating has no voids, pinholes, or cuts.

Installed cable or conductors of a primary distribution system will be rejected by the Government when placed:

a. Openly in cable trays or openly racked along interior walls

b. In the same raceway or conduit with AC/DC control circuits or AC power circuits operating at less than 600 volts

c. In a manner allowing the cable to support its own weight

3.2.1 Pulling Cables in Ducts, Manholes and Utility Tunnels

Submit a Pulling Plan including calculations of pulling tension and side wall pressure anticipated, and the maximum allowable pulling tension for each pull. Do not perform any pull until Government reviews and approves the pulling plan.

Pull medium-voltage cables into ducts and utility tunnels with equipment designed for this purpose, including a power-driven winch, cable-feeding flexible tube guide, cable grips, and lubricants. Employ a sufficient number of trained personnel and equipment to ensure correct installation of the cable.

Set up the cable reel at the side of the manhole or tunnel hatch opening and above the duct or hatch level, allowing the cable to enter through the opening without reverse bending. Install a flexible tube guide through the opening in a manner that prevents the cable from rubbing against the edges of structural members.

Ensure that the pulling force for a cable grip on lead-sheathed cable does not exceed the force calculated in the pulling plan for the sheath cross-sectional area. Use a dynamometer in the pulling line to ensure that the pulling force is not exceeded. Ensure that the pulling force for a nonmetallic-sheathed cable does not exceed the smaller of 1,000 pounds or a value computed from the following equation:

TM = 0.036 X N X CM

Where: TM = maximum allowable pulling tension in pounds

N = number of conductors in the cable

CM = cross-sectional area of each conductor in circular mils

3.2.1.1 Allowable Sidewall Pressure

The allowable sidewall pressure is the smaller of 500 pounds per foot of bend radius or the cable manufacturer's recommended maximum value. Show in the pulling plan submittal the calculations for allowable tension and sidewall pressure as well as the anticipated tension and sidewall pressure for each pull in the project.

Unreel cable from the top of the reel, carefully controlling payout. Attach cable to be pulled through a swivel to the main pulling wire by means of a pulling eye installed by the factory or approved cable splicer .

Attach pulling eyes to the cable conductors of the 3-1/C circuit to prevent damage to the cable structure. Pull the entire 3-1/C circuit simultaneously.

3.2.1.2 Minimum Bending Radius

Minimum bending radius during cable pulling operations is 30 inches. For permanent cable bending/racking the minimum bending radius is 12 times cable diameter.

3.2.1.3 Coating of Cables

Liberally coat cables with a suitable cable-pulling lubricant as it enters the tube guide or duct. Do not use greaser and oil lubricants. Cover nonmetallic sheathed cables with wire-pulling compounds, when required, which have no deleterious effects on the cable. Use rollers, sheaves or tube guides, around which the cable is pulled, conforming to the 30 inches minimum bending radius of the cable during the pulling operations.

3.2.1.4 Pulling Speed

Pull cables into ducts at a speed not to exceed 50 feet per minute and not in excess of maximum permissible pulling tension specified by the cable manufacturer. Cable pulling using a vehicle is not be permitted. Stop pulling operations immediately with any indication of binding or obstruction and do not resume until such difficulty is corrected. Provide sufficient slack for free movement of cable due to expansion or contraction.

3.2.2 Splices and Terminations

Make splices in manholes or tunnels except where cable terminations are specifically indicated. Expedite splicing and terminating of cables in order to minimize exposure and cable deterioration.

Use only equipment and materials recommended by the splice manufacturer including calibrated cutting equipment to ensure consistent cut depths when preparing cable ends for the application of the splice kit. Connect the cable concentric neutral/shield wires across one side of the splice by split bundling the splice neutral wiring and connecting each bundle set to a continuous No. 4 AWG solid bare copper conductor via two compression conductors. Ensure the No. 4 AWG conductor extrudes from the cable splice jacket and connects to the manholes grounding system. Make all connections within the splice utilizing long barrel-type compression connectors and appropriate compression tools with proper size dies to ensure a satisfactory mechanical and electrical joint. Ensure bare connections of concentric neutral/shield wires are either contained within the splice kit or sealed via an additional outer covering,consisting of a heavy wall, heat-shrinkable tubing containing adhesive material (mastic) that melts as heat is applied and the outer tubing shrinks to form a moisture proof environmental seal. Provide outer tubing conforming to ANSI C119.1. Ensure splice meets the requirements of IEEE 404 for a 15 kV rating and is rated by the manufacturer for use on 15 kV class feeder cable systems. Take extra precautions to seal around the exit area of the bare copper jumpers with an additional mastic per the splice manufacturer's recommendations.

Terminate cables in approved cable terminations, rated Class 1 per IEEE 48. Dry terminations with medium voltage pennants, preformed, and hand wrapped stress cones can be used for terminating cables. Provide terminations with adequate means for making external connections to the cable conductors of single-conductor cables (phase and concentric neutral), protecting the cable insulation against moisture, oil, or other contaminants. Take extra precautions in physically protecting and supporting cables, and maintaining the insulation level of the cable.

Ensure that installation includes built-up or prefabricated heat or cold shrink stress-relief cones at the terminals of all shielded cables and at the terminals of single-conductor lead-covered cables rated 15 kV and above, ungrounded.

Field-fabricate cable splices from splicing kits supplied by and in accordance with the cable manufacturer's recommendations for the type, size, and electrical characteristics of the cable specified. Locate cable splices in manholes midway between the cable racks on the walls of the manholes and supported with cable arms at approximately the same elevation as the enclosing duct.

Support all universal demountable splices in a manner that minimizes physical stress on the splice connections. Support each cable end termination using a pair of saddle supports under the cable end termination or cable with a minimum inches and a maximum 30 inches separation between the supports. Secure the cable end termination and cable to the supports in a manner that prevents movement of termination or cable at the support. Install saddle supports on a galvanized steel framing channel that is anchored to the wall, securely fastened to the cable tray, or installed by other approved methods.

3.2.3 Fireproofing

Provide fireproofing (Arc Proofing) for individual cable conductor in manholes, handholes and vaults which carry current at 2200 volts or more.

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Extend the tape 1 inch into the ducts. To prevent unraveling, random wrap the fireproofing tape the entire length of the fireproofing with pressure-sensitive glass cloth tape.

3.2.4 Cable Tag Installation

Install cable tags in each manhole and at each termination as specified. Install cable tags over the fireproofing and position the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes and equipment.

3.3 FIELD QUALITY CONTROL

After the installation of power cables has been completed, including splices, joints, and terminations, and before the cable is energized, subject each medium voltage cable to field testing in accordance with the following requirements:

a. Provide test equipment, labor, and trained technical personnel as necessary to perform the electrical acceptance tests.

b. Record all tests on an approved medium voltage cable test form and submit completed forms to the Contracting Officer.

c. Make arrangements to have tests witnessed and approved by the Contracting Officer.

d. Isolate each power-cable installation completely from extraneous electrical connections at cable splices/terminations and joints. Observe all safety precautions.

e. Ensure each power cable is first given an insulation resistance test using a meg-ohmmeter with a voltage output of at least 2,500-volts. Apply test for a long enough time to fully charge the cable (no less than one minute). Record readings as indicated on forms provided. The minimum reading is 5000 megohms at an ambient temperature of 68 degrees F. Correct readings taken at other than 68 degrees F ambient temperatures accordingly.

f. Conform testing to NETA ATS, and NFPA 70B.

Upon successful completion of the insulation resistance tests, subject the cable to a direct-current high-potential test for 5 minutes applying test voltages in accordance with AEIC CS1 and IEEE 400.2 for paper-impregnated, lead-covered cable; AEIC CS8 and IEEE 400.2 for cross-linked, polyethylene-insulated cable; and AEIC CS8 and IEEE 400.2 for ethylene propylene rubber-insulated cable.

Record leakage current readings every 30 seconds during the first 2 minutes and every minute thereafter for the remainder of the test. When the leakage current continues to increase after the first minute, immediately terminate the test and take steps to find and correct the fault. When a second test becomes necessary, repeat this test procedure.

Upon satisfactory completion of the high-potential test, give the cable a second insulation resistance test as before.

Provide results of the second insulation resistance test that agree with the first test and that indicate no evidence that the cable has been permanently injured by the high-potential test.

Record test data identifying the cable and location, megohm readings versus time, leakage current readings versus time, and cable temperature versus time.

Final acceptance depends upon the satisfactory performance of the cable under test. Do not energize cable until recorded test data has been approved by the Contracting Officer.

Perform radiographic tests on all potheads at the discretion of the

Contracting Officer to determine if voids exist in the pothead. Rework unacceptable terminations at no additional expense to the Government.

3.4 CLOSEOUT ACTIVITIES

Provide manufacturer's instructions showing the recommended sequence and method of installation for medium-voltage power cables.

-- End of Section --

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SECTION 26 05 26.00 40

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to work specified in this section.

Section 26 41 00 LIGHTNING PROTECTION SYSTEMS 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 WELDING SOCIETY (AWS)

AWS A3.0M/A3.0	(2020) Standard Welding Terms and Definitions
AWS B2.1/B2.1M	(2014; Errata 2015) Specification for Welding Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B187/B187M	(2016) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes

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 C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA GR 1	(2007) Grounding Rod Electrodes and Grounding Rod Electorode Couplings

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 780	(2017) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-607	(2015c; Addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-889	(2016; Rev C) Dissimilar Metals

UNDERWRITERS LABORATORIES (UL)

UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 546	(2008) UL Outline of Investigation for Conductor Termination Compounds

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. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Ground Rods; G

Ground Wires; G

Connectors and Fasteners; G

Test Wells; G

Conductive Corrosion Inhibiting Compounds; G

Ground Buses; G

SD-06 Test Reports

Bond Resistance Test; G

Ground Resistance Tests; G

Ground Isolation Test; G

Equipment Continuity Test; G

SD-07 Certificates

Ground Resistance Test Equipment; G

Micro-Ohmmeter Test Equipment; G

SD-11 Closeout Submittals

Record Drawings

1.3 QUALITY CONTROL

1.3.1 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. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 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 which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product 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.

1.3.3 Ground Resistance Test Equipment

Provide combination 3-point and 4-point type ground resistance test equipment specifically designed for grounding electrode resistance and soil resistivity tests. Submit proof of current equipment calibration with test equipment product data.

1.3.4 Micro-Ohmmeter Test Equipment

Perform bond resistance tests using a micro-ohmmeter with the following characteristics:

a. Resistance range selectable and capable of measuring to 10 micro-Ohms using a minimum of 1 ampere of test current.

b. Positive and negative test leads of the 2-wire balanced type. Provide both clamp and probe type connections to allow measurements across all bonded surfaces. Provide long length balanced test lead to allow measurements from a bonding location to the nearest test well.

Submit proof of current equipment calibration with test equipment product data.

PART 2 PRODUCTS

Submit material, equipment, and fixture lists for grounding systems, including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

2.1 MATERIALS

2.1.1 Ground Rods

Provide ground rods of copper-clad steel conforming to UL 467 and ANSI/NEMA GR 1. Ensure ground rods are not less than 3/4 inch in diameter and 10 feet in length.

Where ground rod length is greater than 10 feet, provide sectional type ground rods with each section 10 feet in length. Join sectional type ground rods using exothermic welding completely around both rod/coupling joints. Ensure ground rods have cone-shaped point on the end of the first section driven into the ground.

Provide ground rods and ground rod sections die-stamped near the top with the name or trademark of the manufacturer and the length of the segment in feet.

2.1.2 Ground Wires

2.1.2.1 Bare

Provide annealed bare copper, Class "B" stranded ground and bond wires in accordance with ASTM B8 for wires #4 AWG and larger and solid in accordance with ASTM B3 for wires #6 AWG and smaller. Provide conductors with 98 percent conductivity and sized wires in accordance with the requirements of NFPA 70 and NFPA 780.

2.1.2.2 Insulated

Ensure insulated conductors conform to the requirements of Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL.

Where installed in conduit as part of a complete circuit provide conductors with green insulation for sizes #8 AWG and smaller and with green phase tape at each end and in each junction box for sizes #6 AWG and larger.

2.1.2.3 Straps/Jumpers

Provide copper bonding straps and jumpers with a cross-sectional area of not less than No. 6 AWG. Ensure bonding straps and jumpers for shock-mounted devices with hinged joints are made of woven-wire or braid flexible stranded wire.

2.1.3 Connectors and Fasteners

2.1.3.1 Exothermic Welds

Ensure the molds, materials and powder charges used to make exothermic welds are the standard product of a single manufacturer and listed by the manufacturer for use on the specific type, size, quantity and configuration of conductors to which the weld is applied.

2.1.3.2 Irreversible Compression Lugs

Provide irreversible compression lug type connectors manufactured from tin-plated copper and installed using a hydraulic compression tool and die to apply correct, uniformly distributed, circumferential pressure. Ensure tools and dies are as recommended by the irreversible compression lug type connector manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed onto the conductor. Apply irreversible compression lug type connectors in strict accordance with the manufacturer's written instructions and published installation instructions. Use 2-hole lug type connectors for connections to NEMA cable pads and bus bars, and single-hole connectors otherwise.

2.1.3.3 Mechanical

Provide split bolt and clamp style mechanical type connectors manufactured from copper, copper alloy, or bronze, listed by the manufacturer as suitable for direct burial use. Ensure mechanical type connectors are applied in strict accordance with the manufacturer's published installation instructions.

2.1.3.4 Fasteners

Provide bolts, nuts, washers, lock washers, and associated fasteners used for grounding and bonding connections manufactured of bronze. Where fasteners contact dissimilar metals, apply conductive oxide-inhibiting compound.

2.1.4 Test Wells

Provide test wells that are H2O rated, precast reinforced concrete, circular, with open bottom and concrete or cast iron lid/frame. Ensure test wells have inside dimensions of not less than 12 inches in diameter by 24 inches deep. Provide test well lid with cast "GROUND" legend.

2.1.5 Conductive Corrosion Inhibiting Compounds

Provide conductive corrosion inhibiting compounds UL Listed in accordance with UL 546, listed by the manufacturer as suitable for the application, and suitable for all aluminum and copper conductor/connector applications. Ensure conductive corrosion inhibiting compounds inhibit oxidation at the conductor/connector interface and have no deleterious effect on the conductor/connector metal or EPDM, natural rubber, or polyethylene insulating materials.

2.1.6 Ground Buses

Provide solid copper ground buses conforming to ASTM B187/B187M with minimum dimensions of 0.25 inches thick, 4 inches wide, and 12 inches in length or as indicated. Ensure ground buses are equipped with two UL Recognized red 1000V rated insulated standoffs and stainless steel mounting brackets.

Provide Telecommunications Main Ground Buses and Telecommunications Ground Buses in meeting the standards of TIA-607.

Provide grounding buses with predrilled NEMA hole configuration as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Install grounding systems in accordance with NFPA 70, NFPA 780 and IEEE C2, and as indicated.

Bond exposed non-current-carrying metallic parts of electrical equipment and metallic raceway systems to ground.

Bond grounding conductors in metallic and non-metallic raceways to ground. Make ground connections at equipment and to ground rods as indicated. 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.

Bond wiring system neutrals to ground in accordance with the requirements of NFPA 70. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

Counterpoise ground systems consist of a series of ground rods with a direct buried grounding conductor loop, configured to minimize the number of dead-ends, interconnecting the individual ground rods. Provide ground rods in the locations indicated.

3.1.1 Ground Rods

Install ground rods using a water jetting procedure.

Install ground rods so that the top of the rod is not less than 18 inches below finished grade.

3.1.2 Conductors

Install bare or insulated conductors as indicated. Install bare conductors where not specifically identified as bare or insulated except where installed in conduit with associated phase conductors. Install insulated conductors in conduit with insulation of the same material as the associated phase conductors with which it is installed.

Provide straps/jumpers across joints subject to vibration. Install strap/jumper such that vibration will not change its electrical characteristics. Apply strap/jumper to the metallic structure on each side of the joint; do not penetrate any adjacent parts. Install straps/jumpers in areas that are accessible for maintenance. Install strap/jumper such that it does not restrict the movement of the metallic structures to which it is connected. Install strap/jumper such that it does not weaken the metallic structures to which it is attached. Do not connect two or more straps/jumpers in series.

3.1.3 Counterpoise

Install No. 4/0 AWG bare copper counterpoise grounding conductor direct buried outside of the structure drip line, within 24 to 72 inches of the structure foundation, with a minimum of 18 inches of earth cover. Install counterpoise grounding conductor in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the conductor.

Install ground rods vertically into the earth not less 10 feet with top of ground rod not less than 18 inches below finished grade. Bond ground rods to counterpoise grounding conductor at intervals no less than 20 linear feet nor greater than 40 linear feet of ground counterpoise cable.

3.1.4 Ground Buses

Install ground busses in accordance with manufacturer's instructions.

3.1.5 Building Grounds

Install No. 4/0 AWG bare copper ground conductor from locations indicated to counterpoise. Connect ground conductors to counterpoise using exothermic welds.

3.1.6 Equipment Grounding

Install ground systems for power, telecommunications, and instrumentation. Independently connect each system to the building counterpoise.

3.1.6.1 Equipment and Enclosure Bonding

Bond each metallic enclosure and all electrical equipment to ground. Make at least one copper connection from the system ground point to one or more enclosures in the area such that all enclosures and equipment provide a low-impedance path to ground when properly bonded together.

Individually and directly connect indoor substations, transformers, switchboard frames, switchgear assemblies, motors, motor control centers, air compressors, air handlers, refrigerated air dryers, generators, frames and tracks of cranes to the building ground. Ensure the current-carrying capacity of the grounding conductor is the same as the current-carrying capacity of the power conductors for circuits utilizing power lines size No. 2 AWG and smaller. For circuits with power wiring larger than No. 2 AWG, ensure the grounding conductor is in accordance with NFPA 70.

3.1.6.2 Bonding of Conduit and Raceway Systems

Bond all metal conduit, fittings, junction boxes, outlet boxes, armored and metal sheathed cable, and other raceways. Ensure adequate electrical contact at the joints and terminations. Ensure metallic raceway systems have electrical continuity with equipment. Individually and directly connect equipment to the building ground, independent of the raceway system.

For rigid metal conduit and terminations, ensure threaded connections are wrench-tight with no exposed threads. Ream all ends of the conduit to remove burrs and rough edges. Bond conduits entering boxes and enclosures to the box with locknuts and grounding-type bushings. Locknuts that gouge into the metal box when tightened are not acceptable.

Conduit systems that are interrupted by PVC dielectric links are bonded separately on either side of the link. Do not jumper the dielectric link.

Install flexible metal conduit with an integral grounding conductor.

3.1.6.3 Cable Tray Bonding

Bond cable tray sections together. Cable tray sections in tandem assembly are considered as having electrical continuity when these sections are bonded with the appropriate bolts. Install bond straps across expansion joints. Bond cable trays to the building ground system.

3.1.7 Bonding Materials And Methods

Accomplish bonding of metal surfaces by welding or clamping .

3.1.7.1 Welding

Weld using the exothermic process with procedures conforming to AWS A3.0M/A3.0, AWS B2.1/B2.1M, and manufacturer's recommendation. Where dissimilar metals are to be joined via exothermic weld, follow the weld kit manufacturer's recommendations and published instructions. Ensure connections between dissimilar metals do not produce galvanic action in accordance with MIL-STD-889.

Use welding processes of the exothermic fusion type that makes a connection without corroding or loosening. Ensure process joins all strands and does not cause the parts to be damaged or weakened. Completed connection or joint is equal or larger in size than the conductors joined and has the same current-carrying capacity as the largest conductor. Paint the buried ground connections with a bitumastic paint.

3.1.7.2 Clamping

In external locations, use clamping only where a disconnect type of connection is required. Connection device may utilize spring-loaded jaws or threaded fasteners. Construct device such that positive contact pressure is maintained at all times. Use machine bolts with tooth-type or spring-type lockwashers.

3.1.7.3 Cleaning of Bonding Surfaces

Thoroughly clean surfaces that comprise the bond before joining. Apply an appropriate abrasive with gentle and uniform pressure to ensure a smooth and uniform surface. Do not remove excessive metal from the surface. Clean clad metals in such a manner that the cladding material is not penetrated by the cleaning process. Then clean bare metal with an appropriate solvent to remove any grease, oil, dirt, corrosion preventives, and other contaminants. Bond to the cleaned area within one hour after cleaning. Seal joint and refinish the exposed surfaces within two hours of exposure to prevent oxidation. When additional time is required, apply a corrosion preventive compound until the area can be refinished.

3.1.7.4 Protection of Finished Bonds

Protect finished bonds by painting to match the original finish after the bond is made.

3.2 FIELD QUALITY CONTROL

Perform the following tests in the presence of the Contracting Officer. Furnish test equipment and personnel and submit written results of each test. Notify the Contracting Officer at least 14 calendar working days prior to each test.

Submit written results of each test to Contracting Officer for review and approval. Document each location where test is performed, the field conditions at the time of the test, the measured results of the test, and whether the measured results "PASSED" or "FAILED" relative to specified pass/fail performance criteria.

Perform rework to correct FAILED conditions at no additional cost to the Government.

3.2.1 Bond Resistance Test

Resistance of any bond connection cannot exceed 0.5 milliohm. Rework bonds that exceed this resistance at no additional cost to the Government.

3.2.2 Ground Resistance Tests

Test grounding systems for ground resistance. Total resistance from any point on the ground network to the building counterpoise cannot exceed 50 milliohms.

Make ground resistance and counterpoise tests during dry weather, and no sooner than 48 hours after rainfall. Conduct tests using the ratio method that measures the ratio of the resistance to earth of an auxiliary test electrode to the series resistance of the electrode under test and a second auxiliary electrode. Perform measurements in accordance with IEEE 81.

3.2.3 Ground Isolation Test

Test ground systems for isolation from other ground systems.

3.2.4 Equipment Continuity Test

Test connection from electrical distribution equipment including panelboards, switchboards, transformers, substations, and motor control centers to counterpoise. Measure and record the circuit resistance between electrical equipment ground connections and the counterpoise. The circuit resistance shall not exceed 5 Ohms.

3.3 CLOSEOUT ACTIVITIES

Submit record drawings indicating the location of ground rods, mats, grids, building ground bus, supplementary grounding electrodes, steel building columns, and other metal structures connected to the grounding system.

-- End of Section --

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SECTION 26 08 00

APPARATUS INSPECTION AND TESTING

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 ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this section with additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Acceptance tests and inspections; G

SD-07 Certificates

Qualifications of organization, and lead engineering technician; G

Acceptance test and inspections procedure; G

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Contractor shall engage the services of a qualified testing organization to provide inspection, testing, calibration, and adjustment of the electrical distribution system and generation equipment listed in paragraph entitled "Acceptance Tests and Inspections" herein. Organization shall be independent of the supplier, manufacturer, and installer of the equipment. The organization shall be a first tier subcontractor. No work required by this section of the specification shall be performed by a second tier subcontractor.

a. Submit name and qualifications of organization. Organization shall have been regularly engaged in the testing of electrical materials, devices, installations, and systems for a minimum of 5 years. The organization shall have a calibration program, and test instruments used shall be calibrated in accordance with NETA ATS.

b. Submit name and qualifications of the lead engineering technician performing the required testing services. Include a list of three comparable jobs performed by the technician with specific names and telephone numbers for reference. Testing, inspection, calibration, and adjustments shall be performed by an engineering technician, certified by NETA or the National Institute for Certification in Engineering Technologies (NICET) with a minimum of 5 years' experience inspecting, testing, and calibrating electrical distribution and generation equipment, systems, and devices.

1.4.2 Acceptance Tests and Inspections Reports

Submit certified copies of inspection reports and test reports. Reports shall include certification of compliance with specified requirements, identify deficiencies, and recommend corrective action when appropriate. Type and neatly bind test reports to form a part of the final record. Submit test reports documenting the results of each test not more than 10 days after test is completed.

1.4.3 Acceptance Test and Inspections Procedure

Submit test procedure reports for each item of equipment to be field tested at least 45 days prior to planned testing date. Do not perform testing until after test procedure has been approved.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 ACCEPTANCE TESTS AND INSPECTIONS

Testing organization shall perform acceptance tests and inspections. Test methods, procedures, and test values shall be performed and evaluated in accordance with NETA ATS, the manufacturer's recommendations, and paragraph entitled "Field Quality Control" of each applicable specification section. Tests identified as optional in NETA ATS are not required unless otherwise specified. Equipment shall be placed in service only after completion of required tests and evaluation of the test results have been completed. Contractor shall supply to the testing organization complete sets of shop drawings, settings of adjustable devices, and other information necessary for an accurate test and inspection of the system prior to the performance of any final testing. Contracting Officer shall be notified at least 14 days in advance of when tests will be conducted by the testing organization. Perform acceptance tests and inspections on applicable equipment and systems specified in the following sections:

a. Section 26 32 15.00 ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES. Functional engine shutdown tests, vibration base-line test, and load bank test shall not be performed by the testing organization. These tests shall be performed by the start-up engineer.

b. Section 26 12 19.00 40 THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS

c. Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Medium voltage cables and grounding systems only.

d. Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH

e. Section 26 24 13 SWITCHBOARDS

3.2 SYSTEM ACCEPTANCE

Final acceptance of the system is contingent upon satisfactory completion of acceptance tests and inspections.

3.3 PLACING EQUIPMENT IN SERVICE

A representative of the approved testing organization shall be present when equipment tested by the organization is initially energized and placed in service.

-- End of Section --

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SECTION 26 09 23.00 40

LIGHTING CONTROL DEVICES

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM 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.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

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

UNDERWRITERS LABORATORIES (UL)

UL 98	(2016) UL Standard for Safety Enclosed and Dead-Front Switches
UL 773	(2016; Reprint Nov 2017) UL Standard for Safety Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2016; Reprint May 2018) UL Standard for Safety Nonindustrial Photoelectric Switches for Lighting Control

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in the IEEE Stds Dictionary.

b. DALI: Digital Addressable Lighting Interface used to transmit data to and from lighting control system input devices, end devices, and control equipment.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting System Drawings; G

SD-03 Product Data

Installation Instructions; G

Light Level Sensor; G

Lighting Contactor; G

Photocell Switch; G

SD-06 Test Reports

System Operation Tests

SD-10 Operation and Maintenance Data

Lighting Control System, Data Package 5

1.4 QUALITY CONTROL

1.4.1 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. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

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 which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product 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.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit lighting system drawings showing luminaire configuration, control zones, and detection range of specified control devices. Ensure lighting system drawings include photometric calculations showing lighting levels in foot candles for all areas indicated. Ensure lighting calculations and photometric plans are created using industry standard light modeling software. Hand calculations will not be accepted.

a. Provide lighting control system of the non-centralized and non-addressable type that does not include any programmable devices. Control devices are of the line-voltage or low-voltage types and are used to create specific hard-wired control zones to turn lights on and off or to provide light dimming capabilities.
b. Provide lighting control system of the centralized and addressable type that includes programmable devices. Control devices are of the digital low-voltage or wireless types and are used to create control zones which can be changed without affecting the wiring of the devices. Control zones are used to turn lights on and off or to provide light dimming capabilities.
c. Lighting control system must comply with these specifications, all applicable construction document drawings, all applicable codes, and all local authorities having jurisdiction. Lighting control system equipment includes, but is not limited to, time control switches, manual and safety switches, dimming ballasts, light level sensors, incandescent dimmer switches, lighting contactors, photocell switches, and occupancy sensors.

2.1.1 System Requirements

a. The lighting control system and lighting end devices must revert to the on position in the event of a loss of power or control signal to the system or end devices.
b. Where centralized, addressable system is utilized lighting control zones consisting of one or more networked luminaires and lighting control devices must be capable of providing automatic control from sensors (occupancy and photocell) and manual control local switches. c. Where centralized, addressable system is utilized provide networked luminaires and lighting control devices that store programming in non-volatile memory such that following any loss of power the lighting control zones continue to operate according to the defined settings.

2.2 COMPONENTS

2.2.1 Manual Switches

Provide a switch mechanism consisting of a heavy-duty general-purpose precision snap-acting switch, with NEMA ICS 6 Type 1 or 4 enclosures,, single-pole, single-throw, with a minimum rating of 1,000-watts incandescent-lamp load and 1,200-volt-amperes reactive for vapor-lamp load at rated voltage and frequency suitable for operation on a 277 volt, 60 Hz, single-phase system. Provide with a selector switch having a minimum of three positions: ON, OFF, and AUTOMATIC. Use the automatic position when photoelectric or timer control is desired. Interface the selector switch with the lighting system magnetic contactor to control system activity.

Ensure switches conform to UL 98 as applicable. Provide a quick-make, quick-break type switch such that a screwdriver is required to open the switch door when the switch is on, with blades visible when the door is open. Coordinate terminal lugs with the wire size.

2.2.2 Light Level Sensor

Provide UL listed light level sensor capable of detecting changes in ambient lighting levels, with a dimming range of 20 percent to 100 percent, minimum. Ensure sensor is designed for use with dimming ballast and voltage system to which they are connected. Provide a sensor capable of controlling 40 electronic dimming ballasts, minimum, with a sensor light level adjustable with a set level range from 10 to 100 foot-candles, minimum. Provide a sensor with a bypass function to electrically override the sensor control.

2.2.3 Lighting Contactor

Provide NEMA ICS 2, electrically held contactorwith photocell input for outdoor locations, rated 277 volts, 20 amperes, and three poles, with coils rated 120 volts. Provide in a NEMA1 enclosure conforming to NEMA ICS 6. Provide contactors with silver alloy double-break contacts requiring no arcing contacts. Provide contactor with hand-off-automatic selector switch.

2.2.4 Photocell Switch

Ensure photocell switches conform to UL 773 or UL 773A as applicable. Provide hermetically sealed photocells that use cadmium-sulfide or silicon diode type cells. Provide photocells that are rated at 120 volts ac, 60 Hz with single-throw contacts and designed to fail to the ON position. Provide photocells that turn on at or below 3 foot-candles and off at 4 to 10 foot-candles. Provide time delay to prevent accidental switching from transient light sources. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.

Provide a photocell with the following:

a. In a U.V. stabilized polycarbonate housing with swivel arm and adjustable window slide, rated 1800 VA, minimum.PART 3 EXECUTION

3.1 INSTALLATION

Submit installation instructions for occupancy sensitive control devices in accordance with the manufacturer's recommended instructions for installation.

3.1.1 Photoconductive Control Devices

Install photoconductive control devices in accordance with the manufacturer's installation instructions.

3.1.2 Time Control Switches

Install switches with not less than four 1/4 inch bolts. Do not use sheet metal screws.

3.1.3 Manual and Safety Switches

Coordinate terminal lugs with the wire size. Securely fasten switches to the supporting structure or wall using not less than four 1/4 inch bolts. Do not use sheet metal screws.

3.2 EQUIPMENT IDENTIFICATION

3.2.1 Manufacturer's Nameplate

Provide each item of equipment with a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in an inconspicuous place; the nameplate of the distributing agent is not acceptable.

3.2.2 Labels

Provide labeled control devices, clearly marked for operation of specific lighting functions according to type.

Locate markings where readily visible to service personnel, but unseen from normal viewing angles when devices are in place.

3.3 FIELD QUALITY CONTROL

Perform system operation tests in accordance with referenced standards in this section.

Demonstrate that photoconductive control devices operate satisfactorily in the presence of the Contracting Officer.

Measure and record foot-candle levels in areas indicated and compare to submitted photometric calculations. Perform all lighting measurements in the presence of the Contracting Officer. Take measurements in areas representing a minimum of 10% relative sample and as directed by the Contracting Officer. Ensure measured lighting levels are within 10% of the calculated values. Where lighting levels are determined to be deficient contractor will modify system to bring lighting levels into compliance at no additional cost to the Government.

3.4 CLOSEOUT ACTIVITIES

Submit operation and maintenance data, lighting control system, data package 5, in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein. Show information for all lighting fixtures, control modules, control zones, occupancy sensors, motion sensors, light level sensors, power packs, dimming ballasts, schematic diagrams and all interconnecting control wire, conduit, and associated hardware.

-- End of Section --

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SECTION 26 12 19.00 40

PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 GENERAL

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	((2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2019) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products
ASTM D877/D877M	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.47	(2011) Standard for High Voltage Distribution Class Current-Limiting Type

	Fuses and Fuse Disconnecting Switches
IEEE C57.12.00	(2015) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.34	(2015) Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2015; Corr 2017) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2012) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

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

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-90/027F	(1993) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms
EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"

UNDERWRITERS LABORATORIES (UL)

UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment

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 Stds Dictionary.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pad-Mounted Transformer Drawings; G

SD-03 Product Data

Pad-Mounted Transformers

SD-06 Test Reports

Acceptance Checks And Tests

SD-09 Manufacturer's Field Reports

Pad-mounted Transformer Design Tests

Pad-mounted Transformer Routine and Other Tests

SD-10 Operation and Maintenance Data

Transformer(s), Data Package 5

SD-11 Closeout Submittals

Transformer Test Schedule

Warranty

1.4 QUALITY CONTROL

1.4.1 Pad-Mounted Transformer Drawings

Submit pad-mounted transformer drawings. Indicate on drawings, but not limit to the following:

a. An outline drawing, with front, top, and side views.

b. ANSI nameplate data.

c. Elementary diagrams and wiring diagrams with terminals identified of watthour meter and current transformers.

d. One-line diagram, including switch(es), current transformers, meters, and fuses.

e. Manufacturer's published time-current curves (on full size logarithmic paper) of the transformer high side fuses.

1.4.2 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. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

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. 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 products that 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, use items 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 are 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

Do not use products manufactured more than 3 years prior to date of delivery to site, unless specified otherwise.

1.5 MAINTENANCE MATERIAL SUBMITTALS

1.5.1 Additions to Operation and Maintenance Data

In addition to requirements of Data Package 5, include the following on the actual transformer(s) provided:

a. An instruction manual with pertinent items and information highlighted

b. An outline drawing, front, top, and side views

c. Prices for spare parts and supply list

d. Routine and field acceptance test reports

e. Fuse curves for primary fuses

f. Information on watthour demand meter, CT's, and fuse block

g. Actual nameplate diagram

h. Date of purchase

1.6 WARRANTY

Provide two copies of the warranty to the Contracting Officer. Ensure the equipment items are 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.

PART 2 PRODUCTS

2.1 MANUFACTURED UNITS

Products and materials not considered to be pad-mounted transformers and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.1.1 Three-Phase Pad-Mounted Transformers

IEEE C57.12.34, IEEE C57.12.28 and as specified herein.

2.1.1.1 Compartment Construction

Separate the high- and low-voltage compartments with steel isolating barriers extending the full height and depth of the compartments. Compartment doors are hinged lift-off type with stop in open position and three-point latching.

2.1.1.2 High Voltage, Dead-Front

Ensure the high-voltage compartment contains the incoming line, insulated high-voltage load-break connectors, bushing well inserts, feed-thru inserts, six high-voltage bushing wells configured for loop feed application, load-break switch handle(s), access to oil-immersed fuses, dead-front surge arresters, tap changer handle, connector parking stands with insulated standoff bushings, and ground pad.

a. Insulated high-voltage load-break connectors: IEEE 386, rated 15 kV, 95 kV BIL. Current rating: 200 amperes rms continuous. Short time rating: 10,000 amperes rms symmetrical for a time duration of 0.17 seconds. Provide a connector with a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

b. Bushing well inserts and feed-thru inserts: IEEE 386, 200 amperes, 15 kV Class. Provide a bushing well insert for each bushing well unless indicated otherwise.

c. Load-break switch

(1) Loop feed sectionalizer switches: Provide three, two-position, oil-immersed type switches to permit closed transition loop feed and sectionalizing. Ensure each switch is rated at 15 kV, 95 kV BIL, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 10,000 rms amperes symmetrical. Locate the switch handles in the high-voltage compartment. Operation of switches is as follows:

Arrangeme No.	Description of Switch Arrangement	SWITCH POSITION					
		Line A Switch		Line B Switch		Transformer	
		Open	Close	Open	Close	Open	Close
1	Line A connected to Line B and both lines connected to transformer		**X**		**X**		**X**
2	Transformer connected to Line A only		X	X			X
3	Transformer connected to Line B only	X			X		X
4	Transformer open and loop closed		X		X	X	
5	Transformer open and loop open	X		X		X	

d. Provide bayonet type, oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. Ensure bayonet fuse links sense both high currents and high oil temperature in order to provide thermal protection to the transformer. Coordinate transformer protection with expulsion fuse clearing low-current faults and current-limiting fuse clearing high-current faults beyond the interrupting rating of the expulsion fuse. In order to eliminate or minimize oil spills, include with the bayonet fuse assembly an oil retention valve inside the housing which closes when the fuse holder is removed and an external drip shield. Conspicuously display warning within the high-voltage compartment cautioning against removing or inserting fuses unless the load-break switch is in the open position and the tank pressure has been released.

(1) Bayonet fuse assembly: 150 kV BIL.

(2) Oil-immersed current-limiting fuses: IEEE C37.47; 50,000 rms

amperes symmetrical interrupting rating at the system voltage specified.

e. Provide surge arresters conforming to IEEE C62.11, rated at 6 kV, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap, suitable for plugging into inserts. Provide three arresters for loop feed circuits.

f. Provide a parking stand near each bushing well. Provide insulated standoff bushings for parking of energized load-break connectors on parking stands.

g. Protective caps: IEEE 386, 200 amperes, 15 kV Class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushing well inserts and insulated standoff bushings.

2.1.1.3 Low Voltage

Provide low-voltage compartment containing low-voltage bushings with NEMA spade terminals, accessories, stainless steel or laser-etched anodized aluminum diagrammatic transformer nameplate, and ground pad.

a. Accessories include drain valve with sampler device, fill plug, pressure relief device, liquid level gage, pressure-vacuum gage, and dial type thermometer with maximum temperature indicator.

2.1.1.4 Transformer

a. Less-flammable liquid-insulated, two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

b. Transformer is rated as indicated (in kVA) kVA, 95 kV BIL.

c. Transformer voltage ratings: 13,200 V - 480Y/277 V. Provide primary tap for 4,800 V, unground delta.

d. Ensure tap changer is an externally operated, manual type for changing tap setting when the transformer is de-energized. Provide four 2.5 percent full capacity taps, two above and two below rated primary voltage. Ensure tap changers clearly indicate which tap setting is in use.

e. Ensure audible sound levels comply with the following:

kVA	DECIBELS (MAX)
75	51
112.5	55
150	55
225	55
300	55
500	56
750	57
1000	58
1500	60

f. Include lifting lugs for the transformer and provisions for jacking under base. Ensure the transformer base construction is suitable for using rollers or skidding in any direction. Provide transformer top with an access handhole. Conspicuously display its kVA rating on its enclosure. Ensure the transformer has an insulated low-voltage neutral bushing with NEMA spade terminal, and with removable ground strap.

2.1.1.5 Insulating Liquid

a. Less-flammable transformer liquids: NFPA 70 and FM APP GUIDE for less-flammable liquids having a fire point not less than 300 degrees C tested per ASTM D92 and a dielectric strength not less than 33 kV tested per ASTM D877/D877M. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

(1) Provide a fluid that is a biodegradable electrical insulating and cooling liquid classified by UL and approved by FM as "less flammable" fluids. Ensure the fluid meets the following fluid properties:

(a) Pour point: ASTM D97, less than -15 degree C

(b) Aquatic biodegradation: EPA 712-C-98-075, 100 percent

(c) Trout toxicity: OECD Test 203, zero mortality of EPA 600/4-90/027F, pass

2.1.1.6 Liquid-Filled Transformer Nameplates

Provide distribution transformers with nameplate information in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

2.1.1.7 Corrosion Protection

Fabricate entire transformer assembly, including tank and radiator, base, enclosure, and metering enclosure of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Form enclosure of stainless steel sheets. Paint entire transformer assembly Munsell 7GY3.29/1.5 green. Ensure paint coating system complies with IEEE C57.12.28. The Munsell color notation is specified in ASTM D1535.

2.2 ACCESSORIES

2.2.1 Warning Signs

Provide warning signs for the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28, such as for pad-mounted transformers, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Provide a decal type sign and have nominal dimensions of 7 by 10-inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2-inch high letters. The word "DANGER" is printed in white letters on a red background and the words "HIGH VOLTAGE" is printed in black letters on a white background. Decal is Panduit No. PPSO710D72 or approved equal.

2.2.2 Grounding and Bonding

Ensure equipment conforms to UL 467. Provide grounding and bonding as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2.3 Cast-In-Place Concrete

Concrete associated with electrical work for other than encasement of underground ducts is 4000 psi minimum 28-day compressive strength unless specified otherwise. Ensure all concrete conforms to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE for other projects.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

2.3.1 Transformer Test Schedule

The Government reserves the right to witness tests. Provide transformer test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

   (1) The manufacturer has a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

   (2) The accuracy is directly traceable to the National Institute of Standards and Technology.

   (3) Instrument calibration frequency schedule does not exceed 12 months for both test floor instruments and leased specialty equipment.

   (4) Dated calibration labels are visible on all test equipment.

   (5) Calibrating standard is of higher accuracy than that of the instrument tested.

   (6) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

      (a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

      (b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.3.2 Design Tests

IEEE C57.12.00, and IEEE C57.12.90. Section 5.1.2 in IEEE C57.12.80 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for each of the specified transformer(s). Perform design tests prior to the award of this contract.

a. Submit test reports certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a pad-mounted transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (ONAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a pad-mounted transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests includes the primary windings only of that transformer.

(1) IEEE C57.12.90, paragraph 10.3 LIGHTNING IMPULSE TEST PROCEDURES and IEEE C57.98.

(2) State test voltage levels.

(3) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" requirement for the lifting and moving devices test means a test report confirming that the lifting device being used is capable of handling the weight of the specified transformer in accordance with IEEE C57.12.34.

e. Pressure: "Basically the same design" for the pressure test means a pad-mounted transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

f. Short circuit: "Basically the same design" for the short circuit test means a pad-mounted transformer with the same kVA as the transformer specified.

2.3.3 Routine and Other Tests

IEEE C57.12.00. Routine and other tests are performed by the manufacturer on each of the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence are as follows:

a. Cold resistance measurements (provide reference temperature)

b. Phase relation

c. Ratio

d. No-load losses (NLL) and excitation current

e. Load losses (LL) and impedance voltage

f. Dielectric

(1) Impulse

(2) Applied voltage

(3) Induced voltage

g. Leak

h. Dissolved gas analysis (DGA)

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Foundation for Equipment and Assemblies

Mount transformer on concrete slab. Unless otherwise indicated, the slab is at least 8-inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4-inches from the top of the slab. Place the slab on a 6-inch thick, well-compacted gravel base. Top of concrete slab is approximately 4-inches above finished grade with gradual slope for drainage. Edges above grade are 1/2-inch chamfer. Ensure slab is of adequate size to project at least 8-inches beyond the equipment.

Stub up conduits, with bushings, 2-inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.1.1.1 Cast-In-Place Concrete

Ensure cast-in-place concrete work conforms to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.1.1.2 Sealing

When the installation is complete, seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Ensure seals are of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.2 INSTALLATION

Ensure electrical installations conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2.1 Grounding

Conform grounding to NFPA 70 and IEEE C2, except that grounding systems have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.1.2 Pad-Mounted Transformer Grounding

Provide separate copper grounding conductors and connect them to the ground loop as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.1.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.1.4 Grounding and Bonding Equipment

Conform equipment to UL 467, except as indicated or specified otherwise.

3.2.1.5 Transformer Grounding

Provide a 4/0 bare copper-ground girdle around transformer. Bury girdle one-foot deep and placed 3-feet laterally from the transformer enclosure. Connect girdle to enclosure at two opposite places using 4/0 copper. Exothermically weld joints.

3.2.2 Installation Of Equipment And Assemblies

Install and connect pad-mounted transformers furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.2.2.1 Meters and Current Transformers

ANSI C12.1.

3.2.3 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.2.4 Warning Sign Mounting

Provide the number of signs required to be readable from each accessible side, space the signs a maximum of 30-feet apart.

3.3 FIELD QUALITY CONTROL

3.3.1 Performance of Acceptance Checks and Tests

Perform acceptance checks and tests in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.3.1.1 Pad-Mounted Transformers

a. Visual and mechanical inspection

(1) Compare equipment nameplate information with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

(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, or performing thermographic survey.

(4) Verify correct liquid level in tanks.

(5) Perform specific inspections and mechanical tests as recommended by manufacturer.

(6) Verify correct equipment grounding.

(7) Verify the presence of transformer surge arresters.

b. Electrical tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Verify that the tap-changer is set at specified ratio.

(3) Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.3.1.2 Current Transformers

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) 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.

3.3.1.3 Grounding System

a. Visual and mechanical inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. Equip the instrument with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.3.2 Follow-Up Verification

Upon completion of acceptance checks and tests, 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.

-- End of Section --

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.

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	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2015) American National Standard for Electrical Metallic Tubing (EMT)
ANSI C80.5	(2015) American National Standard for Electrical Rigid Aluminum Conduit
NEMA 250	(2018) 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 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
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	(2018) Motors and Generators
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	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2016) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 14	(2002) Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2015) 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; TIA

	20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 70E	(2018; TIA 18-1; TIA 81-2) Standard for Electrical Safety in the Workplace
NFPA 780	(2017) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-569	(2015d) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-607	(2015c; Addendum 1 2017) 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 4	(2004; Reprint Feb 2018) UL Standard for Safety Armored Cable
UL 5	(2016) UL Standard for Safety Surface Metal Raceways and Fittings
UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 6A	(2008; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 44	(2018) 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 Oct 2019) UL Standard for Safety Panelboards
UL 83	(2017) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 198M	(2018) UL Standard for Mine-Duty Fuses
UL 360	(2013; Reprint Nov 2018) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018) UL Standard for Safety Wire Connectors
UL 486C	(2019) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Jan 2020) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017) UL Standard for Safety Specialty Transformers
UL 508	(2018) UL Standard for Safety Industrial Control Equipment
UL 510	(2017) 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 Nov 2014) 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 Nov 2018) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 674	(2011; Reprint Nov 2018) UL Standard for Safety Electric Motors and Generators for Use in Hazardous (Classified) Locations
UL 797	(2007; Reprint Mar 2017) UL Standard for Safety Electrical Metallic Tubing -- Steel

UL 817	(2015; Reprint May 2017) UL Standard for Safety Cord Sets and Power-Supply Cords
UL 854	(2020) Standard for Service-Entrance Cables
UL 869A	(2006) 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) UL Standard for Safety Machine-Tool Wires and Cables
UL 1203	(2013; Reprint Jan 2020) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2014; Reprint Jul 2017) UL Standard for Safety Surge Protective Devices
UL 1569	(2018) UL Standard for Safety Metal-Clad Cables
UL 1660	(2019) Liquid-Tight Flexible Nonmetallic Conduit
UL 2043	(2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
UL 4248-1	(2017) 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" designation;

submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Panelboards; G

Transformers; G

Cable Trays; 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

Manual Motor Starters; G

Telecommunications Grounding Busbar; G

Surge Protective Devices; G

SD-06 Test Reports

600-volt Wiring Test; G

Grounding System Test; G

Transformer Tests; G

Ground-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, "shall" or "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.

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 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, and EPC-80 in accordance with NEMA TC 2,UL 651, or fiberglass conduit, in accordance with NEMA TC 14.

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.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360.

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 NEMA TC 14 for fiberglass, and UL 514B.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 SURFACE RACEWAY

2.3.1 Surface Metal Raceway

UL 5, two-piece painted steel, totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Provide receptacles as specified herein, spaced a minimum of one every 18 inches.

2.4 CABLE TRAYS

NEMA VE 1. Provide the following:

a. Cable trays: form a wireway system, with a nominal depth as indicated.

b. Cable trays: constructed of aluminum.

c. Cable trays: include splice and end plates, dropouts, and miscellaneous hardware.

d. Edges, fittings, and hardware: finished free from burrs and sharp edges.

e. Fittings: ensure not less than load-carrying ability of straight tray sections and have manufacturer's minimum standard radius.

f. Radius of bends: 12 inches.

2.4.1 Basket-Type Cable Trays

Provide size as indicated with maximum wire mesh spacing of 2 by 4 inch.

2.4.2 Ladder-Type Cable Trays

Provide size as indicated with maximum rung spacing of 12 inches.

2.5 OPEN TELECOMMUNICATIONS CABLE SUPPORT

2.5.1 Open Top Cable Supports

Provide open top cable supports in accordance with UL 2043. Provide galvanized steel open top cable supports.

2.6 OUTLET BOXES AND COVERS

UL 514A, cadmium- or zinc-coated, if ferrous metal. UL 514C, if nonmetallic.

2.6.1 Outlet Boxes for Telecommunications System

Provide the following:

a. Standard type 4 inches square by 2 1/8 inches deep.

b. Depth of boxes: large enough to allow manufacturers' recommended conductor bend radii.

2.7 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 3, unless otherwise notedR.

2.8 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.

2.8.1 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. Conductors indicated to be No. 6 AWG or smaller diameter: copper. Conductors indicated to be No. 4 AWG and larger diameter: copper , unless type of conductor material is specifically indicated, or specified, or required by equipment manufacturer.

2.8.1.1 Equipment Manufacturer Requirements

When manufacturer's equipment requires copper conductors at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to satisfy manufacturer's requirements.

2.8.1.2 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 5e UTP cables in accordance with DLVLC system manufacturer requirements.

2.8.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

2.8.2.1 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.

2.8.2.2 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

2.8.3 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 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 lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.8.4 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.

2.8.4.1 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 3/0 AWG. Provide insulated TBB with insulation as specified in the paragraph INSULATION and meeting the fire ratings of its pathway.

2.8.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications main grounding busbar (TMGB) and the electrical service ground in accordance with TIA-607. Size the bonding conductor for telecommunications the same as the TBB.

2.8.5 Service Entrance Cables

Service Entrance (SE) and Underground Service Entrance (USE) Cables, UL 854.

2.8.6 Wire and Cable for 400 Hertz (Hz) Circuits

Insulated copper conductors.

2.8.7 Metal-Clad Cable

UL 1569; NFPA 70, Type MC cable.

2.8.8 Armored Cable

UL 4; NFPA 70, Type AC cable.

2.8.9 Cord Sets and Power-Supply Cords

UL 817.

2.9 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.

2.10 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: satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.

e. Screws: machine-type with countersunk heads in color to match finish of plate.

f. Sectional type device plates are not be permitted.

g. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.11 SWITCHES

2.11.1 Toggle Switches

NEMA WD 1, UL 20, single pole, three-way, and four-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.

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.

2.11.2 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.

2.11.3 Breakers Used as Switches

For 120- and 277-Volt fluorescent fixtures, mark breakers "SWD" in accordance with UL 489.

2.11.4 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, enclosure as indicated per NEMA ICS 6.

2.12 FUSES

NEMA FU 1. Provide complete set of fuses for each fusible switch. Coordinate time-current characteristics curves of fuses serving motors or connected in series with circuit breakers for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

2.12.1 Fuseholders

Provide in accordance with UL 4248-1.

2.12.2 Cartridge Fuses, Current Limiting Type (Class R)

UL 198M, Class RK-5. Provide only Class R associated fuseholders in accordance with UL 4248-12.

2.12.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 198M, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.12.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 198M, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.13 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.

2.13.1 Split Duplex Receptacles

Provide separate terminals for each ungrounded pole. One receptacle must be controlled separately.

2.13.2 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations". Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, polycarbonate, UV resistant/stabilized cover plate.

2.13.3 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.

2.13.4 Special Purpose Receptacles

Receptacles serving indicated equipment are special purpose. Provide in ratings indicated.

2.13.5 Plugs

Provide heavy-duty, rubber-covered three-, four-, or five-wire cord of required size, install plugs thereon, and attach to equipment. Provide UL listed plugs with receptacles, complete with grounding blades. Where equipment is not available, turn over plugs and cord assemblies to the Government.

2.13.6 Dryer Receptacles

NEMA 14-30 configuration, rated 30 amperes, 125/250 volts. Furnish one matching plug with each receptacle.

2.13.7 Tamper-Resistant Receptacles

Provide duplex receptacle with mechanical sliding shutters that prevent the insertion of small objects into its contact slots.

2.14 PANELBOARDS

Provide panelboards in accordance with the following:

a. UL 67 and UL 50 having a short-circuit current rating as indicated.

b. Panelboards for use as service disconnecting means: 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. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings.

f. Use of "Subfeed Breakers" is not acceptable.

g. Main breaker: "separately" mounted "above" or "below" branch breakers.

h. Where "space only" is indicated, make provisions for future installation of breakers.

i. Directories: indicate load served by each circuit in panelboard.

j. Directories: indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).

k.Type directories and mount in holder behind transparent protective covering.

l. Panelboards: listed and labeled for their intended use.

m. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.14.1 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 conduit hubs welded to the cabinet.

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.

2.14.2 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.

2.14.3 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. Where indicated on the drawings, provide circuit breakers with shunt trip devices. Series rated circuit breakers and plug-in circuit breakers are unacceptable.

2.14.3.1 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.

2.14.3.2 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.

2.14.4 400 Hz Panelboard and Breakers

Provide panelboards and breakers for use on 400 Hz systems rated and labeled "400 Hz."

2.14.5 Lighting Control Panelboards

Provided a lighting control panelboard having the following features:

a. Minimum sixteen schedules including a 7-day repeating schedule with sixteen daily on/off periods.

b. Minimum sixteen lighting zones grouping branch breakers that are controlled by schedules, manual inputs, or override commands.

c. Electronic clock including real-time, astronomical clock, and leap year and daylight savings time adjustments.

d. Burn-hour tracking.

e. Remote circuit breaker operation.

g. Communications with building automation system using Modbus RTU protocol via RS-485 cable connection.

2.15 ENCLOSED CIRCUIT BREAKERS

UL 489. Individual molded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit current interrupting rating as indicated. Enclosure type as indicated. Provide solid neutral.

2.16 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.

2.17 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 enclosure.

c. Taps for transformers 15 kVA and larger: Two 2.5 percent taps Full Capacity Above Nominal (FCAN) and four 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.

2.17.1 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.

2.18 MOTORS

Provide motors in accordance with the following:

a. NEMA MG 1except provide fire pump motors as specified in Section 21 30 00 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-Rated motors designed to operate with adjustable speed drive (ASD).

2.18.1 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.

2.18.2 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.

2.18.3 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.

2.18.4 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 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.

2.19 MOTOR CONTROLLERS

Provide motor controllers in accordance with the following:

a. UL 508, NEMA ICS 1, and NEMA ICS 2, except fire pump controllers as specified in Section 21 30 00 FIRE PUMPS.

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.

i. 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.

j. 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.

k. 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.

l. Provide controllers in hazardous locations with classifications as indicated.

2.19.1 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.

2.19.2 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.

2.19.2.1 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.

2.19.3 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.

2.19.4 Enclosures for Motor Controllers

NEMA ICS 6.

2.19.5 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.

2.19.6 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.

2.19.7 Pilot and Indicating Lights

Provide LED cluster lamps.

2.20 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)

Single pole designed for flush or surface mounting with overload protection and pilot lights.

2.20.1 Pilot Lights

Provide yoke-mounted, seven element LED cluster light module. Color: in accordance with NEMA ICS 2.

2.21 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.

2.22 TELECOMMUNICATIONS SYSTEM

Provide system of telecommunications wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires cable trays, and other accessories for telecommunications outlets and pathway in accordance with TIA-569 and as specified herein. Additional telecommunications requirements are specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.23 GROUNDING AND BONDING EQUIPMENT

2.23.1 Ground Rods

UL 467. Ground rods: cone pointed copper-clad steel, with minimum diameter of 3/4 inch and minimum length 10 feet. Sectional ground rods are permitted.

2.23.2 Ground Bus

Copper ground bus: provided in the electrical equipment rooms as indicated.

2.23.3 Telecommunications Grounding 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 telecommunications main grounding busbar (TMGB) in the telecommunications entrance facility. The telecommunications main grounding busbar (TMGB): sized in accordance with the immediate application requirements and with consideration of future growth. Provide telecommunications grounding 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 TMGB with length as indicated;

c. Listed by a nationally recognized testing laboratory.

2.24 HAZARDOUS LOCATIONS

Electrical materials, equipment, and devices for installation in hazardous locations, as defined by NFPA 70: specifically approved by Underwriters' Laboratories, Inc., or Factory Mutual for particular "Class," "Division," and "Group" of hazardous locations involved. Boundaries and classifications of hazardous locations: as indicated. Equipment in hazardous locations: comply with UL 1203 for electrical equipment and industrial controls and UL 674 for motors.

2.25 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.

2.26 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.

e. Surface: matte finish. Corners: square. Accurately align lettering and engrave into the core.

f. Minimum size of nameplates: one by 2.5 inches.

g. Lettering size and style: a minimum of 0.25 inch high normal block style.

2.27 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.

2.28 FIRESTOPPING MATERIALS

Provide firestopping around electrical penetrations in accordance with Section 07 84 00 FIRESTOPPING.

2.29 WIREWAYS

UL 870. Material: steel galvanized 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 or 3R enclosure per NEMA ICS 6.

2.30 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance, panelboards indicated. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. SPD must have the same short-circuit current rating as the protected equipment and shall 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)
- Phase to ground (L-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

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.

2.31 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.

2.32 SOURCE QUALITY CONTROL

2.32.1 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.

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 Hazardous Locations

Perform work in hazardous locations, as defined by NFPA 70, in strict accordance with NFPA 70 for particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by NFPA 70. Provide conduit with tapered threads.

3.1.3 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.1.3.1 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.

3.1.4 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. 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.

3.1.4.1 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.

3.1.4.2 Metal-Clad Cable

Install in accordance with NFPA 70, Type MC cable.

3.1.4.3 Armored Cable

Install in accordance with NFPA 70, Type AC cable.

3.1.5 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.

3.1.5.1 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).

3.1.5.2 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).

3.1.5.3 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.

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3.1.5.4 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).

3.1.5.5 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40; or fiberglass. Convert nonmetallic conduit to plastic-coated rigid, or IMC, steel conduit before rising through floor slab. Plastic coating: extend minimum 6 inches above floor.

3.1.5.6 Conduit Interior to Buildings for 400 Hz Circuits

Aluminum or nonmetallic. Where 400-Hz conduit runs about ground, provide aluminum conduit. Where 400-Hz circuit runs underground or through concrete, provide PVC Schedule 80 conduit.

3.1.5.7 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.5.8 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.

3.1.5.9 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.

3.1.5.10 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.

3.1.5.11 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. 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. Where conduit crosses building expansion joints, provide suitable 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.

3.1.5.12 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.

3.1.5.13 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.

3.1.5.14 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 conduit in wet and damp locations and in fire pump rooms for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.1.5.15 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-C.1. Size conduits, and cable trays in accordance with TIA-569 and as indicated.

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, and cable trays for telecommunications risers in accordance with TIA-569 and as indicated.

3.1.6 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.

3.1.7 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. 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.

3.1.8 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.

3.1.9 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, or when installed in hazardous areas 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.

3.1.9.1 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.

3.1.9.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, 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.

3.1.10 Mounting Heights

Mount panelboards, enclosed circuit breakers, motor controller and disconnecting switches so height of operating handle at its highest position is maximum 78 inches above floor. Mount lighting switches 48 inches above finished floor. Mount receptacles and telecommunications outlets 30 inches above finished floor, unless otherwise indicated. Mount other devices as indicated. Measure mounting heights of wiring devices and outlets in non-hazardous areas to the bottom of device or outlet. Measure mounting heights of receptacle outlet boxes in the hazardous area to the bottom of the outlet box.

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.

3.1.13 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.

3.1.14 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.15 Grounding and Bonding

Provide in accordance with NFPA 70 and NFPA 780. Ground exposed, non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, and neutral conductor of wiring systems. Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Make connection to water pipe by suitable ground clamp or lug connection to plugged tee. If flanged pipes are encountered, make connection with lug bolted to street side of flanged connection. Supplement metallic water service grounding system with additional made electrode in compliance with NFPA 70. 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.

3.1.15.1 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, provide additional rods. 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.

3.1.15.2 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.

3.1.15.3 Ground Bus

Provide a copper ground bus in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of 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.

3.1.15.4 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.

3.1.15.5 Telecommunications System

Provide telecommunications grounding in accordance with the following:

a. Telecommunications Grounding Busbars: Provide a telecommunications main grounding busbar (TMGB) in the telecommunications entrance facility. Install the TMGB as close to the electrical service entrance grounding connection as practicable. Install telecommunications grounding 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 TMGB 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 exceeds3 feet in length, bond the conductors to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum.

c. Telecommunications Grounding Connections: Telecommunications grounding connections to the TMGB: 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 TMGB to the TMGB. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; bond each TMGB 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 TGB or TMGB 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 TGB 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.

3.1.16 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.

3.1.17 Elevator

Provide circuit to line terminals of elevator controller, and disconnect switch on line side of controller, outlet for control power, outlet receptacle and work light at midheight of elevator shaft, and work light and outlet receptacle in elevator pit.

3.1.18 Government-Furnished Equipment

Contractor shall 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.

3.1.20 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.

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.

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 shall 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 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.

3.5.6 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 24 13

SWITCHBOARDS

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	((2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A780/A780M	(2009; R 2015) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

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	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA PB 2.1	(2013) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NEMA PB 2	(2011) Deadfront Distribution Switchboards

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

UNDERWRITERS LABORATORIES (UL)

UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 891	(2005; Reprint Oct 2012) Switchboards

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor QC approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29, SUSTAINABITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Switchboard Drawings; G

SD-03 Product Data

Switchboard; G

SD-06 Test Reports

Switchboard Design Tests; G

Switchboard Production Tests; G

Acceptance Checks and Tests; G

SD-10 Operation and Maintenance Data

Switchboard Operation and Maintenance, Data Package 5; G

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals; G

Equipment Test Schedule; G

Request for Settings; G

Service Entrance Available Fault Current Label; G

1.5 QUALITY ASSURANCE

1.5.1 Product Data

Include manufacturer's information on each submittal for each component, device and accessory provided with the switchboard including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings.

b. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device.

1.5.2 Switchboard Drawings

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. 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. Include the nameplate data, size, and capacity on submittal. Also include applicable federal, military, industry, and technical society publication references on submittals. Include the following:

a. One-line diagram including breakers, current transformers, and meters.

b. Outline drawings including front elevation, section views, footprint, and overall dimensions.

c. Bus configuration including dimensions and ampere ratings of bus bars.

d. Markings and NEMA nameplate data.

e. Circuit breaker type, interrupting rating, and trip devices, including available settings.

f. Wiring diagrams and elementary diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device. Use this information (designer of record) to provide breaker settings that ensures protection and coordination are achieved.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" or "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 the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.4 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.

1.5.4.1 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.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Switchboard Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.6.2 Assembled Operation and Maintenance Manuals

Assemble and securely bind manuals in durable, hard covered, water resistant binders. Assemble and index the manuals in the following order with a table of contents:

a. Manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA.

b. Catalog data required by the paragraph SD-03, PRODUCT DATA.

c. Drawings required by the paragraph SD-02, SHOP DRAWINGS.

d. Prices for spare parts and supply list.

e. Design test reports.

f. Production test reports.

1.7 WARRANTY

Provide equipment items that are supported by service organizations 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 PRODUCT COORDINATION

Products and materials not considered to be switchboards and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2 SWITCHBOARD

NEMA PB 2 and UL 891.

2.2.1 Ratings

Provide equipment with the following ratings:

a. Voltage rating: 480Y/277 volts AC, three-phase, 4-wire.

b. Continuous current rating of the main bus: as indicated.

c. Short-circuit current rating: as indicated.

d. UL listed and labeled as service entrance equipment.

2.2.2 Construction

Provide the following:

a. Switchboard: consisting of one or more vertical sections bolted together to form a rigid assembly and rear aligned as indicated.

b. All circuit breakers: front accessible.

c. Rear aligned switchboards: front accessible load connections.

d. Where indicated, "space for future" or "space" means to include a vertical bus provided behind a blank front cover. Where indicated, "provision for future" means full hardware provided to mount a breaker suitable for the location.

e. Completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, and control wiring.

2.2.2.1 Enclosure

Provide the following:

a. Enclosure: NEMA ICS 6 Type 1.

b. Enclosure: bolted together with removable bolt-on side and rear covers.

c. Base: includes any part of enclosure that is within 3 inches of concrete pad.

d. Paint color: ASTM D1535 light gray No. 61 or No. 49 over rust inhibitor.

2.2.2.2 Bus Bars

Provide the following:

a. Bus bars: copper with silver-plated contact surfaces.

(1) Phase bus bars: uninsulated.

(2) Neutral bus: rated 100 percent of the main bus continuous current rating.

b. Make bus connections and joints with hardened steel bolts.

c. Main-bus (through bus): rated at the full ampacity of the main throughout the switchboard.

d. Minimum one-quarter by 2 inch copper ground bus secured to each vertical section along the entire length of the switchboard.

2.2.2.3 Main Section

Provide the main section consisting of an individually mounted fixed insulated-case circuit breaker.

2.2.2.4 Distribution Sections

Provide the distribution section consisting of individually mounted, molded-case circuit breakers as indicated.

2.2.3 Protective Device

Provide main and branch protective devices as indicated.

2.2.3.1 Insulated-Case Breaker

Provide the following:

a. UL 489. UL listed and labeled, standard rated branch breakers, manually operated, low voltage, insulated-case circuit breaker, with a short-circuit current rating as indicated at 480Y/277 volts.

b. Breaker frame size: as indicated.

c. Series rated circuit breakers are unacceptable.

2.2.3.2 Molded-Case Circuit Breaker

Provide the following:

a. UL 489. UL listed and labeled, standard rated branch breakers, manually operated, low voltage molded-case circuit breaker, with a short-circuit current rating of as indicated at 480Y/277 volts.

b. Breaker frame size: as indicated.

c. Series rated circuit breakers are unacceptable.

2.2.4 Electronic Trip Units

Equip main breakers with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that provides true rms sensing adjustable time-current circuit protection. Include the following:

a. Current sensors ampere rating: the same as the breaker frame rating.

b. Trip unit ampere rating: as indicated.

c. Ground fault protection: as indicated.

d. Electronic trip units: provide additional features:

  (1) Main breakers: include short delay pick-up and time settings, instantaneous settings and ground fault settings.

  (2) Distribution breakers: include short delay pick-up and time settings, instantaneous settings.

  (3) Main Breakers: include a digital display for phase and ground current.

  (4) Main Breakers: include a digital display for watts, vars, VA, kWh, kvarh, and kVAh.

  (5) Main Breakers: include a digital display for phase voltage, and percent THD voltage and current.

  (6) For electronic trip units that are rated for or can be adjusted to 1,200 amperes or higher, provide arc energy reduction capability with an energy-reducing maintenance switch with local status indicator.

2.2.5 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Provide short-circuiting type terminal boards associated with current transformer. Terminate conductors for current transformers with ring-tongue lugs. Provide terminal board identification that is identical in similar units. Provide color coded external wiring that is color coded consistently for similar terminal boards.

2.2.6 Wire Marking

Mark control and metering conductors at each end. Provide factory installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Provide a single letter or number on each sleeve, elliptically shaped to securely grip the wire, and keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Indicate on each wire marker the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.3 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. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each switchboard, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Identify on each nameplate inscription the function and, when applicable, the position. Provide nameplates of melamine plastic, 0.125 inch thick, white with black center core. Provide matte finish surface. Provide square corners. Accurately align lettering and engrave into the core. Provide nameplates with minimum size of one by 2.5 inches. Provide lttering that is a minimum of 0.25 inch high normal block style.

2.5 SOURCE QUALITY CONTROL

2.5.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Provide the following as part of test equipment calibration:

a. Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. Accuracy: Traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.

d. Dated calibration labels: visible on all test equipment.

e. Calibrating standard: higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Switchboard Design Tests

NEMA PB 2 and UL 891.

2.5.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

a. Short-circuit current test.

b. Enclosure tests.

c. Dielectric test.

2.5.3 Switchboard Production Tests

NEMA PB 2 and UL 891. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

a. 60-hertz dielectric tests.

b. Mechanical operation tests.

c. Electrical operation and control wiring tests.

d. Ground fault sensing equipment test.

2.6 ARC FLASH WARNING LABEL

Provide warning label for switchboards. Locate this self-adhesive warning label on the outside of the enclosure warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.7 SERVICE ENTRANCE AVAILABLE FAULT CURRENT LABEL

Provide label on exterior of switchboards used as service equipment listing the maximum available fault current at that location. Include on the label the date that the fault calculation was performed and the contact information for the organization that completed the calculation. Locate this self-adhesive warning label on the outside of the switchboard. Provide label format as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchboard

ANSI/NEMA PB 2.1.

3.3.2 Meters and Instrument Transformers

ANSI C12.1.

3.3.3 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.5 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.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

Mount switchboard on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 8 inches thick, reinforced with a 6 by 6 inch No. 6 mesh placed uniformly 4 inches from the top of the slab.

b. Place slab on a 6 inch thick, well-compacted gravel base.

c. Install slab such that the top of the concrete slab is approximately 4 inches above the finished grade.

d. Provide edges above grade 1/2 inch chamfer.

e. Provide slab of adequate size to project at least 8 inches beyond the equipment.

f. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

g. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

h. Cut off and bush conduits 3 inches above slab surface.

i. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.4.2 Interior Location

Mount switchboard on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 4 inches thick.

b. Install slab such that the top of the concrete slab is approximately 4 inches above the finished grade.

c. Provide edges above grade 1/2 inch chamfer.

d. Provide slab of adequate size to project at least 8 inches beyond the equipment.

e. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

f. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

g. Cut off and bush conduits 3 inches above slab surface.

h. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

Submit request for settings of breakers to the Contracting Officer after approval of switchboard and at least 30 days in advance of their requirement.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.5.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical, electrical, and mechanical condition.

(3) Verify appropriate anchorage, required area clearances, and correct alignment.

(4) Clean switchboard and verify shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.

(5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

(6) Verify that circuit breaker sizes and types correspond to approved shop drawings as well as to the circuit breaker’s address for microprocessor-communication packages.

(7) Verify that current transformer ratios correspond to approved shop drawings.

(8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(10) Confirm correct application of manufacturer's recommended lubricants.

(11) Inspect insulators for evidence of physical damage or contaminated surfaces.

(12) Verify correct barrier installation.

(13) Exercise all active components.

(14) Inspect all mechanical indicating devices for correct operation.

(15) Verify that filters are in place and vents are clear.

(16) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

(17) Inspect control power transformers.

b. Electrical Tests

(1) Perform insulation-resistance tests on each bus section.

(2) Perform dielectric withstand voltage tests.

(3) Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

(4) Perform control wiring performance test.

(5) Perform primary current injection tests on the entire current circuit in each section of assembly.

3.5.1.2 Circuit Breakers

Low Voltage - Insulated-Case and Low Voltage Molded Case with Solid State Trips

a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect circuit breaker for correct mounting.

(3) Operate circuit breaker to ensure smooth operation.

(4) Inspect case for cracks or other defects.

(5) Inspect all bolted electrical connections for high resistance using low resistance ohmmeter, verifying tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

(1) Perform contact-resistance tests.

(2) Perform insulation-resistance tests.

(3) Perform Breaker adjustments for final settings in accordance with Government provided settings.

(4) Perform long-time delay time-current characteristic tests

(5) Determine short-time pickup and delay by primary current injection.

(6) Determine ground-fault pickup and time delay by primary current injection.

(7) Determine instantaneous pickup current by primary injection.

(8) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

3.5.1.3 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Verify that all 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 tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.5.1.4 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watthour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.5 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) IEEE 81. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contracting Officer 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

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SECTION 26 24 16.00 40

PANELBOARDS

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM 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.

ASTM INTERNATIONAL (ASTM)

ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA PB 1	(2011) Panelboards

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 70E	(2018; TIA 18-1; TIA 81-2) Standard for Electrical Safety in the Workplace

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595	(Rev C; Notice 1) Colors Used in Government Procurement

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations

UL 67	(2018; Reprint Oct 2019) UL Standard for Safety Panelboards
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 869A	(2006) Reference Standard for Service Equipment
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1449	(2014; Reprint Jul 2017) UL Standard for Safety Surge Protective Devices

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. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Panelboards; G

SD-06 Test Reports

Acceptance Tests; G

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

1.3 QUALITY CONTROL

1.3.1 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. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 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 which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product 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.

Products manufactured more than 3 years prior to date of delivery to site are not to be used, unless specified otherwise.

PART 2 PRODUCTS

2.1 PANELBOARDS

Provide panelboards in accordance with NEMA PB 1, UL 67, and UL 50. Ensure panelboards for use as service equipment are also in accordance with UL 869A. Ensure panelboards have current rating, number of phases, and number of wires as indicated or specified herein. Ensure panelboards are rated for 120/208-volt, three-phase or 277/480-volt, three-phaseat 60- or 400-hertz as indicated. Ensure each panelboard, as a complete unit, has a short-circuit current rating equal to or greater than the integrated equipment rating indicated, but in no case less than 10,000 amperes symmetrical.

Provide panelboards with bolt-on circuit breakers only. Use of plug-in style breaker is not permitted. Ensure panelboards are designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining required clearance. Provide main lugs or main circuit breakers mounted "above" or "below" branch breakers with current ratings as indicated. Use of sub-feed breakers is not acceptable unless specifically indicated otherwise. Where "space only" is indicated, make provisions for future installation of breakers.

Submit detail drawings and manufacturer's standard product data for panelboards. Detail drawings consist of fabrication and assembly drawings for all parts of the work in sufficient detail to verify conformity with all requirements. Ensure drawings for panelboards indicate details of bus layout, overall physical features, dimensions, ratings, service requirements, and weights of equipment.

2.2 COMPONENTS

2.2.1 Enclosure

Ensure panelboard enclosures are NEMA 250, Type 1 as indicated and in accordance with UL 50 and NEMA PB 1.

Provide surface mounted panelboard cabinets. Ensure cabinets are constructed of 12 gauge sheet steel and hot-dipped galvanized after fabrication. Ensure front of cabinet is form-flanged or fitted with structural shapes welded or riveted to the sheet steel for supporting the panelboard front. Provide panelboard cabinets fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than 1/8 inch.

Provide front cover with center door for access to circuit breakers. Ensure circuit breaker access doors are equipped with pin-tumbler cylinder locks. Ensure all locks provided, including locks for hinged covers, are identically keyed and properly tagged. Provide two keys for each enclosure.

Finish panelboards with baked enamel. Finish color is ASTM D1535 No. 61 gray conforming to FED-STD-595.

Where indicated, provide panelboards with circuit breakers rated for use on 400 Hz systems and labeled "400 Hz."

2.2.2 Panelboard Buses

Provide copper buses of the rating indicated, with main lugs or main circuit breaker. Provide all panelboards for use on grounded ac systems with a separate grounding bus in accordance with UL 67 bonded to the panelboard enclosure. Ensure grounding bus is a solid bus bar of rectangular cross section equipped with binding screws for the connection of equipment grounding conductors. Provide three-phase, four-wire and single-phase, three-wire panelboards with an isolated full-capacity bus providing spaces for single-pole circuit breaker switches and spaces indicated as spare.

Provide bus bar connections to the branch circuit breakers that are the "distributed phase" or "phase sequence" type. Ensure single-phase, three-wire panelboard busing is such that when any two adjacent single-pole breakers are connected to opposite phases, two-pole breakers can be installed in any location. Ensure that three-phase, four-wire panelboard busing is such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two- or three-pole breakers can be installed at any location. Ensure current-carrying parts of the bus assembly are plated.

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.

2.2.3 Circuit Breakers

Provide circuit breakers that conform to UL 489 and NEMA AB 3 with frame a trip ratings as indicated.

Provide bolt-on type, molded-case, manually operated, trip-free circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection. Completely enclose circuit breakers in a molded case, with a factory-sealed, calibrated sensing element to prevent tampering. Plug-in type, tandem, and half-size circuit breakers are not permitted.

Provide inverse-time-delay thermal-overload protection and instantaneous magnetic short-circuit protection. Provide an instantaneous thermal-magnetic tripping element that is adjustable and accessible from the front of the breaker on frame sizes larger than 100 amperes.Provide circuit breakers with frame sizes 250 ampere and larger with electronic trip units equipped with adjustable long-time and short-time settings in addition to instantaneous.

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 A and that conform to NEMA AB 3. Series rating of circuit breakers or overcurrent protective devices to achieve indicated interrupt rating is not permitted.

Provide the common-trip-type multipole circuit breakers having a single operating handle and a two-position on/off indication. Provide circuit breakers with temperature compensation for operation in an ambient temperature of 104 degrees F. Provide circuit breakers that have root mean square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied. Interrupting ratings may have selective-type tripping (time delay, magnetic, thermal, or ground fault).

Provide a phenolic-composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required to meet lock-out/tag-out requirements of NFPA 70E.

Provide shunt trips where indicated.

Ensure branch circuit breakers supplying convenience receptacle circuits have sensitive instantaneous trip settings of not more than 10 times the trip rating of the breaker to prevent repeated arcing shorts resulting from frayed appliance cords. Provide UL listed single-pole 15- and 20-ampere circuit breakers as "Switching Breakers" at 120 volts ac and 277 volts ac.

When multiple wires per phase are specified, furnish the circuit breakers with connectors made to accommodate multiple wires.

Ensure circuit breaker spaces called out on the drawings are complete with mounting hardware to permit ready installation of the circuit breakers.

2.2.3.1 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.

2.2.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect and trip on current imbalance of 6 milliamperes or greater per requirements of UL 943 for Class A ground-fault circuit interrupter. Tripping of a branch circuit breaker containing ground fault circuit interruption is not to disturb the feeder circuit to the panelboard.

2.2.3.3 Circuit Breakers for HVAC Equipment

Provide circuit breakers for HVAC equipment having motors (group or individual) marked for use with HACR type and UL listed as HACR type.

2.2.4 Directory Card and Holder

Provide a directory card on the inside of hinged fronts and doors under non-flammable plastic, with spaces for circuit numbers and load supplied. Where hinged fronts or doors are not required, provide the directory card under plastic mounted on the left-hand side of the front trim. Ensure the directory card includes type written designations identifying each branch circuit with its respective and numbered circuit breaker.

2.2.5 Surge Protective Devices

Provide parallel type surge protective devices (SPD) which comply with

UL 1449 at the service entrance equipment and other panelboards as indicated. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker. Ensure SPDs are of the Metal Oxide Varistor (MOV) type and rated have fault current rating equal to or greater than the rating of the device to be protected. Where internal fuses are used, ensure fuses will allow maximum rated surge to pass without operating fuse.

Provide SPDs that are external to the equipment to be protected. Ensure SPDs are installed with external protective device sized in accordance with manufacturer's recommendations. Install SPD parallel to equipment to be protected and as close as possible to minimize wire length between SPD and equipment to be protected.

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)
- Phase to ground (L-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, L-G, and N-G Voltage Protection Rating:

600V 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
1,200V for 480Y/277V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120% of nominal voltage for 240 volts and below; 115% of nominal voltage above 240 volts to 480 volts.

2.2.6 Precautionary Label

To ensure persons are aware of immediate or potential hazard in the application, installation, use, or maintenance of panelboards, conspicuously mark each panelboard on the trim or dead front shield with the text (or equivalent) **DANGER** symbol. If the panel is supplied with a door, ensure the label is visible when the door is in the open position.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

Provide panelboards in compliance with UL 67.

PART 3 EXECUTION

3.1 INSTALLATION

Install panelboards in accordance with the manufacturer's instructions. Fully align and mount panels so that the height of the top operating handle does not exceed 78inches above the finished floor.

Ensure directory-card information is typewritten in capital letters to indicate loads served by each circuit and is mounted in holders behind protective covering.

3.2 FIELD QUALITY CONTROL

Do not energize panelboards until the recorded test data has been submitted to and approved by the Contracting Officer.

Provide test equipment, labor, and personnel as required to perform the acceptance tests as specified. Record and submit test data. Include the location and identification of panelboards and megohm readings versus time.

Conduct continuity tests using a dc device with buzzer . Document results as pass-fail.

Conduct continuity and insulation tests on the panelboards after the installation has been completed and before the panelboard is energized. Document results as pass-fail.

Conduct insulation tests on 480-volt panelboards using a 1,000-volt insulation-resistance test set. Record readings every minute until three equal and consecutive readings have been obtained. Ensure resistance between phase conductors and between phase conductors and ground is not less than 50 megohms.

Conduct insulation tests on panelboards rated 300 volts or less using a 500-volt minimum insulation-resistance test set. Record readings after 1 minute and until the reading is constant for 15 seconds. Ensure resistance between phase conductors and between phase conductors and ground is not less than 25 megohms.

Conduct phase-rotation tests on all panelboards using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment in a clockwise direction, facing the source.

3.3 CLOSEOUT ACTIVITIES

Submit manufacturer's instructions for panelboards including special provisions required to install equipment components and system packages. Provide special notices details impedances, hazards and safety precautions.

-- 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	(2017; Errata 1-2 2017; INT 1 2017) 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) 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	(2003; Corr 1 2018) 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	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification and on the drawings shall be as defined in IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

a. Maintenance manual shall provide:
   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

Submittals shall 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 shall indicate but not be limited to the following:

a. Elementary diagrams and wiring diagrams with terminals identified of advanced meter, current transformers, protocol modules, communications modules, and 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. 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.

1.4.3 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

Products manufactured more than 2 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.5 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.

1.6 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. Selfridge facility standards require the use of a Itron Centron Polyphase electric meter (with RF) - ITRON CP3 9S CL20 3 ERT DEMAND + CLOCK.

1.6.2 Selection Criteria

Metering components are part of a system that includes the physical meter, data recorder function and communications (modem) method. Every building site identified shall include sufficient metering components to measure the electrical parameters identified and to store and communicate the values as required in the following sections. Contractor shall verify that the metering system installed on any building site is compatible with the facility-wide communication and meter-reading protocol system. Contractor must connect the metering system to the facility-wide energy and utility monitoring and control system.

PART 2 PRODUCTS

2.1 POWER METERS

2.1.1 Physical and Common Requirements

a. Selfridge facility standards require the use of a Itron Centron Polyphase electric meter (with RF) - ITRON CP3 9S CL20 3 ERT DEMAND + CLOCK.

b. Metering system components shall be installed according to the Metering System Schedule shown in this specification.

c. Meter shall be a Class 20, transformer rated design.

d. Meter shall be rated for use at temperature from -40 degrees Centigrade to +70 degrees Centigrade.

e. Meter shall have NEMA 1 enclosure for surface mounting.

f. Surge withstand shall conform to IEEE C37.90.1.

g. Meter shall have a standard 4 -year warranty.

h. Meter shall comply 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. Meter shall be 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. Meter shall be capable of connection to the service voltage indiof

480Y/277V

c. Meter shall accept independent voltage inputs from each phase. Meter shall be auto-ranging over the full range of input voltages.

d. Voltage input shall be optically isolated to 2500 volts DC from signal and communications outputs. Components shall meet or exceed IEEE C37.90.1 (Surge Withstand Capability).

2.1.3 Current Requirements

a. Meter shall accept independent current inputs from each phase. Current transformer shall be installed with a full load rating as shown in the schedule.

b. Single ratio current transformer shall have an Accuracy Class of 0.6 with a maximum error of +/- 0.6% at 5.0 amps.

c. Current transformer shall have:

1. Insulation Class: All 600 volt and below current transformers shall be rated 10 KV BIL. Current transformers for 2400 and 4160 volt service shall be rated 25 KV BIL.

2. Frequency: Nominal 60Hz, 50Hz for bases that operate on 50Hz.

3. Burden: Burden class shall be selected for the load.

4. Phase Angle Range: 0 to 60 degrees.

d. Meter shall accept current input from standard instrument transformers (5A secondary current transformers.)

e. Current inputs shall have a continuous rating in accordance with IEEE C57.13.

f. Multi-ratio current transformer where indicated shall have a top range equal to or greater than the actual load. The Contractor shall be responsible for determining the actual ratio of each transformer. Current transformer shall conform to IEEE C57.13.

2.1.4 Electrical Measurements

Power meter shall 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 shall be capable of being changed without removal from service. The meter shall 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). Kilowatt-hours shall be recorded for each 15 minute interval and shall accumulate for 30 days. Memory for recording the interval readings shall be internal to the meter and ANSI C12.19 compliant. Meter shall provide time-stamped readings for every measured parameter.

g. Meter readings shall be true RMS.

2.1.5 Meter Accuracy

Power meter shall provide the following accuracies. Accuracies shall be measured as percent of reading at standard meter test points.

a. Power meter shall meet 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

Meter shall include the following output signals.

a. The meter will have a face display plate and shall display every electrical parameter indicated to be recorded. Meters shall not be required to indicate interval data collected in a data logger with a communications output feature. Peak values, instantaneous and cumulative values shall be displayed.b. Meter shall include optical output port capable of 9600 bps communication with a hand-held reading device. Optical device shall be compatible with ANSI C12.18e. Meter shall include output option for pulse output. KYZ pulse output related to kWatts/HR.

2.1.7 Installation Methods

a. Building mounted ("BLDG" in Metering Systems Schedule)

1. Meter bases shall be mounted inside the building near the service entrance equipment.

b. Common features.

1. PTs (if required for proper voltage range) and CTs shall be physically connected to the service entrance cables inside the service entrance disconnect enclosure.

2.1.8 Disconnecting Switches

a. Disconnecting wiring blocks shall be provided between the current transformer and the meter. A shorting mechanism shall be built into the wiring block to allow the current transformer wiring to be changed without removing power to the transformer. The wiring blocks shall be located 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. Voltage-monitoring circuits shall be equipped with disconnect switches to isolate the meter base or socket from the voltage source.

2.1.9 Meter Programming

a. Power meter shall be programmable by software supplied by the meter manufacturer.

b. Software shall have a user-friendly, Windows-compatible interface.

c. Software shall operate on Windows operating systems.

d. Software shall allow the user to configure the meter, troubleshoot meter, query and display meter parameters and configuration data and stored values.

e. Meter firmware shall be 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

The optical port shall 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.

2.2.1.3 Ethernet

For those meters using the Ethernet, logged information shall be sent using open standard Internet Protocols.

a. On-board Ethernet port support

    1. HTTP

    2. SMTP

        (a) Modbus

b. Distribute stored data by

    1. FTP

2.2.2 Communications Protocols and Methods

Communications protocols and methods shall be native to the meter. Provide communications module(s) as required to accomplish the following.

a. Meter shall 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. Meter shall have a port that can be configured as a 10/100 Base-T Ethernet port ("BaseT" in Metering Systems Schedule)

    1. A communication module that converts serial RS232 or RS485 to Ethernet will be acceptable.

2.2.3 Communications Channels Surge Protection

Communications equipment shall be protected against surges induced on its communications channels. Communication interfaces to all field equipment shall be protected 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. Fuses shall not be used for surge protection. Metallic cables and conductors which serve as communications channels between buildings shall have surge protection installed at equipment rated for the application installed at each end, within 3 feet of the building cable entrance. Surge protectors shall meet the requirements of the applicable extension of ANSI C62 (for example, ANSI C62.61).

2.3 METER DATA PROTOCOL

Power meters shall have communicating data protocols native or provided in supplemental modules to communicate with the communications methods that follow.

2.3.1 Open Protocol

Power meter shall support the following open protocols. Contractor shall verify that the meter native protocol is consistent with the facility data recording and communication and data storage system. Contractor shall provide additional converters and modules as required for a complete measurement, recording, communicating and data storage system.

a. Meter shall be 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-graphics-t

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.1.1 Existing Condition Survey

The Contractor shall perform a field survey, including inspection of all existing equipment, resulting clearances, and new equipment locations intended to be incorporated into the system, and furnish an existing conditions report to the Government. The report shall identify those items that are non-workable as defined in the contract documents. The Contractor shall be held responsible for repairs of modifications necessary to make the system perform as required.

3.1.2 Scheduling of Work and Outages

The Contract Clauses shall 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

1. Calibrate watthour meters according to manufacturer's published data.

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 Contractor shall 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, the Contracting Officer shall be given 5 working days' advance notice of the dates and times of checking and testing.

3.2.3 Training

The Contractor shall conduct a training course for meter configuration, operation, and maintenance of the system as specified. The training shall be oriented for all components and systems installed under this contract. Training manuals shall be delivered for 2 trainees with two additional copies delivered for archiving at the project site. The Contractor shall 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, the Contractor shall assume that attendees have a high school education or equivalent, and are familiar with utility systems. Approval of the planned training schedule shall be obtained from the Government at least 30 days prior to the training.

a. Training: The course shall be taught at the project site within thirty days after completion of the installation for a period of one 2 day(s). A maximum of 6 personnel will attend the course. The training shall include:

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
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.46	(2010) Standard for High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
IEEE C57.13	(2016) Requirements for Instrument Transformers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

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 2005; Errata 2008) 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 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA/ANSI C12.11	(2007) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

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

UNDERWRITERS LABORATORIES (UL)

UL 198M	(2018) UL Standard for Mine-Duty Fuses
UL 486E	(2015; Reprint Apr 2019) UL Standard for Safety Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2018) UL Standard for Safety Industrial Control Equipment
UL 845	(2005; Reprint Oct 2018) UL Standard for Safety Motor Control Centers
UL 1203	(2013; Reprint Jan 2020) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations

1.2 SYSTEM DESCRIPTION

The power system covered by this specification consists of: The 480Y/277-volt and 208Y/120-volt power distribution systems..

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
Equipment
System Coordinator
Installation

SD-06 Test Reports

Field Testing

SD-07 Certificates

Devices and Equipment

1.4 QUALITY ASSURANCE

1.4.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis shall 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. Experience data shall include at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers.

1.4.2 System Installer

Calibration, testing, adjustment, and placing into service of the protective devices shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience in protective devices.

1.5 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected when received and prior to acceptance from conveyance. Protect stored items from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced.

1.6 PROJECT/SITE CONDITIONS

Submit certificates attesting that all devices or equipment meet the requirements of the contract documents. Devices and equipment furnished under this section shall be suitable for the following site conditions.

Altitude	600 ft
Ambient Temperature	-22 to 104 degrees F
Frequency	60 Hz; 400 Hz
Hazardous Classification	Unclassified; Class 1, Division 2
Humidity Control	Air coniditioning in Office, Break, Meeting, and other finished areas.
Ventilation	Exhaust fans in Shops and Hangars.

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Provide protective devices and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory utility type use for at least two years prior to bid opening. Submit data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of non-adjustable protective devices.

2.2 NAMEPLATES

Provide nameplates to identify all protective devices and equipment. Nameplate information shall be in accordance with UL 489.

2.3 MOTOR CONTROLS AND MOTOR CONTROL CENTERS

Motor controls and motor control centers shall be in accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508and UL 845.

2.3.1 Motor Starters

Provide combination starters with circuit breakers and fusible switches as indicated.

2.3.2 Thermal-Overload Protection

Each motor of 1/8 hp or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.3.3 Low-Voltage Motor Overload Relays

2.3.3.1 General

Thermal overload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or controller, and shall be rated in accordance with the requirements of NFPA 70. Standard units shall be used for motor starting times up to 7 second.

2.3.3.2 Construction

Manual reset type thermal relays shall be bimetallic construction. Automatic reset type relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

2.3.3.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device and shall not be adjustable. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than 14 degrees F, an ambient temperature-compensated overload relay shall be provided.

2.3.4 Automatic Control Devices

2.3.4.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate horsepower rating.

2.3.4.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.3.4.3 Manual/Automatic Selection

a. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.

b. Connections to the selector switch shall only allow the normal automatic regulatory control devices to be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.4 LOW-VOLTAGE FUSES

2.4.1 General

Low-voltage fuses shall conform to NEMA FU 1. Time delay and nontime delay options shall be as shown or specified. Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilizes fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current characteristics requires for effective power system coordination.

2.4.2 Cartridge Fuses; Current-Limiting Type

Cartridge fuses, current-limiting type, Class RK5shall have tested interrupting capacity not less than 100,000 amperes. Fuse holders shall be the type that will reject Class H fuses.

a. Class R fuses shall conform to UL 198M.

2.4.2.1 Continuous Current Ratings (600 amperes and smaller)

Service entrance and feeder circuit fuses (600 amperes and smaller) shall be Class RK5 , current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.4.2.2 Motor and Transformer Circuit Fuses

Motor, motor controller, transformer, and inductive circuit fuses shall be Class RK5, current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.5 MEDIUM-VOLTAGE AND HIGH-VOLTAGE FUSES

2.5.1 General

Medium-voltage and high-voltage fuses shall be distribution fuse cutouts or power fuses, E-rated, C-rated, or R-rated current-limiting fuses as shown.

2.5.2 Construction

Units shall be suitable for outdoor use. Fuses shall have integral blown-fuse indicators. All ratings shall be clearly visible.

2.5.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Continuous-current ratings shall be as shown.

2.5.3.1 Fuse Cutouts

Medium-voltage fuses and cutouts shall be of the loadbreak enclosed type construction rated 15 kV and of the heavy -duty type. Open-link cutouts are not acceptable. Fuses shall be either indicating or dropout type. Fuse ratings shall be as indicated. Fuses cutouts shall be equipped with mounting brackets suitable for the indicated installations.

2.5.3.2 Power Fuses

Expulsion-type and Current-limiting power fuses shall have ratings in accordance with IEEE C37.46 and as follows:

Nominal voltage	4.8 kV
Rated maximum voltage	15 kV
Maximum symmetrical interrupting capacity	50,000
Rated continuous current	As indicated
BIL	95 kV Minimum

2.5.3.3 E-Rated, Current-Limiting Power Fuses

E-rated, current-limiting, power fuses shall conform to IEEE C37.46.

2.5.3.4 C-Rated, Current-Limiting Fuses

C-rated, current-limiting, power fuses shall open in 1000 seconds at currents between 170 and 240 percent of the C rating.

2.5.3.5 R-Rated, Current-Limiting Fuses

R-rated, current-limiting, fuses shall be used with medium-voltage motor controllers only. R-rated fuses shall conform to IEEE C37.46.

2.6 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

2.6.1 General

Motor short-circuit protectors shall conform to UL 508 and shall be provided as shown. Protectors shall be used only as part of a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection, and shall be rated in accordance with the requirements of NFPA 70.

2.6.2 Construction

Motor short-circuit protector bodies shall be constructed of high temperature, dimensionally stable, long life, nonhygroscopic materials. Protectors shall fit special MSCP mounting clips and shall not be interchangeable with any commercially available fuses. Protectors shall have 100 percent one-way interchangeability within the A-Y letter designations. All ratings shall be clearly visible.

2.6.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Letter designations shall be A through Y for motor controller Sizes 0, 1, 2, 3, 4, and 5, with 100,000 amperes interrupting capacity rating. Letter designations shall correspond to controller sizes as follows:

CONTROLLER SIZE	MSCP DESIGNATION
NEMA 0	A-N
NEMA 1	A-P
NEMA 2	A-S
NEMA 3	A-U
NEMA 4	A-W
NEMA 5	A-Y

2.7 MOLDED-CASE CIRCUIT BREAKERS

2.7.1 General

Molded-case circuit breakers shall conform to UL 489 and UL 489. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers. Circuit breakers and circuit breaker enclosures located in hazardous (classified) areas shall conform to UL 1203.

2.7.2 Construction

Molded-case circuit breakers shall be assembled as an integral unit in a supporting and enclosing housing of glass reinforced insulating material providing high dielectric strength. Circuit breakers shall be suitable for mounting and operating in any position. Lugs shall be listed for copper and aluminum conductors in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.7.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with UL 489. Ratings shall be coordinated with system X/R ratio.

2.7.4 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 100 amperes.

2.7.5 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be toroidal construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Short-time I square times t switch.

f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted.

h. Fixed ground-fault delay.

i. Ground-fault I square times t switch.

j. Overload, Short-circuit, Ground-fault trip indicators shall be provided.

2.7.6 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through I square times t to a value less than the I square times t of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.7.7 SWD Circuit Breakers

Circuit breakers rated 15 amperes or 20 amperes and intended to switch 277 volts or less fluorescent lighting loads shall be marked "SWD."

2.7.8 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

2.7.9 Motor Circuit Protectors (MCP)

Motor circuit protectors shall conform to UL 489 and UL 489 and shall be provided as shown. MCPs shall consist of an adjustable instantaneous trip circuit breaker in conjunction with a combination motor controller which provides coordinated motor circuit overload and short-circuit protection. Motor Circuit Protectors shall be rated in accordance with NFPA 70.

2.8 INSTRUMENT TRANSFORMERS

2.8.1 General

Instrument transformers shall comply with NEMA/ANSI C12.11 and IEEE C57.13.

Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on the drawings.

2.8.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be not less than 2.0 . Other thermal and mechanical ratings of current transformers and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accidental open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

2.8.2.1 For kW Hour and Demand Metering (Low Voltage)

Current transformers shall conform to IEEE C57.13. Current transformers with a metering accuracy Class of 0.3 through 0.6, with a minimum RF of 2 at 86 degrees F, with 600-volt insulation, and 10 kV BIL shall be provided. Butyl-molded, window-type current transformers mounted in the current transformer cabinet shall be provided.

2.9 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. They shall 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 contact 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 shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study. The studies shall 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.

2.9.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: the source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses.

2.9.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. Coordinate with the contracting officer for fault current availability at the site.

2.9.3 Single Line Diagram

A single line diagram shall be prepared 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 shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.9.4 Fault Current Analysis

2.9.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE 242, and IEEE 399.

2.9.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

2.9.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.9.5 Coordination Study

The study shall 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. The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided 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. 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) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.9.6 Study report

a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall 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. The report shall include recommended ratings and settings of all protective devices in tabulated form.

d. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

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.

3.2 INSTALLATION

Submit procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the devices and equipment. Install protective devices in accordance with the manufacturer's published instructions and in accordance with the requirements of NFPA 70 and IEEE C2.

3.3 FIELD TESTING

Prior to field tests, submit the proposed test plan consisting of complete field test procedure, tests to be performed, test equipment required, and tolerance limits, and complete testing and verification of the ground fault protection equipment, where used. Submit performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

3.3.1 General

Perform field testing in the presence of the Contracting Officer. Notify the Contracting Officer 7 days prior to conducting tests. Furnish all materials, labor, and equipment necessary to conduct field tests. Perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. Maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results.

3.3.2 Safety

Provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. Replace any devices or equipment which are damaged due to improper test procedures or handling.

3.3.3 Molded-Case Circuit Breakers

Circuit breakers shall be visually inspected, operated manually, and connections checked for tightness. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

-- 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	(2014) Recommended Practices and Requirements 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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2015) 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	(2014) Adjustable-Speed Drives
NEMA ICS 7.2	(2015) Application Guide for AC Adjustable Speed Drive Systems
NEMA MG 1	(2018) Motors and Generators

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

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

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508C	(2002; Reprint Nov 2010) Power Conversion Equipment

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 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" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29 SUSTAINABILITY REPORTING. 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.

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 508C 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 120 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.

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 have sensors in each phase, Class 10/20 selectable with tripping characteristic selected to protect motor against voltage and current unbalance and single phasing. Provide Class II ground-fault protection, with start and run delays to prevent nuisance trip on staring, analog communication module, NO isolated overload alarm contact, external overload, and reset push button.

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 factory set 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.

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 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, reduce power line transient voltage, line notching, DC bus over-voltage tripping and improve the inverter over-current and over-voltage conditions.

h. Historical logging information and displays:

(1) Running log of total power versus time.

(2) Total run time.

i. The ASD must be capable of automatic control by a remote 4-20 mA signal, by BACnet 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.

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.

(i) 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.

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

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SECTION 26 32 15.00

ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES

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 B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2016) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B31.3	(2016) Process Piping

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2018) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A181/A181M	(2014) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
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	(2020) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

ASTM D975	(2020) Standard Specification for Diesel Fuel Oils

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P	(1995) Performance Standard for Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1	(2000; R 2011) General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation
IEEE 43	(2013) Recommended Practice for Testing Insulation Resistance of Rotating Machinery
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 115	(2019) Guide for Test Procedures for Synchronous Machines: Part I Acceptance and Performance Testing; Part II Test Procedures and Parameter Determination for Dynamic Analysis
IEEE 120	(1989; R 2007) Master Test Guide for Electrical Measurements in Power Circuits
IEEE 519	(2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C50.12	(2005; R 2010) Standard for Salient Pole 50 HZ and 60 Hz Synchronous Generators and Generation/Motors for Hydraulic Turbine Applications Rated 5 MVA and above
IEEE C57.13	(2016) Requirements for Instrument Transformers
IEEE C57.13.1	(2006; R 2012) Guide for Field Testing of Relaying Current Transformers

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2018) International Building Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for

	Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 3046	(2002, 2006, 2009, 2001) Reciprocating Internal Combustion Engines - Performance--Part 1, 3, 4, 5, 6
ISO 8528	(1993; R 2018) Reciprocating Internal Combustion Engine Driven Alternating Current Generator Sets--Part 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13

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-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2018) Motors and Generators
NEMA PB 1	(2011) Panelboards
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA/ANSI C12.11	(2007) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2021) Flammable and Combustible Liquids Code
NFPA 37	(2018) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 54	(2018) National Fuel Gas Code
NFPA 58	(2020) 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

NFPA 99	(2018; TIA 18-1; ERTA 2 2018; ERTA 3 2020) Health Care Facilities Code
NFPA 110	(2016) Standard for Emergency and Standby Power Systems

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE ARP892	(1965; R 1994) DC Starter-Generator, Engine
SAE J537	(2016) Storage Batteries

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-5624	(2016; Rev W) Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-STD-461	(2015; Rev G) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

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

40 CFR 60	Standards of Performance for New Stationary Sources

UNDERWRITERS LABORATORIES (UL)

UL 142	(2006; Reprint Jul 2013) Steel Aboveground Tanks for Flammable and Combustible Liquids
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 1236	(2015; Reprint Mar 2016) UL Standard for Safety Battery Chargers for Charging Engine-Starter Batteries
UL 1437	(2006) Electrical Analog Instruments - Panel Board Types

1.2 RELATED MATERIALS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 26 08 00 APPARATUS INSPECTION AND TESTING apply to this section, except as modified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL

PROCEDURES:

SD-02 Shop Drawings

Engine-Generator Set and Auxiliary Equipment; G

Auxiliary Systems; G

Detailed Drawings; G

Acceptance; G

SD-03 Product Data

Harmonic Requirements; G

Engine-Generator Set Efficiencies; G

Emissions; G

filters; G

special tools; G

Remote Alarm Annunciator; G

Engine-Generator Parameter Schedule

Heat Exchanger

Generator

Manufacturer's Catalog

Spare Parts

Onsite Training

Vibration-Isolation

Posted Data and Instructions; G

Instructions; G

Experience

Field Engineer

General Installation

Exciter

SD-05 Design Data

Performance Criteria

Sound Limitations; G

Integral Main Fuel Storage Tank

Power Factor

Heat Exchanger

Time-Delay on Alarms

Cooling System

Vibration Isolation

Battery Charger

Capacity Calculations for Engine-Generator Set; G

Brake Mean Effective Pressure (BMEP) Calculations; G

Torsional Vibration Stress Analysis Computations; G

Capacity Calculations for Batteries; G

Turbocharger Load Calculations; G

SD-06 Test Reports

Performance Tests

Factory Inspection and Tests

Factory Tests

Onsite Inspection and Tests; G

Acceptance Checks and Tests; G

Functional Acceptance Tests; G

Maintenance Procedures; G

Operation and Maintenance Manuals; G

Inspections; G

Functional Acceptance Test Procedure; G

SD-07 Certificates

Cooling System

Vibration Isolation

Prototype Test

Reliability and Durability

Fuel System Certification; G

Start-Up Engineer; G

Instructor's Qualification Resume; G

Engine Emission Limits; G

Sound Limitations

Site Visit

Current Balance

Materials and Equipment

Factory Inspection and Tests

SD-09 Manufacturer's Field Reports

Engine Tests; G

Generator Tests; G

Assembled Engine-Generator Set Tests; G

SD-10 Operation and Maintenance Data

Preliminary Assembled Operation and Maintenance Manuals; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and the paragraph ASSEMBLED OPERATION AND MAINTENANCE MANUALS.

SD-11 Closeout Submittals

Posted Data and Instructions; G

Training Plan; G

1.4 QUALITY ASSURANCE

1.4.1 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, NEMA, etc., the design, fabrication and installation must also conform to the code.

1.4.2 Vibration Limitation

Limit the maximum engine-generator set vibration in the horizontal, vertical, and axial directions to 6 mils (peak-peak RMS), with an overall velocity limit of 0.95 inches/second RMS, at rated speed for all loads through 110 percent of rated speed. The engine-generator set must be provided with vibration isolation in accordance with the manufacturer's standard recommendation. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

1.4.3 Torsional Analysis

Submit torsional analysis including prototype testing or calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus/minus 10 percent.

1.4.4 Performance Data

Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor. Also submit a description of seismic qualification of the engine-generator mounting, base, and vibration isolation.

1.4.5 Experience

Each component manufacturer must have a minimum of 3 years' experience in the manufacture, assembly and sale of components used with stationary engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler must have a minimum of 3 years' experience in the manufacture, assembly and sale of stationary engine-generator sets for commercial and industrial use. Submit a statement showing and verifying these requirements.

1.4.6 Field Engineer

The engine-generator set manufacturer or assembler must furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. The field engineer must have attended the engine generator manufacturer's training courses on installation and operation and maintenance of engine generator sets. Submit a letter listing the qualifications, schools, formal training, and experience of the field engineer.

1.4.7 Detailed Drawings

Submit detailed drawings showing the following:

a. Base-mounted equipment, complete with base and attachments, including anchor bolt template and recommended clearances for maintenance and operation.

b. Starting system.

c. Fuel system.

d. Cooling system.

e. Exhaust system.

f. Electric wiring of relays, breakers, programmable controllers, and switches including single line and wiring diagrams.

g. Lubrication system, including piping, pumps, strainers, filters, electric heater, controls and wiring.

h. Location, type, and description of vibration isolation devices for all applications.

i. The safety system, including wiring schematics.

j. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and instrumentation.

k. Panel layouts.

l. Mounting and support for each panel and major piece of electrical equipment.

m. Engine-generator set rigging points and lifting instructions.

1.4.8 Auxiliary Systems Engine-Generator Set and Auxiliary Equipment Drawing Requirements

Submit drawings pertaining to the engine-generator set and auxiliary equipment, including but not limited to the following:

a. Certified outline, general arrangement (setting plan), and anchor bolt details. Show total weight and center of gravity of assembled equipment on the steel sub-base.

b. Detailed elementary, schematic wiring, and interconnection diagrams of the engine starting system, jacket coolant heating system, engine protective devices, engine alarm devices, engine speed governor system, generator and excitation system, and other integral devices.

c. Detailed elementary, schematic wiring; and interconnection diagrams of the fuel system, starting battery system, engine-generator control panel, generator circuit breaker, and remote alarm annunciator.

d. Dimensional drawings or catalog cuts of exhaust silencers, radiator, fuel oil cooler, valves and pumps, intake filters, vibration isolators, and other auxiliary equipment not integral with the engine-generator set.

1.4.9 Vibration Isolation System Certification

Submit certification from the manufacturer that the vibration isolation system will reduce the vibration to the limits specified in the paragraph VIBRATION ISOLATION.

1.4.10 Fuel System Certification

When the fuel system requires a fuel oil cooler as described in the paragraph FUEL OIL COOLER, submit certification from the engine manufacturer that the fuel system design is satisfactory.

1.5 DELIVERY, STORAGE, AND HANDLING

Properly protect materials and equipment, in accordance with the manufacturers recommended storage procedures,before, during, and after installation. Protect stored items from the weather and contamination. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

Deliver equipment on pallets or blocking wrapped in heavy-duty plastic, sealed to protect parts and assemblies from moisture and dirt. Protect and prepare batteries for shipment as recommended by the battery manufacturer. Store auxiliary equipment at the site in covered enclosures, protected from atmospheric moisture, dirt, and ground water.

1.6 EXTRA MATERIALS

Provide two sets of special tools and two sets of filters required for maintenance. Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. One handset must be provided for each electronic governor when required to indicate and/or change governor response settings. Furnish 4 liters one gallon of identical paint used on engine-generator set in manufacturer's sealed container with each engine-generator set.

Wrenches and tools specifically designed and required to work on the new equipment, which are not commercially available as standard mechanic's tools, must be furnished to the Contracting Officer.

Provide proposed operating instructions for the engine-generator set and auxiliary equipment laminated between matte-surface thermoplastic sheets and suitable for placement adjacent to corresponding equipment. After approval, install operating instructions where directed.

1.7 MAINTENANCE SERVICES

Submit the operation and maintenance manuals and have them approved prior to commencing onsite tests.

1.7.1 Operation Manual

Provide three copies of the manufacturers standard operation manual . Sections must be separated by heavy plastic dividers with tabs which identify the material in the section. Fold drawings with the title block visible, and placed in 8-1/2 by 11 inch plastic pockets with reinforced holes. The manual must include:

a. Step-by-step procedures for system startup, operation, and shutdown;

b. Drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems with their controls, alarms, and safety systems;

c. Procedures for interface and interaction with related systems to include automatic transfer switches and fire alarm/suppression systems.

1.7.2 Maintenance Manual

Provide three copies of the manufacturers standard maintenance manual . Separate each section by a heavy plastic divider with tabs. Fold drawings with the title block visible, and placed in plastic pockets with reinforced holes. The manual must include:

a. Factory-service, take-down overhaul, and repair service manuals, with parts lists.

b. The manufacturer's recommended maintenance schedule.

c. A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components.

d. A list of spare parts for each piece of equipment and a complete list of materials and supplies needed for operation.

1.7.3 Assembled Operation and Maintenance Manuals

The contents of the assembled operation and maintenance manuals must include the manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA and the manufacturer's O&M information specified in Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH.

a. Manuals must be in separate books or volumes, assembled and bound securely in durable, hard covered, water resistant binder, and indexed by major assembly and components in sequential order.

b. A table of contents (index) must be made part of the assembled O&M. The manual must be assembled in the order noted in table of contents.

c. The cover sheet or binder on each volume of the manuals must be identified and marked with the words, "Operation and Maintenance Manual."

1.8 SITE CONDITIONS

Protect the components of the engine-generator set, including cooling system components, pumps, fans, and similar auxiliaries when not operating and provide components capable of the specified outputs in the following environment:

a. Site Location: Selfridge B158

b. Site Elevation: 580 feet above mean sea level.

c. Ambient Temperatures:

(1) Maximum 100 degrees F dry bulb, 100 degrees F wet bulb.

(2) Minimum 0 degrees F dry bulb.

d. Design Wind Velocity: 16 mph.

e. Prevailing Wind Direction: 200 degrees

f. Seismic Zone: Zone 1 as defined by ICC IBC.

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

a. Provide and install each engine-generator set complete and totally functional, with all necessary ancillary equipment to include: air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; and engine exhaust system. Each engine-generator set must satisfy the requirements specified in the Engine-Generator Parameter Schedule. Submit certification that the engine-generator set and cooling system function properly in the ambient temperatures specified.

b. Provide each engine-generator set consisting of one engine, one generator, and one exciter mounted, assembled, and aligned on one base; and all other necessary ancillary equipment which may be mounted separately. Assemble sets having a capacity of 750 kW or smaller and attach to the base prior to shipping. Sets over 750 kW capacity may be shipped in sections. Provide set components that are environmentally suitable for the locations shown and that are the manufacturer's standard product offered in catalogs for commercial or industrial use. Provide a generator strip heater for moisture control when the generator is not operating. Identify any nonstandard products or components and the reason for their use.

2.1.1 Engine-Generator Parameter Schedule

Engine-Generator Set and Auxiliary Equipment Capacity Calculations for Engine-Generator Set

ENGINE-GENERATOR PARAMETER SCHEDULE	
Identification	Make/Model
Electrical Characteristics	
Power Rating	Emergency Standby Gross bhp rating / Net brake power rating 450 kW at 0.8 power factor
Governor Type	Type Make / Model Isochronous
Overload Capacity (Prime applications only)	110 percent of Service Load for 1 hour in 12 consecutive hours
Service Load	431.5 kVA (maximum) 38 kVA (continuous)
Motor Starting kVA (Max.)	396.5 kVA
Power Factor	0.8 lagging
Engine-Generator Applications	stand-alone
Voltage Regulation (No Load to Full Load)(Stand-alone applications)	plus or minus 2 percent (maximum)
Voltage Bandwidth	plus or minus 1 percent
Frequency	60 Hz
Voltage	480 volts

ENGINE-GENERATOR PARAMETER SCHEDULE	
Phases	3 Phase, Wye
Minimum Generator Sub-transient	13 percent Sub-transient
Nonlinear Loads	400 kVA
Max Step Load Increase	100 percent of Service Load at 0.8 PF
Transient Recovery Time with Step Load Increase (Voltage)	3.2 seconds
Transient Recovery	3.2 seconds
Time with Step Load Increase (Frequency)	
Maximum Voltage Deviation with Step Load Increase	30 percent of rated voltage
Maximum Frequency Deviation with	13 percent of rated frequency
Max Step Load Decrease (without	100 percent of Service Load at 0.8 PF
Frequency Bandwidth (steady state)	plus or minus 0.4 percent
Frequency Regulation (droop) (No Load to Full Load)	3 percent (maximum)
Frequency Bandwidth (steady state)	plus or minus 0.4 percent
Reactances	Synchronous reactance, Xd Transient reactance, X'd Sub-transient reactance, X"d Negative sequence reactance, X2 Zero sequence reactance, Xo
Capacity Calculations	
Calculations must verify that the engine-generator set power rating is adequate for the following load conditions:	

ENGINE-GENERATOR PARAMETER SCHEDULE					
Lighting	0.4 kW				
Computer	2 kW				
Uninterruptible Power Supplies (UPS)	0 kVA, 12 pulse				
Variable Frequency Drives (VFD)	396.5 kVA, 12 pulse				
Motor Starting Sequence	Starting Order	Size (hp)	Locked Rotor NEMA Code	Starting Method	Maximum Voltage Dip
	Fire Pump	400	F	VFD	30 Percent
Other Load	kW at 0.8 power factor				
Capacity Calculations for Batteries					
Calculation must verify that the engine starting battery capacity					
Mechanical Characteristics					
Engine Description	Strokes/cycle Number of cylinders Bore and Stroke, inches				
Engine Speed	1800 rpm				
Piston Speed	2025 fpm				
Heat Exchanger	fin-tube (radiator)				
Engine Cooling Type	water/ethylene glycol				
Intercooler Type	Air-to-Air / Jacket Water				
Induction Method	Naturally Aspirated / Turbocharged				
Turbocharger	Make / Model				
Max Time to Start and be Ready to Assume Load	10 seconds				
Max Summer Outdoor Temp (Ambient)	100 degrees F				
Min Winter Outdoor Temp (Ambient)	0 degrees F				

ENGINE-GENERATOR PARAMETER SCHEDULE	
Installation Elevation	580 above sea level
Engine-Generator Set Efficiencies	
Fuel Consumption	At 0.8 power factor, Gallons / hour for: 1 / 2 load 3 / 4 load Full Load
Generator Efficiency	At 0.8 power factor,(per cent) for: 1 / 2 load 3 / 4 load Full Load
Radiator Capacity	Coolant Type gpm coolant cfm air through radiator Btu per hr of heat exchange based on optimum coolant temperature to and from engine
Engine-Generator Set Emissions Data	
Exhaust Temperature	Degrees F at full load
Weight of Exhaust Gas	lb per hr at full load
Weight of Intake Air	lb per hr at full load
Total Heat Rejected	Btu per hr, at full load to: Jacket Coolant System Fuel Oil Cooling System
Emissions	lb per hr, at full load Total Suspended Particulate Particulate Matter with an average aerodynamic diameter of 10 microns Sulfur Dioxides Nitrogen Oxides (as NO_2) Carbon Monoxide Volatile Organic Compounds
Visible Emissions	Percent opacity at full load
Brake Mean Effective Pressure (BMEP) Calculations	

ENGINE-GENERATOR PARAMETER SCHEDULE
Calculation must verify that the engine meets the specified maximum BMEP, as follows: BMEP psi = (120,000 X bkW) X (792,000 X bhp) (rpm X cu. in.) Where: bkW bhp = bkW' + bkW" bhp' + bhp" bkW" bhp" is the Brake kW horsepower required by engine driven fan for cooling radiator or motor driven fan for cooling radiator. bkW' bhp' = kW/GEN.EFF. kW/(GEN.EFF. times 0.746) GEN.EFF. = Generator efficiency cu. in. = Total engine piston displacement in cubic inches rpm = Engine revolutions per minute kW = Minimum power rating
Torsional Vibration Stress Analysis Computations
Torsional vibrational stresses in the crankshaft and generator shaft of assembled engine and driven generator must not exceed 5000 psi when engine is driving generator at rated speed while assembled unit is loaded to rated engine-generator set power. Computations must be based on a mathematical model of the assembled generator set provided or based on calculations using measured values from tests on a unit identical to the one provided. Calculations based on models of, or measured data from, the unassembled engine and generator will not be acceptable. Calculations must include: a. A description of the system relating information pertinent to analysis such as operating speed range and identification plate data. b. A mass elastic assembly drawing, showing the arrangement of the units in the generator set and dimensions of shafting, including minimum diameters (or section moduli) of shafting in the system. c. A labeled line diagram of the mass elastic system indicating values of masses, stiffness, equivalent lengths, and equivalent diameters including basic assumptions and definition of terms. d. Sample computations showing procedures used to obtain resulting stress values. e. Computations indicating assembled engine-generator speed of 1800 rpm with assembly loaded to rated generator power and the resulting computed critical torsional stress values in the assembled engine crankshaft and generator shaft.
Turbocharger Load Calculations

ENGINE-GENERATOR PARAMETER SCHEDULE
NOTE: When the engine-generator set installation includes field installed exhaust system (i.e., the engine-generator set is installed internal to a building in lieu of in a self-contained outdoor enclosure), include the following paragraph. When the proposed exhaust system layout is different from that shown on the contract drawings, submit calculations showing that the external loads from the exhaust system such as weight and thermal expansion do not exceed the engine manufacturer's maximum allowed forces and moments on the turbocharger.

2.1.2 Rated Output Capacity

Provide each engine-generator-set with power equal to the sum of service load plus the machine's efficiency loss and associated ancillary equipment loads. Rated output capacity must also consider engine and/or generator oversizing required to meet requirements in paragraph Engine-Generator Parameter Schedule.

The engine must meet the specified maximum BMEP requirements at rated speed as calculated in accordance with the calculations in the engine-generator parameter schedule. The engine capacity must be based on the following:

a. Engine burning diesel fuel conforming to ASTM D975, Grade 2-D, or MIL-DTL-5624, Grade JP-5 at an ambient temperature of 85 degrees F. For stationary engines operated in the United States, diesel fuel requirements are found in 40 CFR 60 Subpart IIII.

b. Engine cooled by a radiator fan mechanically driven by the engine or remote with a motor driven fan.

c. Engine cooled by coolant mixture of water and ethylene glycol, 50 percent by volume of each.

Maximum BMEP, psi	
	Turbocharged
Four-cycle engines	327
Engine speed, rpm:	1800

2.1.2.1 Engine Emission Limits

Engine must be certified by the manufacturer to meet applicable EPA emission standards found in 40 CFR 60 Subpart IIII. In addition, engine must meet any applicable state or local emission requirements (ex: California SCAQMD).

2.1.2.2 Performance Class

The voltage and frequency behavior of the generator set must be in accordance with ISO 8528 operating limit values for performance Class G2.

2.1.3 Power Ratings

Power ratings must be in accordance with EGSA 101P.

2.1.4 Transient Response

The engine-generator set governor and voltage regulator must cause the engine-generator set to respond to the maximum step load changes such that output voltage and frequency recover to and stabilize within the operational bandwidth within the transient recovery time. The engine-generator set must respond to maximum step load changes such that the maximum voltage and frequency deviations from bandwidth are not exceeded.

2.1.5 Reliability and Durability

Each standby engine-generator set must have both an engine and a generator capable of delivering the specified power on a standby basis with an anticipated mean time between overhauls of no less than 5,000 hours operating with a load factor of 70 percent. Cite two like engines and two like generators that have performed satisfactorily in a stationary power plant, independent and separate from the physical location of the manufacturer's and assembler's facilities, for standby without any failure to start, including all periodic exercise. Provide like engines and generators that have had no failures resulting in downtime for repairs in excess of 72 hours during two consecutive years of service. Provide engines that are the same model, speed, bore, stroke, number and configuration of cylinders, and rated output capacity. Provide generators that are the same model, speed, pitch, cooling, exciter, voltage regulator and rated output capacity.

Submit a reliability and durability certification letter from the manufacturer and assembler to prove that existing facilities are and have been successfully utilizing the same components proposed to meet this specification, in similar service. Certification may be based on components, i.e. engines used with different models of generators and generators used with different engines, and does not exclude annual technological improvements made by a manufacturer in the basic standard-model component on which experience was obtained, provided parts interchangeability has not been substantially affected and the current standard model meets the performance requirements specified. Provide a list with the name of the installations, completion dates, and name and telephone number of a point of contact.

2.1.6 Engine-Generator Set Enclosure

Provide engine-generator set enclosures that are corrosion resistant and fully weather resistant. The enclosure must contain all set components and provide ventilation to permit operation at Service Load under secured conditions. Provide access doors to controls and equipment requiring periodic maintenance or adjustment. Provide removable panels for access to components requiring periodic replacement. The enclosure must be capable of being removed without disassembly of the engine-generator set or removal of components other than the exhaust system. The enclosure must reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS.

2.1.7 Vibration Isolation

Provide an engine-generator set with a vibration isolation system in accordance with the manufacturer's standard recommendation. Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor plus description of seismic qualification of the engine-generator mounting, base, and vibration isolation. Submit torsional analysis including prototype testing or and calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus 10 percent. Design and qualify vibration isolation systems as an integral part of the base and mounting system in accordance with the seismic parameters specified. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

2.1.8 Harmonic Requirements

Non-linear loads to be served by each engine-generator set are as indicated. The maximum linear load demand (kVA at PF) when non-linear loads will also be in use is as indicated.

2.1.9 Starting Time Requirements

Upon receipt of a signal to start, each engine generator set will start, reach rated frequency and voltage and be ready to assume load within the time specified. For standby sets used in emergency power applications, each engine generator set will start, reach rated frequency and voltage, and power will be supplied to the load terminals of the automatic transfer switch within the starting time specified.

2.2 NAMEPLATES

Provide the manufacturer's name, type or style, model or serial number and rating on a plate secured to the equipment for each major component of this specification. Provide plates and tags sized so that inscription is readily legible to operating or maintenance personnel and securely mounted to or attached in proximity of their identified controls or equipment. Lettering must be normal block lettering, a minimum of 0.25 inch high. As a minimum, provide nameplates for:

Engines	Relays
Generators	Transformers (CT & PT)
Regulators	Day tanks
Pumps and pump motors	Governors
Generator Breaker	Air Starting System
Economizers	Heat exchangers (other than base mounted)

Where the following equipment is not provided as a standard component by the engine generator set manufacturer, the nameplate information may be provided in the maintenance manual in lieu of nameplates.

Battery charger	Heaters
Switchboards	Exhaust mufflers
Switchgear	Silencers
Battery	Exciters

2.2.1 Materials

Construct ID plates and tags of 16 gage minimum thickness bronze or stainless steel sheet metal engraved or stamped with inscription. Construct plates and tags not exposed to the weather or high operational temperature of the engine of laminated plastic, 0.125 inch thick, matte white finish with black center core, with lettering accurately aligned and engraved into the core.

2.2.2 Control Devices and Operation Indicators

Provide ID plates or tags for control devices and operation indicators, including valves, off-on switches, visual alarm annunciators, gages and thermometers, that are required for operation and maintenance of provided mechanical systems. Plates or tags must be minimum of 0.5 inch high and 2 inches long and must indicate component system and component function.

2.2.3 Equipment

Provide ID plates of a minimum size of high and 5 inches long on provided equipment indicating the following information:

a. Manufacturer's name, address, type and model number, serial number, and certificate of compliance with applicable EPA mission standards;

b. Contract number and accepted date;

c. Capacity or size;

d. System in which installed; and

e. System which it controls.

2.3 SAFETY DEVICES

Exposed moving parts, parts that produce high operating temperatures, 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 such that proper operation of the equipment is not impaired.

2.4 MATERIALS AND EQUIPMENT

Submit certification stating that where materials or equipment are specified to comply with requirements of UL, written proof of such compliance has been obtained. The label or listing of the specified agency, or 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 are acceptable as proof.

2.4.1 Circuit Breakers, Low Voltage

UL 489.

2.4.2 Filter Elements

Provide the manufacturer's standard fuel-oil, lubricating-oil, and combustion-air filter elements.

2.4.3 Instrument Transformers

NEMA/ANSI C12.11.

2.4.4 Revenue Metering

IEEE C57.13.

2.4.5 Pipe (Fuel/Lube-Oil, Compressed Air, Coolant, and Exhaust)

ASTM A53/A53M, or ASTM A106/A106M steel pipe. Pipe smaller than 2 inches must be Schedule 80. Pipe 2 inches and larger must be Schedule 40.

2.4.5.1 Flanges and Flanged Fittings

ASTM A181/A181M, Class 60, or ASME B16.5, Grade 1, Class 150.

2.4.5.2 Pipe Welding Fittings

ASTM A234/A234M, Grade WPB or WPC, Class 150 or ASME B16.11, 3000 lb.

2.4.5.3 Threaded Fittings

ASME B16.3, Class 150.

2.4.5.4 Valves

MSS SP-80, Class 150.

2.4.5.5 Gaskets

Manufacturer's standard.

2.4.6 Pipe Hangers

MSS SP-58.

2.4.7 Electrical Enclosures

NEMA ICS 6.

2.4.7.1 Switchboards

NEMA PB 2.

2.4.7.2 Panelboards

NEMA PB 1.

2.4.8 Electric Motors

Provide electric motors that conform to the requirements of NEMA MG 1. Motors must have sealed ball bearings and a maximum speed of 1800 rpm. Motors used indoors must have drip-proof frames; enclose those that are used outside. Alternating current motors larger than 1/2 Hp must be of the squirrel-cage induction type for operation on 208 volts or higher, 60 Hz, and three-phase power. Alternating current motors 1/2 Hp or smaller, must be suitable for operation on 120 volts, 60 Hz, and single-phase power. Direct current motors must be suitable for operation on 125 volts.

2.4.9 Motor Controllers

Provide motor controllers and starters that conform to the requirements of NFPA 70 and NEMA ICS 2.

2.5 ENGINE

Each engine must operate on No. 2-D diesel fuel conforming to ASTM D975, must be designed for stationary applications and must be complete with ancillaries. The engine must be a standard production model shown in the manufacturer's catalog describing and depicting each engine-generator set and all ancillary equipment in sufficient detail to demonstrate complete specification compliance. The engine must be naturally aspirated, supercharged, or turbocharged. The engine must be 2- or 4-stroke-cycle and compression-ignition type. The engine must be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. The engine must have a minimum of two cylinders. Opposed-piston type engines must have more than four cylinders. Each block must have a coolant drain port. Equip each engine with an over-speed sensor.

ISO 3046. Diesel engines must be four-cycle naturally aspirated, or turbocharged, or turbocharged and intercooled; vertical in-line or vertical Vee type; designed for stationary service. Engines must be capable of immediate acceleration from rest to normal speed without intermediate idle/warm up period or pre-lubrication to provide essential electrical power. Two-cycle engines are not acceptable.

2.5.1 Sub-base Mounting

Mount each engine-generator set on a structural steel sub-base sized to support the engine, generator, and necessary accessories, auxiliaries and control equipment to produce a complete self-contained unit as standard with the manufacturer. Design the structural sub-base to properly support the equipment and maintain proper alignment of the engine-generator set in the specified seismic zone. In addition, provide sub-base with both lifting rings and jacking pads properly located to facilitate shipping and installation of the unit. Factory align engine and generator on the sub-base and securely bolt into place in accordance with the manufacturer's standard practice. Crankshaft must have rigid coupling for connection to the generator.

2.5.2 Assembly

Completely shop assemble each engine-generator set on its structural steel sub-base. Paint entire unit with manufacturer's standard paints and colors. After factory tests and before shipping, thoroughly clean and retouch painting as necessary to provide complete protection.

2.5.3 Turbocharger

If required by the manufacturer to meet the engine-generator set rating, provide turbine type driven by exhaust gas from engine cylinders, and direct connected to the blower supplying air to the engine intake manifold.

2.5.4 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.5.5 Crankcase Protection

2.5.6 Miscellaneous Engine Accessories

Provide the following engine accessories where the manufacturer's standard design permits:

a. Piping on engine to inlet and outlet connections, including nonstandard companion flanges.

b. Structural steel sub-base and vibration isolators, foundation bolts, nuts, and pipe sleeves.

c. Level jack screws or shims, as required.

d. Rails, chocks, and shims for installation of sub-base on the foundation.

e. Removable guard, around fan. Support guard, on engine sub-base, to suit manufacturer's standard.

2.5.7 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.6 FUEL SYSTEM

Provide fuel system conforming to the requirements of NFPA 30 and NFPA 37 and containing the following elements.

2.6.1 Pumps

Fuel transfer pumps may be mounted on the day tank. Pump must be horizontal, positive displacement. Direct-connect pump to motor through a flexible coupling. Equip each pump with a bypass relief valve, if not provided with an internal relief valve. Provide motor and controller in accordance with the paragraphs ELECTRIC MOTORS and MOTOR CONTROLLERS, respectively.

2.6.1.1 Main Pump

Provide engines with an engine driven pump. The pump must supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet the performance indicated within the parameter schedule. Base the fuel flow rate on meeting the load requirements and all necessary recirculation.

2.6.2 Fuel Filter

Provide a minimum of one full-flow fuel filter for each engine. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark the inlet and outlet connections of the filter.

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters must be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.6.3 Relief/Bypass Valve

Provide a relief/bypass valve to regulate pressure in the fuel supply line, return excess fuel to a return line and prevent the build-up of excessive pressure in the fuel system.

2.6.4 Integral Main Fuel Storage Tank

Provide each engine with an integral main fuel tank. Each tank must be factory installed and provided as an integral part of the generator manufacturer's product. Provide each tank with connections for fuel supply line, fuel return line, local fuel fill port, gauge, vent line, and float switch assembly. Provide a fuel return line cooler as recommended by the manufacturer and assembler. The temperature of the fuel returning to the tank must be below the flash point of the fuel. Mount the tank within the enclosure for each engine-generator set provided with weatherproof enclosures. The fuel fill line must be accessible without opening the enclosure.

a. All Tanks: UL 142. Provide integral in skid double wall (110 percent containment) fuel tanks with a minimum capacity of 8 hours of engine-generator set operation at full-rated load . Epoxy coat day tanks inside and prime and paint outside. Construct tanks of not less than 3/16 inch steel plate with welded joints and necessary stiffeners on exterior of tank. Provide a braced structural steel framework support. Weld tank top tight. Provide 4 1/2 inch square inspection port with a 2 inch NPT fill connection and spill box. Provide proper normal and emergency venting for the primary tank and emergency venting only for the secondary tank / containment basin in accordance with UL 142 requirements.

b. Float Switches for Day Tanks: Provide tank-top mounted or external float cage, single-pole, single-throw type designed for use on fuel oil tanks. Arrange high level float switches to close on rise of liquid level, and low level float switches to close on fall of liquid level. Mount float cage units with isolating and drain valves. Contacts must be suitable for the station battery voltage.

   (1) Critical low level float switch which must activate at 5 percent of normal liquid level must shut engine off.

   (2) Low-low level float switch which must activate alarm at 30 percent of normal liquid level.

   (3) Low level float switch which must open the fuel oil solenoid valve and start the fuel transfer pump at 75 percent of normal liquid level.

   (4) High level float switch which must close the fuel oil solenoid

valve and stop the fuel transfer pump at 90 percent of normal liquid level.

(5) Critical high level float switch which must activate alarm at 95 percent of normal liquid level.

c. Leak Detector Switch for All Tanks: Actuates when fuel is detected in containment basin, stops fuel transfer pump, and closes the fuel oil solenoid valve.

d. Control Panel for All Tanks: Provide NEMA ICS 6, Type 3R, enclosed control panel for each day tank. Control panel must include the following accessories.

(1) Power available LED (green).

(2) Critical low fuel alarm contacts for shut down of engine.

(3) Low-low level fuel alarm LED.

(4) Low-low level fuel alarm contracts for remote annunciator.

(5) Critical high level fuel alarm LED.

(6) Leak detecting alarm LED.

(7) Alarm horn.

e. Tank Gages for All Tanks: Provide buoyant force type gages for fuel tanks with dial indicator not less than 4 inches in size and arranged for top mounting. Calibrate each reading dial or scale for its specific tank to read from empty to full, with intermediate points of 1/4, 1/2, and 3/4.

f. Integral Base Tanks Used as Primary Tank: Provide a 2 inch opening at the tank fill port, fitted an overfill prevention valve (OPV). Additionally, the fill opening must be perpendicular to the tank in order to allow operation of the OPV. Integral base tank must be sized and configured such that the filling and venting nozzles are outside the generator cabinet for ease of accessibility, inspection, and maintenance. Level gage must be in the line of sight from the fill port.

g. External tanks (all non-integral base tanks) are specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.6.4.1 Fuel Transfer Pump

Fuel transfer pumps may be mounted on the day tank. Pump must be horizontal, positive displacement. Direct-connect pump to motor through a flexible coupling. Equip each pump with a bypass relief valve, if not provided with an internal relief valve. Provide motor and controller in accordance with the paragraphs ELECTRIC MOTORS and MOTOR CONTROLLERS, respectively.

2.6.4.2 Capacity

Each tank must have capacity to supply fuel to the engine for an uninterrupted 8-hour period at 100 percent rated load without being refilled.

2.6.4.3 Local Fuel Fill

Each local fuel fill port on the day tank must have a screw-on cap.

2.6.4.4 Fuel Level Controls

Provide tanks with a float-switch assembly to perform the following functions:

a. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.

b. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.

2.6.4.5 Arrangement

Integral tanks may allow gravity flow into the engine. Gravity flow tanks and any tank that allows a fuel level above the fuel injectors must have an internal or external factory installed valve located as near as possible to the shell of the tank. The valve must close when the engine is not operating. Provide integral day tanks with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The fuel supply line from the tank to the manufacturer's standard engine connection must be welded pipe.

2.7 LUBRICATION

Provide engine with a separate lube-oil system conforming to NFPA 30 and NFPA 37. Pressurize each system by engine-driven pumps. Regulate system pressure as recommended by the engine manufacturer. Provide a pressure relief valve on the crankcase for closed systems. Vent the crankcase in accordance with the manufacturer's recommendation. Do not vent the crankcase to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, must be piped to vent to the outside. The system must be readily accessible for service such as draining, refilling, etc. Each system must permit addition of oil and have oil-level indication with the set operating. The system must utilize an oil cooler as recommended by the engine manufacturer.

2.7.1 Lube-Oil Filter

Provide one full-flow filter for each pump. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark inlet and outlet connections.

2.7.2 Lube-Oil Sensors

Equip each engine with lube-oil pressure sensors located downstream of the filters and provide signals for required indication and alarms. Submit two complete sets of filters, required for maintenance, supplied in a suitable storage box. Provide these filters in addition to filters replaced after testing.

2.7.3 Precirculation Pump

Provide a motor-driven precirculation pump powered by the station battery, complete with motor starter, if recommended by the engine manufacturer.

2.8 COOLING SYSTEM

Provide each engine with its own cooling system to operate automatically while its engine is running. The cooling system coolant must use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across each engine must not exceed that recommended below. Submit a letter which certifies that the engine-generator set and cooling system function properly in the ambient temperature specified, stating the following values:

a. The maximum allowable inlet temperature of the cooling air.

b. The minimum allowable inlet temperature of the cooling air across the engine.

c. The maximum allowable temperature rise in the cooling air across the engine.

d. The minimum allowable inlet fuel temperature.

2.8.1 Coolant Pumps

Provide centrifugal coolant pumps. Each engine must have an engine-driven primary pump. Provide secondary pumps that are electric motor driven and have automatic controllers. Control raw-water circulating pump by manual-off-automatic controllers and must be electric motor driven.

2.8.2 Heat Exchanger

Provide heat exchanger with the size and capacity to limit the maximum allowable temperature rise in the coolant across the engine to that recommended and submitted for the maximum summer outdoor design temperature and site elevation. Submit manufacturer's data to quantify heat rejected to the space with the engine generator set at rated capacity. Provide heat exchangers that are corrosion resistant, suitable for service in ambient conditions of application.

2.8.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosion resistant film, provided that corrective measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Provide internal surfaces that are compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Provide heat exchangers that are pressure type incorporating a pressure valve, vacuum valve and a cap. Design caps for pressure relief prior to removal. Provide heat exchanger and cooling system that is capable of withstanding a minimum pressure of 7 psi and protect with a strong grille or screen guard. Provide heat exchanger with at least two tapped holes; equip one tapped hole with a drain cock, and plug the rest.

Provide for each engine-generator set, as standard with the manufacturer.

a. Design Conditions: Each radiator unit must have ample capacity to remove not less than the total Btu per hour of heat rejected by its respective engine at 100 percent full-rated load to the jacket water, fuel oil, and lubricating oil system, and intercooler. Radiator capacity must be rated at optimum temperature of coolant leaving the engine and intercooler as recommended by the engine manufacturer with an ambient dry bulb air temperature outside the enclosure of 100 degrees F maximum, and 0 degrees F minimum at the site elevation specified in the paragraph SITE CONDITIONS, and with the coolant mixture specified in the paragraph ENGINE CAPACITY. Pressure drop through the radiator must not exceed 6 psi when circulating the maximum required coolant flow. Radiator air velocity must be a maximum of 1500 feet per minute.

b. Engine Mounted Radiator Construction: Radiator fan must direct airflow from the engine outward through the radiator. Fan must be V-belt driven directly from the engine crankshaft. Radiator fan must have sufficient capacity to meet design conditions against a static restriction of 985 inch of water. Fan static capacity must be adjusted to suit the ductwork furnished. Cooling section must have a tube and fin-type core consisting of copper or copper base alloy tubes with nonferrous fins. Select engine-driven fans for quiet vibration-free operation. Make provision for coolant expansion either by self-contained expansion tanks or separately mounted expansion tanks, as standard with the manufacturer. Provide suitable guards for each fan and drive.

c. Coolant solution must be a mixture of clean water and ethylene glycol, 50 percent by volume each. Provide an anti-freeze solution tester suitable for the mixture.

2.8.3 Thermostatic Control Valve

Provide a modulating type, thermostatic control valve in the coolant system to maintain the coolant temperature range submitted in paragraph SUBMITTALS.

2.8.4 Temperature Sensors

Equip each engine with coolant temperature sensors. Provide temperature sensors with signals for pre-high and high indication and alarms.

2.9 SOUND LIMITATIONS

Submit sound power level data for the packaged unit operating at 100 percent load in a free field environment. The data should demonstrate compliance with the sound limitation requirements of this specification. Submit certification from the manufacturer stating that the sound emissions meet the specification. Do not exceed the following sound pressure levels in any of the indicated frequencies when measured in a free field at a radial distance of 22.9 feet 7 meters at 45 degrees apart in all directions when operating at 100 percent load.

Frequency Band (Hz)	Maximum Acceptable Sound Level (Decibels)
31	74
63	74
125	74

Frequency Band (Hz)	Maximum Acceptable Sound Level (Decibels)
250	74
500	74
1,000	74
2,000	74
4,000	74
8,000	74

2.10 AIR INTAKE EQUIPMENT

Locate filters and silencers in locations that are convenient for servicing. Provide high-frequency filter type silencers and locate in the air intake system as recommended by the engine manufacturer. Provide silencer to reduce the noise level at the air intake so that the indicated pressure levels specified in paragraph SOUND LIMITATIONS will not be exceeded. A combined filter-silencer unit meeting requirements for the separate filter and silencer items may be provided. Provide copper or rubber expansion elements in air-intake lines.

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters must be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.11 EXHAUST SYSTEM

Provide a separate and complete system for each engine. Support piping to minimize vibration. Where a V-type engine is provided, use a V-type connector, with necessary flexible sections and hardware, to connect the engine exhaust outlets.

2.11.1 Flexible Sections and Expansion Joints

Provide a flexible section at each engine and an expansion joint at each muffler. Provide flexible sections and expansion joints that have flanged connections. Provide flexible sections made of convoluted seamless tube without joints or packing. Provide bellows type expansion joints. Provide stainless steel expansion and flexible elements suitable for engine exhaust gas at the maximum exhaust temperature that is specified by the engine manufacturer. Provide expansion and flexible elements that are capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.11.2 Exhaust Muffler

Provide a chamber type exhaust muffler. Provide welded steel muffler designed for inside vertical mounting. Provide eyebolts, lugs, flanges, or other items as necessary for support in the location and position indicated. Do not exceed the engine manufacturer's recommended pressure drop. Outside mufflers must be zinc coated or painted with high temperature 400 degrees F resisting paint. The muffler and exhaust piping together must reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. Provide muffler with a drain valve, nipple, and cap at the low-point of the muffler.

A residential class silencer must be provided for each engine which will reduce the exhaust sound spectrum by the following listed values at a 75 foot radius from the outlet, with generator set loaded to rated capacity and clear weather. Inlet and outlet connections must be flanged.

Octave Band Center Frequency (Hertz)								
Minimum Silencer Attenuation Decibels	63	125	250	500	1000	2000	4000	8000
Residental Class	10	25	32	30	25	25	24	23

2.11.3 Exhaust Piping

Slope horizontal sections of exhaust piping downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction must be long radius. Insulate exhaust piping, mufflers and silencers installed inside any building in accordance with paragraph THERMAL INSULATION and covered to protect personnel. Provide vertical exhaust piping with a hinged, gravity-operated, self-closing, rain cover.

Field installed exhaust piping must conform to the following:

a. Exhaust Piping: Provide flanges for connections to engines, exhaust mufflers, and flexible connections. Provide steel pipe conforming to ASTM A53/A53M for each engine complete with necessary fittings, flanges, gaskets, bolts, and nuts. Exhaust piping must be Schedule 40 pipe for 12 inches and smaller, standard weight for sizes 14 inches through 24 inches, and 0.25 inch wall thickness for sizes larger than 24 inches. Flanges must be Class 150 slip-on forged steel welding flanges in accordance with ASME B16.5, with material in accordance with ASTM A181/A181M, Grade I. Fittings must be butt welding conforming to ASTM A234/A234M, with wall thickness same as adjoining piping. Fittings must be of same material and wall thickness as pipe. Built-up miter welded fittings may be used. Miter angles of each individual section must not exceed 22.5 degrees total and not more than 11.25 degrees relative to the axis of the pipe at any one cut. Gaskets for exhaust piping must be of high temperature asbestos-free material suitable for the service and must be ASME B16.21, composition ring, 0.0625 inch thick. Bolting material for exhaust flanges must be alloy-steel bolt-studs conforming to ASTM A193/A193M, Grade B7 bolts and alloy-steel nuts conforming to ASTM A194/A194M, Grade 7. Bolts must be of sufficient length to obtain full bearing on the nuts and must project not more than two full threads beyond the nut. Provide stainless steel counterbalance type rain caps at termination of each exhaust pipe.

b. Expansion (Flexible) Joints: Provide sections of multiple corrugated stainless steel expansion joints in the engine exhaust piping for each engine to absorb expansion strains and vibration transmitted to the piping. Flexible joints must be suitable for operation at 200 degrees F above normal exhaust gas temperature at 100 percent load, 10,000 cycles, minimum. Joints must be flanged and located between engine exhaust manifold and exhaust piping, must be the same size as exhaust piping size, and must be designed and constructed for engine exhaust service.

c. Hangers and Supports: MSS SP-58.

d. Piping Sleeves: Provide where piping passes through masonry or concrete walls, floors, roofs, and partitions. Sleeves must be placed during construction. Unless indicated otherwise, pipe sleeves must comply with following requirements: sleeves in outside walls below and above grade, in floor, or in roof slabs, must be standard weight zinc coated steel pipe. Sleeves in partitions must be zinc coated sheet steel having a nominal weight of not less than 0.90 pound per square foot. Space between piping insulation and the sleeve must not be less than 0.25 inch. Sleeves must be held securely in proper position and location during construction. Sleeves must be sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs must extend 2 inches above the finished floor. Space between the pipe and the sleeve must be firmly packed with insulation and caulked at both ends of the sleeve with plastic waterproof cement.

e. Piping Insulation: Provide exhaust piping insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.12 EMISSIONS

The finished installation must comply with Federal, state, and local regulations and restrictions regarding the limits of emissions. Submit certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions specified. At a minimum this certification must include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and for hazardous air pollutants (HAPs).

2.13 STARTING SYSTEM

Provide starting system for standby engine generator sets used in emergency applications in accordance with NFPA 99 and NFPA 110and as follows.

2.13.1 Controls

Provide an engine control switch with functions including: run/start (manual), off/reset, and, automatic mode. Provide start-stop logic for adjustable cycle cranking and cool-down operation. Arrange the logic for manual starting and fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION. Provide electrical starting systems with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.13.2 Capacity

Provide starting system with sufficient capacity, at the maximum outdoor summer temperature specified to crank the engine without damage or overheating. The system must provide a minimum of three cranking periods with 15 second intervals between cranks. Each cranking period must have a maximum duration of 15 seconds. Starting must be accomplished using an adequately sized dc starter system with a positive shift solenoid to engage the starter motor and to crank the engine continuously for 60 seconds without overheating.

2.13.3 Electrical Starting

Manufacturers recommended dc system, utilizing a negative circuit ground. Starting motors must be in accordance with SAE ARP892.

2.13.3.1 Battery

Provide a starting battery system including the battery, battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. Provide battery in accordance with SAE J537. Size critical system components (rack, protection, etc.) to withstand the seismic acceleration forces specified. Provide lead-acid battery with sufficient capacity, at the minimum outdoor and maximum outdoor temperature specified, to provide the specified cranking periods. Valve-regulated lead-acid batteries are not acceptable.

Provide maintenance free, sealed, lead-acid, SAE Type D engine starting batteries. Batteries must have sufficient capacity to provide 60 seconds of continuous cranking of the engine in an ambient temperature of 0 degrees F.

2.13.3.2 Battery Charger

Provide a current-limiting battery charger, conforming to UL 1236, that automatically recharges the batteries. Submit battery charger sizing calculations. The charger must be capable of an equalize charging rate for recharging fully depleted batteries within 24 hours and a floating charge rate for maintaining the batteries at fully charged condition. Provide an ammeter to indicate charging rate. Provide a voltmeter to indicate charging voltage. Provide a timer for the equalize charging-rate setting. A battery is considered to be fully depleted when the output voltage falls to a value which will not operate the engine generator set and its components.

Provide 120 volt ac, enclosed, automatic equalizing, dual-rate, solid-state, constant voltage type battery charger with automatic ac line compensation. DC output must be voltage regulated and current limited. Charger must have two ranges, float and equalize, and must provide continuous taper charging. The charger must have a continuous output rating of not less than 10 amperes and must be sized to recharge the engine starting batteries in a minimum of 8 hours while providing the control power needs of the engine-generator set. Enclosure must be NEMA ICS 6, Type 1 . The following accessories must be included:

a. DC ammeter

b. DC voltmeter

c. Equalize light

d. AC on light

e. Low voltage light

f. High voltage light

g. Equalize test button/switch

h. AC circuit breaker

i. Low dc voltage alarm relay

j. High dc voltage alarm relay

k. Current failure relay

l. AC power failure relay

2.13.4 Storage Batteries

Provide storage batteries of suitable rating and capacity to supply and maintain power for the remote alarm annunciator for a period of 90 minutes minimum without the voltage applied falling below 87.5 percent of normal. Provide a 120 volt ac automatic battery charger.

2.13.5 Starting Aids

Provide one or more of other following methods to assist engine starting.

2.13.5.1 Jacket-Coolant Heaters

Mount a thermostatically controlled electric heater in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3 degrees F of the control temperature. The heater must operate independently of engine operation so that starting times are minimized. Power for the heaters must be 480 volts ac. Include necessary equipment, piping, controls, wiring, and accessories.

2.13.5.1.1 Prime Rated Sets

The control temperature must be the higher of the manufacturer's recommended temperature or the minimum coolant inlet temperature of the engine recommended in paragraph SUBMITTALS.

2.13.5.1.2 Standby Rated Sets

The control temperature must be the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.13.5.2 Lubricating-Oil Heaters

Mount a thermostatically controlled electric heater in the engine lubricating-oil system to automatically maintain the oil temperature within plus or minus 3 degrees F of the control temperature. The heater must operate independently of engine operation so that starting times are minimized. Power for the heaters must be 480 volts ac.

2.13.6 Exerciser

Provide exerciser in accordance with Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.14 GOVERNOR

Provide a forward acting type engine speed governor system. Steady-state frequency band and frequency regulation (droop) must be in accordance with the operating limit values of the performance class specified in the paragraph PERFORMANCE CLASS.

Provide engine with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100 percent of rated output capacity. Configure the governor for safe manual adjustment of the speed/frequency during operation of the engine-generator set, without special tools, from 90 to 110 percent of the rated speed/frequency, over a steady state load range of 0 to 100 percent or rated capacity. Submit two complete sets of special tools required for maintenance (except for electronic governor handset). Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. Provide a suitable tool box for tools. Provide one handset for each electronic governor when required to indicate and/or change governor response settings.

2.15 GENERATOR

Provide synchronous type, one or two bearing, generator conforming to the performance criteria in NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Submit calculations of the engine and generator output power capability, including efficiency and parasitic load data. Provide Class H insulation.

a. Select NEMA MG 1, Part 16, standby duty, and temperature rise of 130 degrees C for engine-generator sets which are expected to operate for less than 300 hours per year. Select NEMA MG 1, Part 22, continuous duty, and temperature rise of 105 degrees C for engine-generator sets expected to operate 300 hours or greater per year or rated 300 kW and above.

b. Select 2/3 pitch design option for engine-generator sets rated 300 kW and above.

c. Select 10-12 lead re-connectable for engine-generator sets rated 300 kW to 800 kW.

d. For applications requiring high SCR loading or in harsh environments laden with salts and chemicals, select vacuum pressure impregnation (VPI) insulated coils. When engine-generator sets are rated 800 kW and larger, also select form wound coils.

e. Provide salient-pole type, ac, brushless-excited, revolving field, air-cooled, self-ventilated, drip-proof guarded, coupled type, synchronous generator conforming to NEMA MG 1, Part 16 , and IEEE C50.12. Generator must be rated for standby duty at 100 percent of the power rating of the engine-generator set as specified in paragraph ENGINE-GENERATOR SET RATINGS AND PERFORMANCE. Temperature rise of each of the various parts of the generator must not exceed 130 degrees C as measured by resistance, based on a maximum ambient temperature of 40 degrees C. Winding insulation must be Class H.

f. Stator: Stator windings must be 2/3 pitch design .

g. Rotor: The rotor must have connected amortisseur windings.

h. Generator Space Heater: Provide 120 volt ac heaters. Heater capacity must be as recommended by the generator manufacturer to aid in keeping the generator insulation dry.

i. Grounding: Provide non-corrosive steel grounding pads located at two opposite mounting legs.

j. Filters: Provide manufacturer's standard generator cooling air filter assembly.

k. Design generator to protect against mechanical, electrical and thermal damage due to vibration, 25 percent overspeeds, or voltages and temperatures at a rated output capacity of 110 percent for prime applications and 100 percent for standby applications.

l. Provide generator ancillary equipment meeting the short circuit requirements of NEMA MG 1. Select drip-proof guarded option for generators without weatherproof enclosures.

m. Submit manufacturer's standard data for each generator (prototype data at the specified rating or above is acceptable), listing the following information:

(1) Direct-Axis sub-transient reactance (per unit).

(2) The generator kW rating and short circuit current capacity (both symmetric and asymmetric).

2.15.1 Current Balance

At 100 percent rated output capacity, and load impedance equal for each of the 3 phases, the permissible current difference between any 2 phases must not exceed 2 percent of the largest current on either of the 2 phases. Submit certification stating that the flywheel has been statically and dynamically balanced and is capable of being rotated at 125 percent of rated speed without vibration or damage.

2.15.2 Voltage Balance

At any balanced load between 75 and 100 percent of rated output capacity, the difference in line-to-neutral voltage among the 3 phases must not exceed 1 percent of the average line-to-neutral voltage. For a single phase load condition, consisting of 25 percent load at unity power factor placed between any phase and neutral with no load on the other 2 phases, the maximum simultaneous difference in line-to-neutral voltage between the phases must not exceed 3 percent of rated line to neutral voltage. The single-phase load requirement must be valid utilizing normal exciter and regulator control. The interpretation of the 25 percent load for single phase load conditions means 25 percent of rated current at rated phase voltage and unity power factor.

2.15.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced rated output capacity must not exceed 10 percent. The RMS of all harmonics must be less than 5.0 percent and that of any one harmonic less than 3.0 percent of the fundamental at rated output capacity. Design and configure engine-generator to meet the total harmonic distortion limits of IEEE 519.

2.16 EXCITER

Provide brushless generator exciter. Provide semiconductor rectifiers that have a minimum safety factor of 300 percent for peak inverse voltage and forward current ratings for all operating conditions, including 110 percent generator output at 104 degrees F ambient. The exciter and regulator in combination must maintain generator-output voltage within the limits specified.

Provide a brushless excitation system consisting of an exciter and rotating rectifier assembly , and permanent magnet generator integral with the generator and a voltage regulator. Insulation class for parts integral with the generator must be as specified in paragraph GENERATOR. System must provide a minimum short circuit of 300 percent rated engine-generator set current for at least 10 seconds. Steady state voltage regulation must be in accordance with the operating limit values of the performance class specified in the paragraph PERFORMANCE CLASS.

a. Exciter and Rotating Rectifier Assembly: Rectifiers must be provided with surge voltage protection.

b. Permanent Magnet Generator: Provide a voltage spike suppression device for permanent magnet generator (PMG) excitation systems.

c. Voltage Regulator: Voltage regulator must be solid state or digital, automatic, three-phase sensing, volts per hertz type regulator. Regulator must receive its input power from a PMG. Voltage variation for any 40 degree C change over the operating temperature range must be less than plus or minus 1.0 percent. Operating temperature must be minus 40 degree C to plus 70 degree C. Voltage adjust range must be plus to minus 5.0 percent of nominal. Inherent regulator features must include over excitation shutdown.

2.16.1 Electromagnetic Interference (EMI) Suppression

Provide as an integral part of the generator and excitation system, EMI suppression complying with MIL-STD-461.

2.17 VOLTAGE REGULATOR

Provide a solid-state voltage regulator, separate from the exciter, for each generator. Maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100 percent of rated output capacity. Configure regulator for safe manual adjustment of the engine-generator voltage output without special tools, during operation, from 90 to 110 percent of the rated voltage over the steady state load range of 0 to 100 percent of rated output capacity. Regulation drift exceeding plus or minus 0.5 percent for an ambient temperature change of 68 degrees F is not acceptable. Reactive droop compensation or reactive differential compensation must load share the reactive load proportionally between sets during parallel operation. Provide voltage regulator with a maximum droop of 2 percent of rated voltage over a load range from 0 to 100 percent of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.18 GENERATOR ISOLATION AND PROTECTION

Provide necessary devices for electrical protection and isolation of each engine-generator set and its ancillary equipment. The generator circuit breaker (IEEE Device 52) ratings must be consistent with the generator rated voltage and frequency, with continuous, short circuit withstand, and interrupting current ratings to match the generator capacity. Provide manually operated generator circuit breaker. Mount a set of surge capacitors at the generator terminals. Provide monitoring and control devices as specified in paragraph GENERATOR PANEL.

The generator circuit breaker must comply with UL 489 requirements for molded case, adjustable thermal magnetic trip type circuit breaker. The circuit breaker continuous current rating must be adequate for the power rating of the engine-generator set and the circuit breaker must be rated to withstand the short circuit current provided by the generator set. Provide circuit breaker in a NEMA ICS 6, Type 1 enclosure mounted on the engine-generator set.

2.18.1 Devices

Provide switches, circuit breakers, switchgear, fuses, relays, and other protective devices.

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects must conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical connections under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide controllers and contactors with maximum of 120-volt control circuits, and auxiliary contacts for use with controls furnished. When motors and equipment furnished are larger than size indicated, the cost of providing additional electrical service and related work must be included under this section.

2.19 SAFETY SYSTEM

Provide and install devices, wiring, remote panels, and local panels, etc., as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. Provide a safety system with a self-test method to verify its operability. Provide alarm signals that have manual acknowledgment and reset devices. The alarm signal systems must reactivate for new signals after acknowledgment is given to any signal. Configure the systems so that loss of any monitoring device will be dealt with as an alarm on that system element.

2.19.1 Audible Signal

Provide audible alarm signal sound at a frequency of 70 Hz at a volume of 75 dB at 10 feet. The sound must be continuously activated upon alarm and silenced upon acknowledgment. Locate signal devices as shown.

2.19.2 Visual Signal

The visual alarm signal must be a panel light. The light must be normally off, activated to be blinking upon alarm. The light must change to continuously lit upon acknowledgement. If automatic shutdown occurs, the display must maintain activated status to indicate the cause of failure and must not be reset until cause of alarm has been cleared and/or restored to normal condition. Shutdown alarms must be red; all other alarms must be amber.

2.19.3 Alarms and Action Logic

2.19.3.1 Shutdown

Accomplish simultaneous activation of the audible signal, activation of the visual signal, stopping the engine, and opening the generator main circuit breakers.

2.19.3.2 Problem

Accomplish activation of the visual signal.

2.19.4 Safety Indications and Shutdowns

Provide a local alarm panel with the following shutdown and alarm functions in accordance with NFPA 110 level 1 mounted either on or adjacent to the engine generator set.

A remote alarm panel is required for audible alarms, e.g., in the control room.

Indicator Function (at battery voltage)	NFPA 110 Level 1 CV S RA	NFPA 110 Level 2 CV S RA
Overcrank	X X X	X X O
Low water temperature	X NA X	X NA O
High engine temperature pre-alarm	X NA X	O NA NA
High engine temperature	X X X	X X O
Low lube oil pressure pre-alarm	NA NA NA	NA NA NA
Low lube oil pressure	X X X	X X O
Overspeed	X X X	X X O
Low fuel main tank	X NA X	O NA O
Low coolant level	X O X	X O X
EPS supplying load	X NA NA	O NA NA
Control switch not in automatic position	X NA X	X NA X
High battery voltage	X NA NA	O NA NA
Low cranking voltage	X NA X	O NA NA
Low voltage in battery	X NA NA	O NA NA

Indicator Function (at battery voltage)	NFPA 110 Level 1 CV S RA	NFPA 110 Level 2 CV S RA
Battery charger ac failure	X NA NA	O NA NA
Lamp test	X NA NA	X NA NA
Contacts for local and remote common alarm	X NA X	X NA X
Audible alarm silencing switch	NA NA X	NA NA O
Low starting air pressure	X NA NA	O NA NA
Low starting hydraulic pressure	X NA NA	O NA NA
Air shutdown damper when used	X X X	X X O
Symbology: CV: Control panel-mounted visual. S: Shutdown of EPS indication. RA: Remote audible. Symbology: CV: Control panel-mounted visual. S: Shutdown of EPS indication. RA: Remote audible. X: Required. O: Optional. NA: Not applicable.		

2.19.5 Time-Delay on Alarms

For startup of the engine-generator set, install time-delay devices bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. Submit the magnitude of monitored values which define alarm or action set points, and the tolerance (plus and/or minus) at which the devices activate the alarm or action for items contained within the alarm panels. The lube-oil time-delay device must return its alarm to normal status after the engine starts. The coolant time-delay device must return its alarm to normal status 5 minutes after the engine starts.

2.20 SYNCHRONIZING PANEL

Provide panel as specified in paragraph PANELS and provide controls, gauges, meters, and displays to include:

a. Frequency meters, dial type, with a range of 90 to 110 percent of rated frequency. Do not use vibrating-reed type meters . One must monitor generator output frequency ("Generator Frequency Meter") and the other must monitor the frequency of the parallel source ("Bus Frequency Meter").

b. Voltmeters, ac, dial type, 3-phase, with 4-position selector switch for the generator output ("Generator Volt Meter") and for the parallel power source ("Bus volt meter").

c. Automatic synchronizer.

d. Manual synchronizing controls.

e. Indicating lights for supplementary indication of synchronization.

f. Synchroscope.

g. Wattmeter, indicating.

2.21 PANELS

Each panel must be of the type and kind necessary to provide specified functions. Mount panels on the engine-generator set base by vibration/shock absorbing type mountings . Mount instruments flush or semiflush. Provide convenient access to the back of panels to facilitate maintenance. Calibrate instruments using recognized industry calibration standards. Provide a panel identification plate identifying the panel function. Provide a plate identifying the device and its function for each instrument and device on the panel. Provide switch plates identifying the switch-position function.

2.21.1 Enclosures

Design enclosures for the application and environment, conforming to NEMA ICS 6. Locking mechanisms must be keyed alike.

Provide for each engine-generator set and fabricate from zinc coated or phosphatized and shop primed 16 gage minimum sheet steel in accordance with the manufacturer's standard design. Provide a complete, weatherproof enclosure for the engine, generator, and auxiliary systems and equipment. Support exhaust piping and silencer so that the turbocharger is not subjected to exhaust system weight or lateral forces generated in connecting piping that exceed the engine manufacturer's maximum allowed forces and moments. The housing must have sufficient louvered openings to allow entrance of outside air for engine and generator cooling at full load. Design louvered openings to exclude driving rain and snow. Provide properly arranged and sized, hinged panels in the enclosure to allow convenient access to the engine, generator, and control equipment for maintenance and operational procedures. Provide hinged panels with spring type latches which must hold the panels closed securely and will not allow them to vibrate. Brace the housing internally to prevent excessive vibration when the set is in operation

2.21.2 Analog

Provide analog electrical indicating instruments in accordance with UL 1437 with semi-flush mounting. Switchboard, switchgear, and control-room panel-mounted instruments must have 250 degree scales with an accuracy of not less than 99 percent. Unit-mounted instruments must be the manufacturer's standard with an accuracy of not less than 98 percent. The instrument's operating temperature range must be minus 4 to plus 158 degrees F. Distorted generator output voltage waveform of a crest factor less than 5 must not affect metering accuracy for phase voltages, hertz and amps.

2.21.3 Electronic

Electronic indicating instruments must be true RMS indicating instruments, 100 percent solid state, state-of-the-art, microprocessor controlled to provide specified functions. Provide control, logic, and function devices that are compatible as a system, sealed, dust and water tight, and that utilize modular components with metal housings and digital instrumentation. Provide an interface module to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy less than 98 percent for unit mounted devices and 99 percent for control room, panel mounted devices, throughout a temperature range of minus 4 to 158 degrees F is not acceptable. Provide LED or back lit LCD data display. Additionally, the display must provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height must be 0.5 inch .

2.21.4 Parameter Display

Provide indication or readouts of the tachometer, lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and safety system parameters. Specify a momentary switch for other panels.

2.22 SURGE PROTECTION

Electrical and electronic components must be protected from, or designed to withstand the effects of surges from switching and lightning.

2.23 AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION

Provide fully automatic operation for the following operations: engine-generator set starting and load transfer upon loss of normal source; retransfer upon restoration of the normal source; and stopping of each engine-generator set after cool-down. Devices must automatically reset after termination of their function.

2.23.1 Automatic Transfer Switch

Provide automatic transfer switches in accordance with Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.23.2 Monitoring and Transfer

Provide devices to monitor voltage and frequency for the normal power source and each engine-generator set, and control transfer from the normal source and retransfer upon restoration of the normal source. Describe functions, actuation, and time delays as described in Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.24 MANUAL ENGINE-GENERATOR-SET SYSTEM OPERATION

Provide complete facilities for manual starting and testing of each set without load, loading and unloading of each set.

2.25 BASE

Provide a steel base. Design the base to rigidly support the engine-generator set, ensure permanent alignment of rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure that alignment is maintained during shipping and normal operation. The base must permit skidding in any direction during installation and must withstand and mitigate the affects of synchronous vibration of the engine and generator. Provide base with suitable holes for anchor bolts and jacking screws for leveling.

2.26 THERMAL INSULATION

Provide thermal insulation as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.27 PAINTING AND FINISHING

Clean, prime and paintthe engine-generator set in accordance with the manufacturer's standard color and practice.

2.28 FACTORY INSPECTION AND TESTS

Submit six complete reproducible copies of the factory inspection result on the checklist format specified below. Perform the factory tests on each engine-generator set. The component manufacturer's production line test is acceptable as noted. Run each engine-generator set for at least 1 hour at rated output capacity prior to inspections. Complete inspections and make all necessary repairs prior to testing. Use engine generator controls and protective devices that are provided by the generator set manufacturer as part of the standard package for factory tests. When controls and switchgear are not provided as part of the generator set manufacturer's standard package, the actual controls and protective devices provided for the project are not required to be used during the factory test. The Contracting Officer may provide one or more representatives to witness inspections and tests.

2.28.1 Factory Inspection

Perform inspections prior to beginning and after completion of testing of the assembled engine-generator set. Look for leaks, looseness, defects in components, proper assembly, etc. and note any item found to be in need of correction as a necessary repair. Use the following checklist for the inspection:

INSPECTION ITEM	GOOD	BAD	NOTES
Drive belts			
Governor and adjustments			
Engine timing mark			
Starting motor			

INSPECTION ITEM	GOOD	BAD	NOTES
Starting aids			
Coolant type and concentration			
Radiator drains			
Block coolant drains			
Coolant fill level			
All coolant line connections			
All coolant hoses			
Combustion air filter			
Combustion air silencer			
Lube oil type			
Lube oil sump drain			
Lube-oil filter			
Lube-oil-level indicator			
Lube-oil-fill level			
All lube-oil line connections			
All lube-oil lines			
Fuel type and amount			
All fuel-line connections			
All fuel lines			
Fuel filter			
Coupling and shaft alignment			
Voltage regulators			
Battery-charger connections			

INSPECTION ITEM	GOOD	BAD	NOTES
All wiring connections			
Instrumentation			
Hazards to personnel			
Base			
Nameplates			
Paint			
Exhaust-heat recovery unit			
Switchboard			
Switchgear			

2.28.2 Factory Tests

Submit a letter giving notice of the proposed dates of factory inspections and tests at least 14 days prior to beginning tests, including:

a. A detailed description of the manufacturer's procedures for factory tests at least 14 days prior to beginning tests.

b. Six copies of the Factory Test data described below in 8-1/2 by 11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Separate sections by heavy plastic dividers with tabs. Provide full size (8-1/2 by 11 inch minimum) data plots showing grid lines, with full resolution.

(1) A detailed description of the procedures for factory tests.

(2) A list of equipment used, with calibration certifications.

(3) A copy of measurements taken, with required plots and graphs.

(4) The date of testing.

(5) A list of the parameters verified.

(6) The condition specified for the parameter.

(7) The test results, signed and dated.

(8) A description of adjustments made.

On engine-generator set tests where the engine and generator are required to be connected and operated together, the load power factor must be the power factor specified in the engine generator set parameter schedule . For engine-generator set with dual-fuel operating capability, perform the following tests using the primary fuel type . Perform electrical measurements in accordance with IEEE 120. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulation must be in accordance with IEEE 1. In the following tests where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Tests specifically for the generator may be performed utilizing any prime mover.

a. Insulation Resistance for Stator and Exciter Test, IEEE 115 and IEEE 43, to the performance criteria in NEMA MG 1, Part 22. Generator manufacturer's production line test is acceptable.

b. High Potential Test, in accordance with IEEE 115 and NEMA MG 1, test voltage in accordance with NEMA MG 1. Generator manufacturer's production line test is acceptable.

c. Winding Resistance Test, Stator and Exciter, in accordance with IEEE 115. Generator manufacturer's production line test is acceptable.

d. Phase Balance Voltage Test, to the performance criteria specified in paragraph GENERATOR. This test can be performed with any prime mover. Generator manufacturer's production line test results are acceptable.

   (1) Start and operate the generator at no load.

   (2) Adjust a regulated phase voltage (line-to-neutral) to rated voltage.

   (3) Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

   (4) Apply 75 percent rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

   (5) Apply rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

   (6) Calculate average line-neutral voltage and percent deviation of individual line-neutral voltages from average for each load condition.

e. Current Balance on Stator Winding Test, by measuring the current on each phase of the winding with the generator operating at 100 percent of Rated Output Capacity, with the load impedance equal for each of the three phases: to the performance criteria specified in paragraph GENERATOR.

f. Voltage Waveform Deviation and Distortion Test in accordance with IEEE 115 to the performance criteria specified in paragraph GENERATOR. Use high-speed recording instruments capable of recording voltage waveform deviation and all distortion, including harmonic distortion. Include appropriate scales to provide a means to measure and interpret results.

g. Voltage and Frequency Droop Test. Verify that the output voltage and frequency are within the specified parameters as follows:

   (1) With the generator operating at no load, adjust voltage and

frequency to rated voltage and frequency. Record the generator output frequency and line-line and line-neutral voltages.

(2) Increase load to Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

(3) Calculate the percent droop for voltage and frequency with the following equations:

$$\text{Voltage droop percent} = \frac{(\text{No-Load Volts}) - (\text{Rated Capacity Volts})}{(\text{Service-Load Volts})} \times 100$$

$$\text{Frequency droop percent} = \frac{(\text{No-Load Hertz}) - (\text{Rated Capacity Hertz})}{(\text{Service-Load Hertz})} \times 100$$

(4) Repeat steps 1 through 3 two additional times without making any adjustments.

h. Frequency and Voltage Stability and Transient Response. Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Include the following tabular data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Frequency (before and after load changes).

(5) Generator output power (before and after load changes).

(6) Graphic representations must include the actual instrument trace of voltage and frequency showing: charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

(a) Perform and record engine manufacturer's recommended pre-starting checks and inspections.

(b) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

(c) With the unit at no load, apply the Maximum Step Load Increase.

(d) Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

(e) Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

(f) Apply the Maximum Step Load Increase.

(g) Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

(h) Repeat steps (c) through (g).

i. Test Voltage Unbalance with Unbalanced Load (Line-to-Neutral) to the performance criteria specified in paragraph GENERATOR. Prototype test data is acceptable in lieu of the actual test. Submit manufacturer's standard certification that prototype tests were performed for the generator model proposed. This test may be performed using any prime mover.

(1) Start and operate the generator set at rate voltage, no load, rated frequency, and under control of the voltage regulator. Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(2) Apply the specified load between terminals L_1-L_2, L_2-L_0, and L_3-L_0 in turn. Record all instrument readings at each line-neutral condition.

(3) Express the greatest difference between any two of the line-to-line voltages and any two of the line-to-neutral voltages as a percent of rated voltage.

(4) Compare the largest differences expressed in percent with the maximum allowable difference specified.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the job, perform a Site Visit to verify the information shown on the drawings, before performing any work. Submit a letter stating the date the site was visited and listing discrepancies found. Notify the Contracting Officer in writing of any discrepancies.

3.2 GENERAL INSTALLATION

Provide clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Submit a copy of the manufacturer's installation procedures and a detailed description of the manufacturer's recommended break-in procedure. Install pipe, duct, conduit, and ancillary equipment to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.3 PIPING INSTALLATION

Weld piping. Provide flanged valve connections. Provide flanged connections at equipment. Provide threaded connections to the engine if the manufacturers standard connection is threaded. Except where otherwise specified, use welded flanged fittings to allow for complete dismantling and removal of each piping system from the facility without disconnecting or removing any portion of any other system's equipment or piping. Make connections to equipment with vibration isolation-type flexible connectors. Support and align piping and tubing to prevent stressing of flexible hoses and connectors. Flash pipes extending through the roof. Install piping clear of windows, doors and openings, to permit thermal expansion and contraction without damage to joints or hangers, and install a 1/2 inch drain valve with cap at each low point.

The installation of gas engines must conform to the requirements of NFPA 37 and its references therein, including NFPA 54, NFPA 58, and ASME B31.3.

3.3.1 Support

Provide hangers, inserts, and supports to accommodate any insulation and conforming to MSS SP-58. Space supports no more than 7 feet on center for pipes 2 inches in diameter or less, no more than 12 feet on center for pipes larger than 2 inches but smaller than 4 inches in diameter, and not more than 17 feet on center for pipes larger than 4 inches in diameter. Provide supports at pipe bends or change of direction.

3.3.1.1 Ceiling and Roof

Support exhaust piping with appropriately sized Type 41 single pipe roll and threaded rods; support all other piping with appropriately sized Type 1 clevis and threaded rods.

3.3.1.2 Wall

Make wall supports for pipe by suspending the pipe from appropriately sized Type 33 brackets with the appropriate ceiling and roof pipe supports.

3.3.2 Flanged Joints

Provide flanges that are Class 125 type, drilled, and of the proper size and configuration to match the equipment and engine connections. Provide gasketed flanged joints that are square and tight.

3.3.3 Cleaning

After fabrication and before assembly, piping interiors must be manually wiped clean of debris.

3.3.4 Pipe Sleeves

Fit pipes passing through construction such as ceilings, floors, or walls with sleeves. Extend each sleeve through and fasten in its respective structure and cut flush with each surface. Build the structure tightly to the sleeve. The inside diameter of each sleeve must be minimum 1/2 inch, and where pipes pass through combustible materials 1 inch larger than the outside diameter of the passing pipe or pipe insulation/covering.

3.4 ELECTRICAL INSTALLATION

Perform electrical installation in compliance with NFPA 70, IEEE C2, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. For vibration isolation, provide flexible fittings for conduit, cable trays, and raceways attached to engine-generator sets; provide flexible stranded conductor for metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set; and provide crimp-type terminals or lugs for terminations of conductors on the engine generator set.

3.5 FIELD PAINTING

Perform field painting as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 ONSITE INSPECTION AND TESTS

Perform and report on factory tests and inspections prior to shipment. Provide certified copies of manufacturer's test data and results. Test procedures must conform to ASME, IEEE, and ANSI standards, and to ISO requirements on testing, as appropriate and applicable. The manufacturer performing the tests must provide equipment, labor, and consumables necessary for tests and measuring and indicating devices must be certified to be within calibration. Tests must indicate satisfactory operation and attainment of specified performance. If satisfactory, equipment tested will be given a tentative approval. Equipment must not be shipped before approval of the factory test reports for the following tests.

Submit a letter giving notice of the proposed dates of onsite inspections and tests at least 14 days prior to beginning tests.

a. Submit a detailed description of the Contractor's procedures for onsite tests including the test plan and a listing of equipment necessary to perform the tests at least 14 days prior to beginning tests.

b. Submit six copies of the onsite test data described below in 8-1/2 by 11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Separate sections by heavy plastic dividers with tabs. Provide full size (8-1/2 by 11 inch minimum) data plots showing grid lines, with full resolution.

    (1) A detailed description of the procedures for onsite tests.

    (2) A list of equipment used, with calibration certifications.

    (3) A copy of measurements taken, with required plots and graphs.

    (4) The date of testing.

    (5) A list of the parameters verified.

    (6) The condition specified for the parameter.

    (7) The test results, signed and dated.

    (8) A description of adjustments made.

3.6.1 Test Conditions

3.6.1.1 Data

Make and record measurements of all parameters necessary to verify that each set meets specified parameters. If the results of any test step are not satisfactory, make adjustments, replacements, or repairs and repeat the step until satisfactory results are obtained. Unless otherwise indicated, record data in 15 minute intervals during engine-generator set operation and include: readings of all engine-generator set meters and gauges for electrical and power parameters; oil pressure; ambient temperature; and engine temperatures available from meters and gauges supplied as permanent equipment on the engine-generator set. Perform electrical measurements in accordance with IEEE 120. Definitions of terms are in accordance with IEEE 100. Provide temperature limits in the rating of electrical equipment and for the evaluation of electrical insulations in accordance with IEEE 1.

3.6.1.2 Power Factor

Submit the generator capability curve showing generator kVA output capability (kW vs. kvar) for both leading and lagging power factors ranging from 0 to 1.0. For all engine-generator set operating tests the load power factor must be the power factor specified in the engine-generator set parameter schedule .

3.6.1.3 Contractor Supplied Items

Provide equipment and supplies required for inspections and tests including fuel, test instruments, and loadbanks at the specified power factors.

3.6.1.4 Instruments

Verify readings of panel gauges, meters, displays, and instruments provided as permanent equipment during test runs, using test instruments of greater precision and accuracy. Test instrument accuracy must be within the following: current plus or minus 1.5 percent, voltage plus or minus 1.5 percent, real power plus or minus 1.5 percent, reactive power plus or minus 1.5 percent, power factor plus or minus 3 percent, frequency plus or minus 0.5 percent. Calibrate test instruments by a recognized standards laboratory within 30 days prior to testing.

3.6.1.5 Sequence

Provide the sequence of testing as specified in the approved testing plan unless variance is authorized by the Contracting Officer. Perform field testing in the presence of the Contracting Officer. Schedule and sequence tests in order to optimize run-time periods; however, follow the general order of testing: Construction Tests; Inspections; Pre-operational Tests; Safety Run Tests; Performance Tests; and Final Inspection.

3.6.2 Construction Tests

Perform individual component and equipment functional tests for fuel piping, coolant piping, and lubricating-oil piping, electrical circuit continuity, insulation resistance, circuit protective devices, and equipment not provided by the engine-generator set manufacturer prior to connection to the engine-generator set.

3.6.2.1 Piping Test

a. Flush lube-oil and fuel-oil piping with the same type of fluid intended to flow through the piping, until the outflowing fluid has no obvious sediment or emulsion.

b. Test fuel piping which is external to the engine-generator set in accordance with NFPA 30. Pressure all remaining piping which is external to the engine-generator set with air pressure at 150 percent of the maximum anticipated working pressure, but not less than 150 psi, for a period of 2 hours to prove the piping has no leaks. If piping is to be insulated, perform the test before the insulation is applied.

3.6.2.2 Electrical Equipment Tests

a. Perform low-voltage cable insulation integrity tests for cables connecting the generator breaker to the automatic transfer switch . Test low-voltage cable, complete with splices, for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. Apply a test voltage of 500 volts dc for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. Provide the minimum value of insulation as follows:

(1) R in meg-ohms = (rated voltage in kV plus 1) x 304.8/(length of cable in meters)

(2) R in meg-ohms = (rated voltage in kV plus 1) x 1000/(length of cable in feet)

(3) Each cable failing this test must be repaired or replaced. The repair cable must be retested until failures have been eliminated.

3.6.3 Inspections

Perform the following inspections jointly by the Contracting Officer and the Contractor, after complete installation of each engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Submit a letter certifying that all facilities are complete and functional; that each system is fully functional; and that each item of equipment is complete, free from damage, adjusted, and ready for beneficial use. Perform checks applicable to the installation. Document and submit the results of those which are physical inspections (I) in accordance with paragraph SUBMITTALS. Present manufacturer's data for the inspections designated (D) at the time of inspection. Verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Provide manufacturer's statements to certify provision of features which cannot be verified visually.

Drive belts	I
Governor type and features	I
Engine timing mark	I

Starting motor	I
Starting aids	I
Coolant type and concentration	D
Radiator drains	I
Block coolant drains	I
Coolant fill level	I
Coolant line connections	I
Coolant hoses	I
Combustion air filter	I
Intake air silencer	I
Lube oil type	D
Lube oil sump drain	I
Lube-oil filter	I
Lube-oil level indicator	I
Lube-oil fill level	I
Lube-oil line connections	I
Lube-oil lines	I
Fuel type	D
Fuel level	I
Fuel-line connections	I
Fuel lines	I
Fuel filter	I
Access for maintenance	I
Voltage regulator	I
Battery-charger connections	I
Wiring and terminations	I
Instrumentation	I

Hazards to personnel	I
Base	I
Nameplates	I
Paint	I
Exhaust-heat system	I
Exhaust muffler	I
Switchboard	I
Switchgear	I
Access provided to controls	I
Enclosure is weather resistant	I
Engine and generator mounting bolts (application)	I

3.6.4 Engine Tests

Perform customary commercial factory tests in accordance with ISO 3046 on each engine and associated engine protective device, including, but not limited to the following:

a. Perform dynamometer test at rated power. Record horsepower at rated speed and nominal characteristics such as lubricating oil pressure, jacket water temperature, and ambient temperature.

b. Test and record the values that the low oil pressure alarm and protective shutdown devices actuate prior to assembly on the engine.

c. Test and record values that the high jacket water temperature alarm and protective shutdown devices actuate prior to assembly on the engine.

3.6.5 Generator Tests

Tests must be performed on the complete factory assembled generator prior to shipment. Conduct tests in accordance with IEEE 115, and NEMA MG 1.

3.6.5.1 Routine Tests

Perform the following routine tests on the generators and their exciters:

a. Resistance of armature and field windings.

b. Mechanical balance.

c. Phases sequence.

d. Open circuit saturation curve and phase (voltage) balance test.

e. Insulation resistance of armature and field windings.

f. High potential tes.t

3.6.5.2 Design Tests

Submit the following design tests made on prototype machines that are physically and electrically identical to the generators specified.

a. Temperature rise test

b. Short circuit saturation curve and current balance test

3.6.6 Assembled Engine-Generator Set Tests

Perform the following tests on the assembled engine-generator set.

3.6.6.1 Initial Stabilization Readings

Operate the engine-generator set and allow the set to stabilize at rated kW at rated power factor, rated voltage, and rated frequency. During this period record instrument readings for output power (kW), terminal voltage, line current, power factor, frequency (rpm) generator (exciter) field voltage and current, lubricating oil pressure, jacket water temperature, and ambient temperature at minimum intervals of 15 minutes. Adjust the load, voltage, and frequency to maintain rated load at rated voltage and frequency. Adjustments to load, voltage, or frequency controls must be recorded on the data sheet at the time of adjustment. Stabilization must be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made.

3.6.6.2 Regulator Range Test

Remove load and record instrument readings (after transients have subsided). Adjust voltage to the maximum attainable value or to a value just prior to actuation of the overvoltage protection device. Apply rated load and adjust voltage to the minimum attainable value or a value just prior to activation of the under-voltage protection device. The data sheets must indicate the voltage regulation as a percent of rated voltage and the maximum and minimum voltages attainable. Voltage regulation must be defined as follows:

$$\text{Percent Regulation} = \frac{((\text{No-Load Voltage}) - (\text{Rated-Load Voltage})) \times 100}{(\text{Rated-Load Voltage})}$$

3.6.6.3 Frequency Range Test

Adjust the engine-generator set frequency for the maximum attainable frequency at rated load. Record instrument readings. Adjust the engine-generator set frequency for the specified minimum attainable frequency at rated load. Record instrument readings. Reduce the load to zero and adjust the engine-generator set frequency for the maximum attainable frequency. Record instrument readings. Adjust the engine-generator set frequency for the minimum attainable frequency. Record instrument readings. The data sheet must show the maximum and minimum frequencies attained at rated load, and at no load.

3.6.6.4 Transient Response Test

Drop the load to no load and re-apply rated load three times to ensure that the no load and rated load voltage and frequency values are repeatable and that the frequency and voltage regulation is within the limits specified. Record generator terminal voltage and frequency using a high speed strip chart recorder. The data sheet must show the following results:

a. Frequency

(1) Stability bandwidth or deviation in percent of rated frequency.

(2) Recovery time.

(3) Overshoot and undershoot.

b. Voltage

(1) Stability bandwidth or deviation in percent of rated voltage.

(2) Recovery time.

(3) Overshoot and undershoot.

3.6.7 Pre-operational Tests

3.6.7.1 Protective Relays

Visually and mechanically inspect, adjust, test, and calibrate protective relays in accordance with the manufacturer's published instructions. Include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Implement relay settings in accordance with the installation coordination study. Manually or electrically operate relay contacts to verify that the proper breakers and alarms initiate. Field test relaying current transformers in accordance with IEEE C57.13.1.

3.6.7.2 Insulation Test

Test generator and exciter circuits insulation resistance in accordance with IEEE 43. Take stator readings including generator leads to ATS at the circuit breaker. Record results of insulation resistance tests. Readings must be within limits specified by the manufacturer. Verify mechanical operation, insulation resistance, protective relay calibration and operation, and wiring continuity of ATS assembly. Do not damage generator components during test.

3.6.7.3 Engine-Generator Connection Coupling Test

When the generator provided is a two-bearing machine, inspect and check the engine-generator connection coupling by dial indicator to prove that no misalignment has occurred. Use the dial indicator to measure variation in radial positioning and axial clearance between the coupling halves. Take readings at four points, spaced 90 degrees apart. Align solid couplings and pin-type flexible couplings within a total indicator reading of 0.0005 to 0.001 inch for both parallel and angular misalignment. For gear-type or grid-type couplings, 0.002 inch will be acceptable.

3.6.8 Safety Run Test

For the following tests, repeat the associated safety tests if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

c. Activate the manual emergency stop switch and verify that the engine stops.

d. Remove the high and pre-high lubricating oil temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

e. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine-generator set at no load until the output voltage and frequency stabilize. Monitor the temporarily installed temperature gauges. If either temperature reading exceeds the value required for an alarm condition, activate the manual emergency stop switch.

f. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

g. Remove the high and pre-high coolant temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

h. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine generator-set at no load until the output voltage and frequency stabilize.

i. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

j. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

k. Operate the engine generator-set for at least 2 hours at 75 percent of

Service Load.

l. Verify proper operation and set-points of gauges and instruments.

m. Verify proper operation of ancillary equipment.

n. Manually adjust the governor to increase engine speed past the over-speed limit. Record the RPM at which the engine shuts down.

o. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

p. Manually adjust the governor to increase engine speed to within 2 percent of the over-speed trip speed previously determined and operate at that point for 5 minutes. Manually adjust the governor to the rated frequency.

q. Manually fill the day tank to a level above the overfill limit. Record the level at which the overfill alarm sounds. Verify shutdown of the fuel transfer pump. Drain the day tank down below the overfill limit.

r. Shut down the engine. Remove the time-delay low lube oil pressure alarm bypass and try to start the engine.

s. Attach a manifold to the engine oil system (at the oil pressure sensor port) that contains a shutoff valve in series with a connection for the engine's oil pressure sensor followed by an oil pressure gauge ending with a bleed valve. Move the engine's oil pressure sensor from the engine to the manifold. Open the manifold shutoff valve and close the bleed valve.

t. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

u. Close the manifold shutoff valve. Slowly allow the pressure in the manifold to bleed off through the bleed valve while watching the pressure gauge. Record the pressure at which the engine shuts down. Catch oil spillage from the bleed valve in a container. Add the oil from the container back to the engine, remove the manifold, and reinstall the engine's oil pressure sensor on the engine.

v. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 100 percent of Service Load. Record the maximum sound level in each frequency band at a distance of 75 feet from the end of the exhaust and air intake piping directly along the path of intake and discharge for horizontal piping; or at a radius of 35 feet from the engine at 45 degrees apart in all directions for vertical piping. If a sound limiting enclosure is provided, modify or replace the enclosure, the muffler, and intake silencer must be modified or replaced as required to meet the sound requirements contained within this specification

w. Manually drain off fuel slowly from the day tank to empty it to below the low fuel level limit and record the level at which the audible alarm sounds. Add fuel back to the day tank to fill it above low level alarm limits.

3.6.9 Performance Tests

In the following tests, where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. For the following tests, repeat the associated tests if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries.

3.6.9.1 Continuous Engine Load Run Test

Test the engine-generator set and ancillary systems at service load to demonstrate durability; verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, repeat the entire test. Accomplish the engine load run test during daylight hours, with an average ambient temperature of 75 degrees F, during the month of August. After each change in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Take data taken at 15 minute intervals and include the following:

Electrical: Output amperes, voltage, real and reactive power, power factor, frequency.

Pressure: Lube-oil.

Temperature: Coolant, Lube-oil, Exhaust, Ambient.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warmup period.

c. Operate the engine generator-set for 2 hours at 75 percent of Service Load.

d. Increase load to 100 percent of Service Load and operate the engine generator-set for 4 hours.

e. For prime rated units, increase load to 110 percent of Service Load and operate the engine generator-set for 2 hours.

f. Decrease load to 100 percent of Service Load and operate the engine generator-set for 2 hours or until all temperatures have stabilized.

g. Remove load from the engine-generator set.

3.6.9.2 Voltage and Frequency Droop Test

For the following steps, verify that the output voltage and frequency return to and stabilize within the specified bandwidth values following each load change. Record the generator output frequency and line-line and line-neutral voltages following each load change.

a. With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency.

b. Increase load to 100 percent of Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

c. Calculate the percent droop for voltage and frequency with the following equations.

$$\text{Voltage droop percent} = \frac{\text{No-load volts - rated output capacity volts}}{\text{Rated output capacity volts}} \times 100$$

$$\text{Frequency droop percent} = \frac{\text{No load hertz - rated output capacity hertz}}{\text{Rated output capacity volts}} \times 100$$

d. Repeat steps a. through c. two additional times without making any adjustments.

3.6.9.3 Voltage Regulator Range Test

a. While operating at no load, verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.

b. Increase load to 100 percent of Rated Output Capacity. Verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.

3.6.9.4 Governor Adjustment Range Test

a. While operating at no load, verify that the governor adjusts from 90 to 110 percent of rated frequency.

b. Increase load to 100 percent of Rated Output Capacity. Verify that the governor adjusts from 90 to 110 percent of rated frequency.

3.6.9.5 Frequency and Voltage Stability and Transient Response

Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Include the following tabular data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Frequency (before and after load changes).

(5) Generator output power (before and after load changes.

(6) Include the actual instrument trace of voltage and frequency in graphic representations showing:

Charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

c. With the unit at no load, apply the Maximum Step Load Increase.

d. Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

e. Repeat steps c. through d.

3.6.10 Automatic Operation Tests

Test the automatic operating system to demonstrate automatic starting of each engine-generator set. Utilize load banks at the indicated power factor and actual loads to be served for this test, and the loading sequence is the indicated sequence. Record load-sharing characteristics during all operations. Perform this test for a minimum of two successive, successful tests. Include the following data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Generator output frequency (before and after load changes).

(5) Power division and exchange between generator sets.

(6) Real and reactive power on each set.

a. Initiate loss of the preferred power source and verify the specified sequence of operation.

b. Verify resetting of automatic starting and transfer logic.

3.6.11 Automatic Operation Tests for Stand-Alone Operation

Test the automatic loading system to demonstrate automatic starting, of each engine-generator set. Utilize the actual loads to be served for this test, and the loading sequence is the indicated sequence. Perform this test for a minimum of two successive, successful tests. Include the following data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Generator output frequency (before and after load changes).

a. Initiate loss of the primary power source and verify automatic sequence of operation.

b. Restore the primary power source and verify sequence of operation.

c. Verify resetting of controls to normal.

3.7 GROUNDING

NFPA 70 and IEEE C2, except that grounding systems must have a resistance to solid earth ground not exceeding 5 ohms.

3.7.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION . Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.7.2 Engine-Generator Set Grounding

Provide separate copper grounding conductors and connect them to the ground system as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" must apply.

3.7.3 Connections

Make joints in grounding conductors by exothermic weld or compression connector. Exothermic welds and compression connectors must be installed as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION paragraph regarding GROUNDING.

3.7.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.8 START-UP ENGINEER

Provide the services of a qualified factory trained start-up engineer, regularly employed by the engine-generator set manufacturer. The start-up services must include conducting preliminary operations and functional acceptance tests. The start-up engineer must be present at the engine generator set installation-site, full-time, while preliminary operations and functional acceptance tests are being conducted.

3.9 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the engine-generator set and auxiliary equipment.

3.9.1 Performance of Acceptance Checks and Tests

The acceptance checks and tests must be accomplished by the testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.9.2 Generator Sets

Complete as specified in the paragraph ACCEPTANCE CHECKS AND TESTS.

3.9.2.1 Automatic Transfer Switches

Complete acceptance checks and tests as specified in Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH.

3.9.3 Preliminary Operations

The start-up engineer must conduct manufacturer recommended start-up procedures and tests to verify that the engine-generator set and auxiliary equipment are ready for functional acceptance tests. Give the Contracting Officer 15 days' advance notice that preliminary operations will be conducted. After preliminary operation has been successfully conducted, the start-up engineer will notify the Contracting Officer in writing stating the engine-generator set and auxiliary equipment are ready for functional acceptance tests.

3.9.4 Preliminary Assembled Operation and Maintenance Manuals

Preliminary assembled operation and maintenance manuals must have been submitted to and approved by the Contracting Officer. Manuals must be prepared as specified in the paragraph ASSEMBLED OPERATION AND MAINTENANCE MANUALS.

3.9.5 Functional Acceptance Test Procedure

Test procedure must be prepared by the start-up engineer specifically for the engine-generator set and auxiliary equipment. The test agenda must cover the requirements specified in the paragraph FUNCTIONAL ACCEPTANCE TESTS. The test procedure must indicate in detail how tests are to be conducted. A statement of the tests that are to be performed without indicating how the tests are to be performed is not acceptable. Indicate what work is planned on each workday and identify the calendar dates of the planned workdays. Specify what additional technical support personnel is needed such as factory representatives for major equipment. Specify on which testing workday each technical support personnel is needed. Data recording forms to be used to document test results are to be submitted with the proposed test procedure. A list of test equipment and instruments must also be included in the test procedure.

3.9.6 Test Equipment

Test equipment and instruments must be on hand prior to scheduling field tests or, subject to Contracting Officer approval, evidence must be provided to show that arrangements have been made to have the necessary equipment and instruments on-site prior to field testing.

3.10 FIELD QUALITY CONTROL

Give Contracting Officer 30 days' notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The Contractor must be responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary power conditions. The Contractor must provide labor, equipment, fuel, test load, and consumables required for the specified tests. The test load must be a cataloged product. Calibration of measuring devices and indicating devices must be certified. Refer to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, for requirements for a cataloged product. Perform the following field tests.

3.10.1 Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.10.1.1 Circuit Breakers - Low Voltage Insulated Case/Molded Case

a. Visual and Mechanical Inspection

   (1) Compare nameplate data with specifications and approved shop drawings.

   (2) Inspect circuit breaker for correct mounting.

   (3) Operate circuit breaker to ensure smooth operation.

   (4) Inspect case for cracks or other defects.

   (5) Verify tightness of accessible bolted connections and cable connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

   (6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

   (1) Perform contact-resistance tests.

   (2) Perform insulation-resistance tests.

   (3) Adjust breaker(s) for final settings in accordance with engine-generator set manufacturer's requirements.

3.10.1.2 Current Transformers

a. Visual and Mechanical Inspection

   (1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform polarity tests.

(3) Perform ratio-verification tests.

3.10.1.3 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watt-hour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer secondary circuits are intact.

3.10.1.4 Battery Systems

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(4) Measure electrolyte specific gravity and temperature and visually check fill level.

(5) Verify adequacy of battery support racks, mounting, anchorage, and clearances.

b. Electrical Tests

(1) Set charger float and equalizing voltage levels.

(2) Verify all charger functions and alarms.

(3) Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.

(4) Perform a capacity load test.

3.10.1.5 Engine-Generator Set

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect for correct anchorage and grounding.

b. Electrical and Mechanical Tests

(1) Perform an insulation-resistance test on generator winding with respect to ground. Calculate polarization index.

(2) Perform phase rotation test to determine compatibility with load requirements.

3.10.1.6 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method defined in IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. Take measurements in normally dry weather, not less than 48 hours after rainfall. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.10.2 Functional Acceptance Tests

The tests must be performed by the start-up engineer. Upon successful test completion, the start-up engineer must provide the Contracting Officer with a written test report within 15 calendar days showing the tests performed and the results of each test. The report must include the completed approved test data forms and certification from the start-up engineer that the test results fall within the manufacturer's recommended limits and meet the specified requirements performance. The report must be dated and signed by the start-up engineer, and submitted for approval by the Contracting Officer. The Contracting Officer will witness final acceptance tests. Testing must include, but not be limited to, the following:

a. Verify proper functioning of each engine protective shutdown device and pre-shutdown alarm device. Testing of the devices must be accomplished by simulating device actuation and observing proper alarm and engine shutdown operation.

b. Verify proper functioning of the engine over-speed trip device. Testing of the over-speed trip device must be accomplished by raising the speed of the engine-generator set until an over-speed trip is experienced.

c. Verify proper functioning of the crank cycle/terminate relay. Testing of the relay must be accomplished by engaging the starter motor with the engine being prevented from running. Observe the complete crank/rest cycle as described in the paragraph STARTING SYSTEM.

d. Verify proper functioning of the following automatic and manual operations. Testing must include, but not be limited to, the following:

    (1) Loss of Utility: Initiate a normal power failure with connected test load of rated kW at 1.0 power factor. Record time delay on start, cranking time until engine starts and runs, time to come up to operating speed, voltage and frequency overshoot, and time to achieve steady state conditions with all switches transferred to emergency position.

    (2) Return of Utility: Return normal power and record time delay on retransfer for each automatic transfer switch, and time delay on engine cool-down and shutdown.

    (3) Manual starting.

    (4) Emergency stop.

e. Operate the engine-generator set at rated current (amperes) until the jacket water temperature stabilizes. Stabilization will be considered to have occurred when three consecutive temperature readings remain unchanged. Continue to operate the generator set for an additional 2 hours. Record instrument readings for terminal voltage, line current, frequency (Hz), engine speed rpm, lubricating oil pressure, jacket water temperature, and ambient temperature at 5 minute intervals for first 15 minutes and at 15 minute intervals thereafter.

f. Emissions Tests. Provide on-site testing by a certified testing organization of each engine-generator set. Testing must be in accordance with an EPA approved method, 40 CFR 60, (Appendix, Method 7, 7A, 7B, 7C, 7D or 7E). Emissions at rated full load must be within the limits specified in the paragraph ENGINE EMISSIONS LIMITS.

3.11 DEMONSTRATION

Upon completion of the work and at a time approved by the Contracting Officer, the Contractor must provide instructions by a qualified instructor to the Government personnel in the proper operation and maintenance of the equipment. Government personnel must receive training comparable to the equipment manufacturer's factory training. The duration of instruction must be for not less than one 8 hour working day for instruction of operating personnel and not less than one 8 hour working day for instruction of maintenance personnel.

3.11.1 Instructor's Qualification Resume

Instructors must be regular employees of the engine-generator set manufacturer. The instruction personnel provided to satisfy the requirements above must be factory certified by the related equipment manufacturer to provide instruction services. Submit the name and qualification resume of instructor to the Contracting Officer for approval.

3.11.2 Training Plan

Submit training plan 30 calendar days prior to training sessions. Training plan must include scheduling, content, outline, and training material (handouts). Content must include, but not be limited to, the following:

3.11.2.1 Operating Personnel Training

This instruction includes operating the engine-generator set, auxiliary equipment including automatic transfer switches in all modes, and the use of all functions and features specified.

3.11.2.2 Maintenance Personnel Training

Training must include mechanical, hydraulic, electrical, and electronic instructions for the engine-generator set and auxiliary equipment including automatic transfer switches.

a. Mechanical Training: Must include at least the following:

(1) A review of mechanical diagrams and drawings.

(2) Component location and functions.

(3) Troubleshooting procedures and techniques.

(4) Repair procedures.

(5) Assembly/disassembly procedures.

(6) Adjustments (how, when, and where).

(7) Preventive maintenance procedures.

(8) Review of flow diagram.

(9) Valve locations and function.

(10) Valve and hydraulic equipment adjustment and maintenance procedures.

(11) Hydraulic system maintenance and servicing.

(12) Lubrication points, type, and recommended procedures and

frequency.

b. Electrical and Electronic Maintenance Training: Must include at least the following:

(1) A review of electrical and electronic systems including wiring diagrams and drawings.

(2) Troubleshooting procedures for the machine and control systems.

(3) Electrical and electronic equipment servicing and care.

(4) Use of diagnostics to locate the causes of malfunction.

(5) Procedures for adjustments (locating components, adjustments to be made, values to be measured, and equipment required for making adjustments).

(6) Maintenance and troubleshooting procedures for microprocessor or minicomputer where applicable.

(7) Circuit board repair procedures where applicable (with schematics provided).

(8) Use of diagnostic tapes.

(9) Recommended maintenance servicing and repair for motors, switches, relays, solenoids, and other auxiliary equipment and devices.

3.12 ONSITE TRAINING

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 must start after the system is functionally completed but prior to final acceptance.

a. Submit a letter giving the date proposed for conducting the onsite training course, the agenda of instruction, a description of the digital video recording to be provided. The course instructions must cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as major elements of the operation and maintenance manuals. Additionally, the course instructions must demonstrate routine maintenance procedures as described in the operation and maintenance manuals.

b. One full size reproducible Mylar ach drawing must accompany the booklets. Mylars must be rolled and placed in a heavy cardboard tube with threaded caps on each end. The manual must include step-by-step procedures for system startup, operation, and shutdown; drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems together with their controls, alarms, and safety systems; the manufacturer's name, model number, and a description of equipment in the system. The instructions must include procedures for interface and interaction with related systems to include automatic transfer switches and fire alarm/suppression systems. Each booklet must include a CD containing an ASCII file of the procedures.

c. Provide approved operation and maintenance manuals for the training course. Post approved instructions prior to the beginning date of the training course. Coordinate the training course schedule with the using service's work schedule, and submit for approval 14 days prior to beginning date of proposed beginning date of training.

3.13 INSTALLATION

Installation must conform to the applicable requirements of IEEE C2, NFPA 30, NFPA 37, and NFPA 70.

3.14 FINAL TESTING AND INSPECTION

a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

b. Increase the load in steps no greater than the Maximum Step Load Increase to 100 percent of Service Load, and operate the engine-generator set for at least 30 minutes. Measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.

c. Remove load and shut down the engine-generator set after the recommended cool down period.

d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Verify any corrective action for effectiveness by running the engine for 8 hours at Service Load, then re-examine the oil and filter.

e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.

f. Visually inspect and check engine and generator mounting bolts for tightness and visible damage.

g. Replace air, oil, and fuel filters with new filters.

3.15 MANUFACTURER'S FIELD SERVICE

The engine generator-set manufacturer must furnish a qualified representative to supervise the installation of the engine generator-set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment.

3.16 POSTED DATA AND INSTRUCTIONS

Post Data and Instructions prior to field acceptance testing of the engine generator set.

a. Provide two sets of typed instructions/data in 8-1/2 x 11 inch format, laminated in weatherproof plastic, and placed in three-ring vinyl binders. Place the binders as directed by the Contracting Officer. Provide the instructions prior to acceptance of the engine generator set installation.

b. Include a one-line diagram, wiring and control diagrams and a complete layout of the system in the first set. Include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions in the second set. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches).

c. Submit instructions including: the manufacturers pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches). Provide weatherproof instructions, laminated in plastic, and post where directed.

3.17 ACCEPTANCE

Submit drawings which accurately depict the as-built configuration of the installation, upon acceptance of the engine-generator set installation. Revise layout drawings to reflect the as-built conditions and submit them with the as-built drawings. Final acceptance of the engine-generator set will not be given until the Contractor has successfully completed all tests and all defects in installation material or operation have been corrected.

-- End of Section --

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH

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 B117	(2016) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 20	(2020) Standard for the Installation of Stationary Pumps for Fire Protection
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 110	(2016) Standard for Emergency and Standby Power Systems

UNDERWRITERS LABORATORIES (UL)

UL 508	(2018) UL Standard for Safety Industrial

	Control Equipment
UL 1008	(2014) Transfer Switch Equipment
UL 1066	(2012; Reprint Mar 2017) UL Standard for Safety Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Automatic Transfer Switch Drawings; G

SD-03 Product Data

Automatic Transfer Switches; G

REMOTE ANNUNCIATOR AND CONTROL SYSTEM PANEL; G

SD-06 Test Reports

Acceptance Checks and Tests; G

Functional Acceptance Tests; G

Factory Testing; G

Factory Test Reports; G

SD-07 Certificates

Proof of Listing; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manual, Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, Data Package 5; G

1.3 OPERATION AND MAINTENANCE MANUAL

Assemble and bind manuals in durable, hard-covered, water resistant binders. Assemble and index the manuals per the following table of contents:

a. Manufacturer's O&M per "SD-10 Operation and Maintenance Data".

b. Catalog data required by "SD-03 Product Data"

c. Drawings required by "SD-02 Shop Drawings".

1.3.1 Additions to Operation and Maintenance Manuals

In addition to requirements of SD-10 Data Package 5, include the followings on the actual equipment provided:

a. An outline drawing, front, top, and side views.

b. Prices for spare parts and supply list.

c. Date of Purchase.

d. Corrective maintenance procedures.

e. Operating manual outlining step-by-step procedures for system startup, operation, and shutdown.

f. Include simplified wiring and control diagrams in the manual for system as installed.

g. Provide typical contact voltage drop readings under specified conditions for use during periodic maintenance. Provide instructions for determination of contact integrity.

1.3.2 Spare Parts

Furnish the following the following minimum spare parts and any other spare parts required in one-year operation, of the same material and workmanship, meeting the same requirements, and interchangeable with the corresponding original parts.

a. Fuses: Two of each type and rating.

1.4 QUALITY ASSURANCE

1.4.1 Proof of Listing

Submit proof of listing by UL 1008.

1.4.2 Automatic Transfer Switch Drawings

Include the following as a minimum:

a. An outline drawing, including front, top, and side views.

b. Provide a nameplate of corrosion-resistant material with not less than 1/8 inch tall characters showing manufacturer's name and equipment ratings. Mount nameplate to front of enclosure and meet the nameplate requirements of NEMA ICS 2.

c. Provide detail drawings that include manufacturer's name and catalog number, electrical ratings, total system transfer statement, reduced normal supply voltage at which transfer to the alternate supply is initiated, transfer delay times, short-circuit current rating, wiring diagram, description of interconnections, testing instructions, acceptable conductor type for terminals, tightening torque for each wire connector, and other required UL 1008 markings.

d. Submit interface equipment connection diagram showing conduit and wiring between ATS and related equipment. Provide diagrams showing interlocking provisions and cautionary notes, if any.

e. Drawings are to indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.4.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "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. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated

1.4.4 Standard Product

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.

1.4.4.1 Alternative Qualifications

Products having less than a 2-year field service record are acceptable if the manufacturer has been regularly engaged in the design and production of automatic transfer switches and if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 years prior to date of delivery to site are not acceptable.

1.5 DELIVERY AND STORAGE

Protect equipment placed in storage from humidity and temperature variations, moisture, water intrusion, dirt, dust, or other contaminants. In harsh environments where temperatures exceed non-operational parameters established within this specification, provide an environmentally controlled equipment storage facility to ensure temperature parameters are within equipment specification. Provide documentation of same to the Government when storage is implemented.

1.6 ENVIRONMENTAL CONDITIONS

Provide an ATS that is suitable for prolonged performance under following service conditions:

a. Operating altitude: Sea level to 3,300 ft. (Systems applied at higher altitudes are to be derated in accordance with the manufacturer's instructions).

b. Operating ambient temperature range: 40 to 104 degrees F.

c. Operating relative humidity: 0 to 90 percent, without condensation.

PART 2 PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCHES

Each automatic transfer switch must be rated and marked for total system transfer and have the current and voltage ratings as indicated. Provide a switch operating mechanism that is electrically operated, have quick-make, quick-break, load break contacts, and be mechanically held in both positions. Provide an ATS that is UL listed. ATS must be manufactured and tested in accordance with applicable requirements of NEMA ICS 2, UL 1008 and UL 1066. ATS must conform to NFPA 110. Provide the ATS with the following characteristics:

a. Voltage: 480 volts ac.

b. Amperage: 100 amps ac. Provide an ATS with a continuous load current rating of the switch rating.

c. Number of Phases: Three.

d. Number of Wires: Four.

e. Frequency: 60 Hz.

f. Poles: Four switched. One of the poles is the neutral.

g. ATS Withstand Current Rating: Rated to withstand closing current short-circuit current of 42,000 amperes, RMS symmetrical.

h. Nonwelding Contacts: Provide contacts that are nonwelding at the available fault current rating.

i. Phase and Neutral Contacts: Provide contacts with silver alloy composition. Provide neutral contacts with the same continuous current rating as main or phase contacts.

j. Configuration. Provide an ATS for use in optional standby systems described in NFPA 70.

k. ATS Configuration. Provide an open transition ATS. Neutral is to break and make with the phase contacts.

l. Service Entrance Rated. Provide an integrated circuit breaker and automatic transfer switch. Provide a separate deadfront compartment for the circuit breaker on switches 600 amp and larger. Provide label indicating that the ATS is the service disconnect. Provide a circuit breaker that is rated for 80% of the switch contact current rating. All components, except as noted herein, are to havea continuous load rating.

m. Fire Pump Service. Provide a manual operating means that is externally operable without opening the enclosure on transfer switches for fire pump service. The manual means is to open and close the switch contacts at the same rate of speed as that caused by the automatic operation of the switch. The ATS is to meet the requirements found in NFPA 20.

2.1.1 Undervoltage Sensing - Normal/Preferred Source

Undervoltage Sensing - Normal Source. Provide undervoltage sensing for each phase in the normal/preferred source. Sense low phase-to-ground voltage on each phase. Provide sensing circuit with adjustable dropout, 75-98 percent of nominal value and adjustable pickup, 85-100 percent of nominal value. Factory set dropout value to 85 percent. Factory set pickup value to 90 percent.

2.1.2 Adjustable Time Delay - Override Transfer

Adjustable Time Delay - Override Transfer. For override of normal-source voltage sensing to delay transfer and engine starting signals. Engine starting control contacts with adjustable commit-to-start delay circuit, 0.0-6.0 seconds. Factory set at 1 second.

2.1.3 Voltage/Frequency Lockout Relay - Alternate/Emergency Source

Voltage/Frequency Lockout Relay. Prevent premature transfer to alternate/emergency source. Provide pickup voltage that is adjustable from 85-100 percent of nominal. Factory set for pickup at 90 percent. Provide pickup frequency that is adjustable from 90-97 percent of nominal. Factor set frequency pickup for 95 percent.

2.1.4 Adjustable Time Delay - Transfer to Alternate/Emergency Power Source

Adjustable Time Delay - Transfer to Alternate Power Source. Transfer to alternate power sourcesource time delay for transfer switches as indicated, adjustable 0-5 minutes. Factory set to 0 seconds. ATS is to monitor the frequency and voltage of alternate power source and transfer when frequency and voltage are stabilized.

2.1.5 Adjustable Time Delay- Re-transfer to Normal/Preferred Source

Adjustable Time Delay- Transfer to Source. Re-transfer to normal source time delay, adjustable 0-30 minutes. Factory set at 10 minutes. Time delay is automatically defeated upon loss or sustained undervoltage of alternate power source, provided that normal source has been restored.

2.1.6 Engine-Generator Exerciser

Exerciser. Solid-state, programmable-time switch exerciser to allow automatic starting of the generator set, subsequent load transfer, retransfer of load and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from on a daily, weekly, bi-weekly or monthly basis.. Running periods are adjustable from 10-30 minutes. Factory settings are for 7-day exercise cycle, 20 minute running period and 5-minute cool-down period. Exerciser features include the following:

a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer or dual independent exercisers that allow for unloaded and loaded schedule testing.

b. Push-button programming control with digital display of settings.

c. Integral battery operation of time switch when normal control power is not available.

2.1.7 Engine Shutdown Time Delay

Engine Shutdown. Provide time delay that is adjustable from 0 to 5 minutes and is factory set at 5 minutes.

2.1.8 Engine Starting Contacts
Provide 1 isolated normally closed and 1 isolated normally open contact that is rated 5 A at 250 VAC/30 VDC minimum.

2.1.9 Controls for Fire Pump Service Automatic Transfer Switch
Provide the following additional controls features:

Phase reversal of the normal source is to initiate transfer to the emergency/alternate source.

2.1.10 Unassigned Auxiliary Contacts

Provide two normally open and two normally closed, single-pole, double-throw auxiliary contacts for each switch position rated at 10 amperes at 240 volts.

2.1.11 Front Panel Devices

Provide devices mounted on cabinet front consisting of:

a. Mode selector switch with the following positions and associated functions. Selector switch can be part of the microprocessor controller consisting of an LCD screen with a graphical interface or as a stand-alone test switch.

   (1) TEST - Simulates loss of normal/preferred source system operation.

   (2) NORMAL - Transfers system to normal/preferred source bypassing re-transfer time delay.

b. Switch position indicating lights or graphical LCD display. Indicate source to which load is connected.

c. Source-Available Monitor. Provide source-available indicating lights or graphical LCD display monitor that is labeled to show when one or both sources of power are available. If indicating lights are used, then the prefernce is to have Green be normal/preferred power and Red be for alternate/emergency power; however, other color schemes are allowes if clearly marked..

d. Provide a transfer override switch. Provide automatic transfer switch microprocess or based controller, which offers field selectable/adjustable inputs and outputs for transfer switch operation. Override switch must bypass automatic transfer controls so ATS will transfer and remain connected to generator power source, regardless of condition of normal/preferred source. Provide an indicating light to show override status.

e. Lamp test button.

2.2 ENCLOSURE

Provide an enclosure that meets the following:

a. Provide ATS and accessories in a wall-mounted, ventilated or unventilated NEMA 250, Type 1, smooth sheet metal enclosure constructed in accordance with applicable requirements of NEMA ICS 6, UL 508, UL 1066, and UL 1008. Provide at least No. 14 metal gauge.

b. Factory wiring within enclosure and field wiring terminating within enclosure must comply with NFPA 70. Provide wire that is permanently tagged or marked near terminal at each end with wire number shown on approved detail drawing, when wiring is not color coded. Conform terminal block to NEMA ICS 4. Arrange terminals for entrance of external conductors from top and bottom of enclosure as shown. Main switch terminals, including neutral terminal if used, must be pressure type suitable for termination of external copper conductors shown.

2.2.1 Construction

Construct enclosure for ease of removal and replacement of ATS components and control devices from front without disconnection of external power conductors or removal or disassembly of major components.

2.2.2 Cleaning and Painting

Protect both the inside and outside surfaces of an enclosure, including means for fastening against corrosion by enameling, galvanizing, plating, powder coating, or other equivalent means. Protection is not required for metal parts that are inherently resistant to corrosion, bearings, sliding surfaces of hinges, or other parts where such protection is impractical. Provide manufacturer's standard finish material, process, and color that is free from runs, sags, peeling, or other defects. An enclosure marked Type 1, 3R, 4 or 12 is acceptable if there is no visible rust at the conclusion of a salt spray (fog) test using the test method in ASTM B117, employing a 5 percent by weight, salt solution for 24 hours. Type 4X enclosures are acceptable following performance of the above test with an exposure time of 200 hours.

2.2.3 Field Fabricated Nameplates

Nameplate is to comply with ASTM D709. Provide laminated plastic nameplates for each equipment enclosure as specified or as indicated on the drawings. Provide an inscription on each nameplate that identifies the name of the equipment, sources of power, calculated short circuit with date and the location e.g. 'SWB-1 Electrical Room 103'. Provide nameplates that are made of melamine plastic, 0.125 inch thick, white with black center core. Provide the nameplate with a surface that is matte finished and that has square corners.. Accurately align lettering and engrave into the core. Provide nameplates that are at least 1.0 by 2.5 inches with a minimum lettering size of 0.25 inch high normal block style.

2.3 REMOTE ANNUNCIATOR AND CONTROL SYSTEM PANEL

Provide a remote annunciator and control system that utilizes a touchscreen human machine interface (HMI) with the ability to remotely monitor and control multiple transfer switches from a single panel. Minimum screen size is 7 inches. Provide password protection and date/time stamped alarm history. The controller is to have internal battery backup. In the event of a communication link failure, the system is to automatically revert to stand-alone, self-contained operation. Automatic transfer switch sensing, controlling or operating function is not to depend on remote panel for proper operation. Provide a surface mounted cabinet. Communication is to be by a RS-485 connection. The annunciator controller is to be configured to monitor and control 3 transfer switches.

2.3.1 Monitor

Monitor the following:

a. Sources available

b. Switch position.

c. Switch in test mode.

d. Overvoltage

e. Failure of communication link.

f. Engine test or exercise.

2.3.2 Alarm Screen

Alarm for the following conditions:

a. Alternate source closed

b. Undervoltage

c. Lockout.

2.3.3 Control Functions

Provide a means to perform the following functions from the controller: an alarm silence button in addition to monitoring the following items:

a. Control of switch-test initiation.

b. Control of switch operation in either direction.

c. Control of time-delay bypass for transfer to normal source.

d. Control to perform an engine test.

e. Manage up to eight (8) transfer switches from a single remote annunicator and control panel

2.4 FACTORY TESTING

Submit a description of proposed field test procedures, including proposed date and steps describing each test, its duration and expected results, not less than 2 weeks prior to test date. Submit certified factory and field test reports, within 14 days following completion of tests. Provide reports that are certified and dated and that demonstrate that tests were successfully completed prior to shipment of equipment.

2.4.1 Prototype Factory Testing

A prototype of specified ATS is to be factory tested in accordance with UL 1008. In addition, perform factory tests on each ATS as follows:

a. Insulation resistance test to ensure integrity and continuity of entire system

b. Main switch contact resistance test.

c. Visual inspection to verify that each ATS is as specified.

d. Mechanical test to verify that ATS sections are free of mechanical hindrances.

e. Electrical tests to verify complete system electrical operation and to set up time delays and voltage sensing settings.

2.4.2 Factory Test Reports

Provide three certified copies of factory test reports from the manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

Installation must conform to the requirements of NFPA 70 and manufacturer's recommendation.

3.2 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the automatic transfer switch.

3.2.1 Performance of Acceptance Checks and tests

Complete as specified in paragraph entitled "Acceptance Checks and Tests". The Acceptance Checks and Tests are to be accomplished by the Testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.2.2 Manufacturers O&M Information

The manufacturers O&M information required by the paragraph entitled "SD-10 Operation and Maintenance Data", is to be submitted to and approved by the Contracting Officer.

3.2.3 Test Equipment

Ensure all test equipment and instruments is on hand prior to scheduling field tests, or subject to Contracting Officer's approval, evidence must be provided to show that arrangements have been made to have the necessary equipment and instruments on site prior to field testing.

3.3 FIELD QUALITY CONTROL

Give Contracting Officer 15 days notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The

Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The contractor is responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary power conditions. The contractor provides labor, equipment, apparatus, including test load, and consumables required for the specified tests. Calibration of all measuring devices and indicating devices must be certified. Provide the services of a qualified factory-trained manufacturer's representative to assist the contractor in installation and start-up of the equipment specified under this section. The manufacturer's representative is to provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly components contained herein. Provide a test load that is a cataloged product in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Perform the following field tests in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.3.1 Automatic Transfer Switch Acceptance Checks and Tests

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Verify that manual transfer warnings are attached and visible.

(5) Verify tightness of all control connections.

(6) Verify tightness of accessible bolted connections by calibrated torque-wrench method. Thermographic survey is not required.

(7) Perform manual transfer operation.

(8) Verify positive mechanical interlocking between normal and alternate sources.

b. Electrical Tests

(1) Measure contact-resistance. Correct values that exceed 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

(2) Perform insulation-resistance on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole for one minute. Perform tests in both source positions.

(3) Verify settings and operations of control devices.

(4) Calibrate and set all relays and timers.

3.3.2 Functional Acceptance Tests

Functional Acceptance Tests must be coordinated with Section 26 32 15.00 ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES.Functional Acceptance Test must be coordinated with Section 21 30 00 FIRE PUMPS. Include simulating power failure and demonstrating the following operations for each automatic transfer switch. Demonstrate in service that the automatic transfer switches are in good operating condition, and function not less than five times.

a. Perform automatic transfer tests:

 (1) Simulate loss of normal/preferred power.

 (2) Return to normal/preferred power.

 (3) Simulate loss of emergency/alternate power.

 (4) Simulate all forms of single-phase conditions.

b. Verify correct operation and timing of the following functions:

 (1) Normal source voltage-sensing relays.

 (2) Engine start sequence.

 (3) Time delay upon transfer.

 (4) Alternate source voltage-sensing relays.

 (5) Automatic transfer operation.

 (6) Interlocks and limit switch function.

 (7) Time delay and retransfer upon normal power restoration.

3.3.3 Infrared Scanning

After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after acceptance.

b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

c. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 TRAINING

Provide 4 hours of training to maintenance personnel on the proper operation, maintenance and adjustment of the automatic transfer switch. Coordinate this training with that of the generator equipment.

-- 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	(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 780	(2017) Standard for the Installation of Lightning Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 96	(2016a) UL Standard for Safety Lightning Protection Components
UL 467	(2013; Reprint Jun 2017) 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" 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. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. 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. 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.

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.

2.2 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 copper-clad steel 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 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.

2.2.4 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, including tie-ins to existing lightning protection systems. Lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, grounding electrodesand ground ring electrode conductor. Expose conductors on the structures except where conductors are required to be in protective sleeves. 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 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 Air Terminals

Use adhesive shoes with adhesive approved by the roof manufacturer when installing air terminals on "rubber" (EPDM) type roofs.

3.1.1.2 Roof Conductors

Use adhesive shoes with adhesive approved by the roof manufacturer when installing roof conductors on "rubber" (EPDM) type roofs.

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 and ground ring electrode 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 when a ground ring electrode is not used. 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. For ground ring electrode, provide continuous No. 4/0 bare stranded copper cable. Lay ground ring electrode around the perimeter of the structure in a trench not less than 3 feet nor more than 8 feet from the nearest point of the structure foundation, and at least beyond the drip line for the facility. Install ground ring electrode to a minimum depth of 30 inches. Install a ground ring electrode in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the cable.

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

3.4 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 26 51 00

INTERIOR LIGHTING

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 A580/A580M	(2018) Standard Specification for Stainless Steel Wire
ASTM A641/A641M	(2020) 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	(2018) 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 B164	(2003; R 2014) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B633	(2019) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM D4674 REV A	(2002; R 2010) Standard Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments

EUROPEAN UNION (EU)

Directive 2011/65/EU	(2011) Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10	(2011; Errata 2015) IES Lighting Handbook
IES LM-79	(2008) Electrical and Photometric Measurements of Solid-State Lighting Products

IES LM-80	(2015) Measuring Lumen Maintenance of LED Light Sources
IES RP-16	(2017) Nomenclature and Definitions for Illuminating Engineering
IES TM-21	(2019) Projecting Long Term Lumen Maintenance of LED Light Sources
IES TM-30	(2018) IES Method for Evaluating Light Source Color Rendition

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

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
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 77	(2017) Temporal Light Artifacts: Test Methods and Guidance for Acceptance Criteria
NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2017) Electric Lamps— Specifications for the Chromaticity of Solid State Lighting Products
NEMA C82.77-10	(2020) Harmonic Emission Limits - Related Power Quality Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA SSL 1	(2016) Electronic Drivers for LED Devices, Arrays, or Systems
NEMA SSL 3	(2011) High-Power White LED Binning for General Illumination
NEMA SSL 7A	(2015) Phase-Cut Dimming for Solid State Lighting: Basic Compatibility
NEMA WD 1	(1999; R 2015) Standard for General Color Requirements for Wiring Devices

NEMA WD 7	(2011; R 2016) Occupancy Motion Sensors 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 101	(2018; ERTA 18-1; ERTA 18-2; ERTA 18-3; ERTA 18-4; TIA 18-1; TIA 18-2; TIA 18-3; TIA 18-4) Life Safety Code

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

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 94	(2013; Reprint Sep 2017) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 508	(2018) UL Standard for Safety Industrial Control Equipment
UL 844	(2012; Reprint Mar 2019) UL Standard for Safety Luminaires for Use in Hazardous (Classified) Locations
UL 916	(2015) Standard for Energy Management Equipment
UL 924	(2016; Reprint May 2018) UL Standard for Safety Emergency Lighting and Power Equipment
UL 1472	(2015) UL Standard for Safety Solid-State Dimming Controls
UL 1598	(2008; Reprint Oct 2012) Luminaires
UL 1598C	(2014) Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits
UL 2043	(2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
UL 8750	(2015; Reprint Oct 2019) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires, luminaire accessories, or lighting equipment are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Cybersecurity requirements are specified in Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications and on the drawings, must be as defined in IEEE 100 and IES RP-16.

b. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in IES LM-80.

c. For LED luminaires, "Luminaire Efficacy" (LE) is the appropriate measure of energy efficiency, measured in lumens/watt. This is gathered from LM-79 data for the luminaire, in which absolute photometry is used to measure the lumen output of the luminaire as one entity, not the source separately and then the source and housing together.

d. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire Drawings; G

Occupancy/Vacancy Sensor Coverage Layout; G; S

Lighting Control System One-Line Diagram; G

Sequence of Operation for Lighting Control System; G

SD-03 Product Data

Luminaires; G

Light Sources; G

LED Drivers; G

Luminaire Warranty; G

Lighting Controls Warranty; G

Local Area Controller; G

Lighting Control Panel; G

Gateway; G

Lighting Contactor; G

Switches; G

Wall Box Dimmers; G

Scene Wallstations; G

Occupancy/Vacancy Sensors; G

Photosensors; G

Power Packs; G

Power Hook Luminaire Hangers; GMini Inverters; G

Exit Signs; G

Emergency Drivers; G

SD-05 Design Data

Luminaire Design Data; G

SD-06 Test Reports

IES LM-79 Test Report; G

IES LM-80 Test Report; G

IES TM-21 Test Report; G

IES TM-30 Test Report; G

Occupancy/Vacancy Sensor Verification Test; G

Photosensor Verification Test; G

SD-07 Certificates

LED Driver and Dimming Switch Compatibility Certificate; G

SD-10 Operation and Maintenance Data

Lighting System, Data Package 5; G

Lighting Control System, Data Package 5; G

Maintenance Staff Training Plan; G

End-User Training Plan; G

1.5 QUALITY ASSURANCE

Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES HB-10 as applicable, for the lighting system specified.

1.5.1 Luminaire Drawings

Include dimensions, accessories installation details, and construction details. Photometric data, including CRI, CCT, LED driver type, zonal lumen data, and candlepower distribution data must accompany shop drawings.

1.5.2 Luminaire Design Data

a. Provide safety certification and file number for the luminaire family that must be listed, labeled, or identified in accordance with the NFPA 70. Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).

b. Provide long term lumen maintenance projections for each LED luminaire in accordance with IES TM-21. Data used for projections must be obtained from testing in accordance with IES LM-80.

1.5.3 IES LM-79 Test Report

Submit test report on manufacturer's standard production model of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data in IES format as outlined under "14.0 Test Report" in IES LM-79.

1.5.4 IES LM-80 Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "8.0 Test Report" in IES LM-80.

1.5.5 IES TM-21 Test Report

Submit test report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in IES TM-21.

1.5.6 IES TM-30 Test Report

Submit color vector graphic in accordance with IES TM-30 on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Include spectral distribution of test LED light source.

1.5.7 LED Driver and Dimming Switch Compatibility Certificate

Submit certification from the luminaire, driver, or dimmer switch manufacturer that ensures compatibility and operability between devices without flickering and to specified dimming levels.

1.5.8 Occupancy/Vacancy Sensor Coverage Layout

Provide floor plans showing coverage layouts of all devices using manufacturer's product information.

1.5.9 Test Laboratories

Test laboratories for the IES LM-79 and IES LM-80 test reports must be one of the following:

a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program for both LM-79 and LM-80 testing.

b. One of the qualified labs listed on the Department of Energy - LED Lighting Facts Approved Testing Laboratories List for LM-79 testing.

c. One of the EPA-Recognized Laboratories listed for LM-80 testing.

1.5.10 Regulatory Requirements

Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70, unless more stringent requirements are specified or indicated. Provide luminaires and assembled components that are approved by and bear the label of UL for the applicable location and conditions unless otherwise specified.

1.5.11 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 must have been in satisfactory commercial or industrial use for six months prior to bid opening. The six-month period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the six-month 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.

1.5.11.1 Alternative Qualifications

Products having less than a six-month 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.

1.5.11.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than six months prior to date of delivery to site, unless specified otherwise.

1.6 WARRANTY

Support all equipment items 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.

1.6.1 Luminaire Warranty

Provide and transfer to the government the original LED luminaire manufacturers standard commercial warranty for each different luminaire manufacturer used in the project.

a. Provide a written ten year minimum replacement warranty for material, luminaire finish, and workmanship. Provide written warranty document that contains all warranty processing information needed, including customer service point of contact, whether or not a return authorization number is required, return shipping information, and closest return location to the luminaire location.

    (1) Finish warranty must include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

    (2) Material warranty must include:

        (a) All LED drivers and integral control equipment.

        (b) Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective, non-starting, or operating below 70 percent of specified lumen output.

b. Warranty period must begin in accordance with the manufacturer's standard warranty starting date.

c. Provide replacements that are promptly shipped, without charge, to the using Government facility point of contact and that are identical to or an improvement upon the original equipment. All replacements must include testing of new components and assembly.

1.6.2 Lighting Controls Warranty

Provide and transfer to the government the original lighting controls manufacturers standard commercial warranty for each different lighting controls manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Warranty service must be performed by a factory-trained engineer or technician.

a. Unless otherwise noted, provide a written ten year minimum warranty on the complete system for all systems with factory commissioning. Provide warranty that covers 100 percent of the cost of any replacement parts and services required over the ten years which are directly attributable to the product failure. Failures include, but are not limited to, the following:

    (1) Software: Failure of input/output to execute switching or dimming commands.

    (2) Damage of electronic components due to transient voltage surges.

(3) Failure of control devices, including but not limited to occupancy sensors, photosensors, and manual wall station control devices.

b. Provide a written ten year minimum warranty on all input devices against defect in workmanship or materials provided by device manufacturer.

c. Provide a written ten year minimum warranty on all control components attached to luminaires against defect in workmanship or materials.

1.7 OPERATION AND MAINTENANCE MANUALS

1.7.1 Lighting System

Provide operation and maintenance manuals for the lighting system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting system for the building. Include the following:

a. Manufacturers' operating and maintenance manuals.

b. Luminaire shop drawings for modified and custom luminaires.

c. Luminaire Manufacturers' standard commercial warranty information as specified in paragraph LUMINAIRE WARRANTY.

1.7.2 Lighting Control System

Provide operation and maintenance manuals for the lighting control system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting control system for the building. Include the following:

a. Lighting control system layout and wiring plan.

b. Lighting control system one-line diagram.

c. Product data for all devices, including installation and programming instructions.

d. Occupancy/vacancy sensor coverage layout.

e. Training materials, such as videos or in-depth manuals, that cover basic operation of the lighting control system and instructions on modifying the lighting control system. Training materials must include calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

f. Sequence of operation descriptions for each typical room type, including final programming, schedules, and calibration settings.

g. "As-built" lighting control panel schedules.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

2.2 LUMINAIRES

UL 1598, NEMA C82.77-10. Provide luminaires as indicated in the luminaire schedule and NL plates or details on project plans, complete with light source, wattage, and lumen output indicated. All luminaires of the same type must be provided by the same manufacturer. Luminaires must be specifically designed for use with the driver and light source provided.

2.2.1 Luminaires

UL 8750, IES LM-79, IES LM-80. For all luminaires, provide:

a. Complete system with LED drivers and light sources.

b. Housings constructed of non-corrosive materials. All new aluminum housings must be anodized or powder-coated. All new steel housings must be treated to be corrosion resistant.

c. IES TM-21, IES LM-80. Minimum L70 lumen maintenance value of 50,000 hours unless otherwise indicated in the luminaire schedule. Luminaire drive current value must be identical to that provided by test data for luminaire in question.

d. Minimum efficacy as specified in the luminaire schedule. Theoretical models of initial lamp lumens per watt are not acceptable. If efficacy values are not listed in the luminaire schedule, provide luminaires that meet the following minimum values:

Luminaire Style	Minimum Luminaire Efficacy
Recessed 1 by 4, 2 by 4, and 2 by 2	100 LPW
Recessed Downlight (fixed, adjustable, wallwash)	80 LPW
Linear, Ambient (indirect wall mount, linear pendent)	100 LPW
High Bay, Low Bay, and Industrial Locations	100 LPW
Food Service and Hazardous Locations	60 LPW
Exterior Wall Sconce	50 LPW

e. UL listed for dry or damp location typical of interior installations. Any luminaire mounted on the exterior of the building must be UL listed for wet location typical of exterior installations.

f. LED driver and light source package, array, or module are accessible for service or replacement without removal or destruction of luminaire.

g. Lenses constructed of heat tempered borosilicate glass, UV-resistant acrylic, or silicone. Sandblasting, etching and polishing must be performed as indicated in the luminaire description.

2.2.1.1 Luminaire Conversion Kits

Provide luminaire conversion kits that meet UL 1598C Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits.

2.2.2 Luminaires for Hazardous Locations

In addition to requirements stated herein, provide LED luminaires for hazardous locations which conform to UL 844 or which have Factory Mutual certification for the class and division indicated.

2.3 LIGHT SOURCES

NEMA ANSLG C78.377, NEMA SSL 3. Provide type, delivered lumen output, and wattage as indicated in the luminaire schedule on project plans.

2.3.1 LED Light Sources

Provide LED light sources that meet the following requirements:

a. NEMA ANSLG C78.377. Emit white light and have a nominal CCT of 3000 Kelvin, unless indicated otherwise.

b. Minimum Color Rendering Index (CRI) of 80.

c. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

d. Light source color consistency by utilizing a binning tolerance within a 3-step McAdam ellipse.

2.4 LED DRIVERS

NEMA SSL 1, UL 8750. Provide LED drivers that are electronic, UL Class 1 or Class 2, constant-current type and that comply with the following requirements:

a. The combined driver and LED light source system does not exceed the minimum luminaire efficacy values as listed in the luminaire schedule provided.

b. Operates at a voltage of 120-277 volts at 50/60 hertz, with input voltage fluctuations of plus/minus 10 percent.

c. Power Factor (PF) greater than or equal to 0.90 at full input power and across specified dimming range.

d. Maximum Total Harmonic Distortion (THD) less than 20 percent at full input power and across specified dimming range.

e. Operates for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.

f. Withstands Category A surges of 4 kV without impairment of performance. Provide surge protection that is integral to the driver.

g. Integral thermal protection that reduces the output power to protect the driver and light source from damage if the case temperature approaches or exceeds the driver's maximum operating temperature.

h. 47 CFR 15. Complies with the requirements of the Federal Communications Commission (FCC) rules and regulations, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).

i. Class A sound rating.

j. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

k. Provide dimming capability as indicated in the luminaire schedule on project plans. Dimmable drivers must dim down to 10 percent. Dimmable drivers must be controlled by a Class 2 low voltage 0-10VDC controller or Digital Addressable Lighting Interface (DALI)dimming signal protocol unless otherwise specified. LED drivers of the same family/series must track evenly across multiple luminaires at all light levels.

2.5 LIGHTING CONTROLS

Provide network certification for all networked lighting control systems and devices in accordance with the requirements of Section 25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS. Provide lighting control systems that do not switch off battery-operated or emergency backup luminaires or exit signs in path of egress. Provide system with override of lighting control devices controlling luminaires in path of egress with activation of fire alarm system.

2.5.1 System

Provide lighting control system that operates the lighting system as described in the lighting control strategies in the project plans. Submit Sequence of Operation for Lighting Control System describing the operation of the proposed lighting control system and devices. Sequence of Operation must provide the strategies identified in the lighting control strategies.

2.5.1.1 Localized Control Systems

Provide room or area-wide lighting control system capable of manual control, time-based control, and receiving input from photosensors and occupancy/vacancy sensors.

2.5.1.1.1 Local Area Controller

Provide controller designed for single area or room with the following requirements:

a. Operates at a voltage of 120-277 volts at 50/60 hertz.

b. 2 zone, with 2 relays rated 20 amps each with at least one manual switch per zone.

c. Provide inputs for occupancy/vacancy sensors, photosensors, and low-voltage wall switches.

d. Provide daylight harvesting capability with full-range dimming control with input from photosensor.

e. Provide capability for receptacle load control from occupancy sensors.

f. Capable of 0-10V dimming.

g. Provide override 'ON' function with input from Fire Alarm Control Panel for all emergency lighting. Controller must not turn off power to emergency batteries or exit signs.

2.5.1.2 Centralized Control Systems

Provide a centralized lighting control system capable of manual control, time-based control, receiving input from photosensors and occupancy/vacancy sensors, with the capabilities of controlling, monitoring, and programming changes from one centralized on-site location, and integration with other building systems.

2.5.1.2.1 Lighting Control Panel

UL 916, 47 CFR 15. Provide an electronic, programmable lighting control panel complete with microprocessor, capable of providing lighting control with input from internal programming, digital switches, and other control devices.

Enclose panel hardware in a surface-mounted, NEMA 1, painted, steel enclosure with lockable access door and ventilation openings. Internal low-voltage compartment must be separated from line-voltage compartment of enclosure with only low-voltage compartment accessible upon opening of door. Provide additional remote cabinets that communicate back to main control panel as required. Provide Lighting Control Panels that meet the following criteria:

a. Input voltage of 120-277 at 50/60 Hz, with internal low-voltage VDC power supply as required.

b. Solid-state, microprocessor-based, internal astronomical time clock. Microprocessor must have nonvolatile memory and must reset automatically after power interruptions of up to 90 days.

c. Interface for providing local programming and control capability, with physical key-locked cover or programmed security access code to prevent unauthorized use.

d. Dimming modules capable of 0-10V dimming.

e. Modules and control panels include multichannel output with at least 4 channels, with multiple inputs for manual control, photosensors, and occupancy/vacancy sensors.

f. Outputs that require line-voltage switching are provided by relays which are designed for 10 years of use at full rated load.

g. Control processor indicates failure of normal power and which circuits are supplied by alternative power source if connected to emergency lighting units.

h. Provide building automation system write access points to lighting control system for manual override or building schedules.

i. Provide building automation read access points to lighting control system for calculated energy use in kilowatt-hours.2.5.1.2.2 Gateway

Provide gateway in accordance with Section 25 10 10 UTILITY MONITORING AND

CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION. Provide hardware and software to enable the BAS to monitor, control, display, and record data for use in processing reports. Provide BACnet communication interface that enables remote control and monitoring of lighting from a workstation according to read access points and write access points listed in this section. Control features and monitoring points displayed locally at lighting panel must be available through the Gateway. Provide Gateway that meets the following requirements:

a. Microprocessor-based communications device that perform bi-directional protocol translation.

b. Support full bi-directional communication and translation.

c. Contain its own microprocessor, RAM, battery, communication ports, and power supply.

2.5.1.2.3 Lighting Contactor

NEMA ICS 2, NEMA ICS 6. Provide an electrically-held lighting contactor housed in a NEMA 1 enclosure. Provide contactor with one normally closed(NC), single pole contacts, rated 600 volts, 30 amps. Provide coil operating voltage of 120 volts.

2.5.2 Devices

2.5.2.1 Switches

Provide line-voltage toggle switches as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. When used for non-digital loads, devices must be rated at 20 Amps inductive load, and be compatible with the lighting control systems.

2.5.2.2 Wall Box Dimmers

UL 1472, UL 20, IEEE C62.41, NEMA 77, NEMA SSL 7A. Dimmers must provide flicker-free, continuously variable light output throughout the dimming range of 10 percent to 100 percent. Devices must be capable of operating at their full rated capacity regardless of being single or ganged-mounted, and be compatible with three-way and four-way switching scenarios.

Provide wall-box dimmers that meet the following requirements:

a. Device operates as part of a lighting control system.

b. Device operates with the use of a vertical slider, paddle, rotary, button, or toggle with adjacent vertical slider.

c. Finish of device matches switches and outlets in the same area.

d. Back box in wall has sufficient depth to accommodate body of switch and wiring.

e. Dimmer is capable of controlling 0-10 volt LED drivers. Dimmers and the drivers they control must be provided from the same manufacturer or tested and certified as compatible for use together.

f. Radio frequency interference suppression is integral to device.

2.5.2.3 Scene Wallstations

Provide scene wallstations that are compatible with the other components of the lighting control system and capable of Class 1 or 2 wiring methods in accordance with the NEC and local codes. Provide devices that contain on/off group, preset scene functions, or dim up/dim down interface through front panel. Programming of new scenes or zone assignments must be accomplished by authorized personnel from the space being controlled. Provide labeling for each button, including laminated sheet with scene descriptions to be posted near each scene controller.

2.5.2.4 Occupancy/Vacancy Sensors

IEEE C62.41, NEMA WD 1, UL 94, UL 916, UL 508, ASTM D4674 REV A, NEMA WD 7. Provide occupancy/vacancy sensors with coverage patterns as indicated on manufacturer shop drawings. Provide no less quantity of sensors as shown on plans, but add additional sensors when required to fulfill coverage requirement for the specific model of sensor provided. Provide vacancy sensor operation that requires manual control to activate luminaires and turns luminaires off after a set time of inactivity. Provide ceiling or wall-mounted occupancy/vacancy sensors that meet the following requirements:

a. Operating voltage of 120-277 volts.

b. Time delay of 30 seconds to 30 minutes with at least four intermediate time delay settings.

c. Sensors are ceiling mounted.

d. Networked sensor with no minimum or maximum load. Sensor is programmed to control zones.

e. Shielded or controlled by internal logic to adjust sensitivity to avoid false triggering due to ambient temperature, air temperature variations or HVAC air movement.

f. Sensor is equipped to automatically energize the connected load upon loss of normal power when located in a means of egress.

g. Occupancy and vacancy operation is field-adjustable and programmable via lighting control system processor.

h. No leakage current to load when in the off mode.

i. Utilize zero-crossing circuitry to prevent damage from high inrush current and to promote long life operation.

j. Allow the adding or deleting of specific luminaires or zones to the assigned sensor without the use of ladders. Provide sensors that allow for remote control adjustments of operational parameters (sensitivity, time delay), and that are be able to transmit, receive, and store system information through the lighting control system processor.

2.5.2.4.1 Passive Infrared Sensors

Provide Passive Infrared Sensors (PIR) sensors that detect occupancy by sensing heat and movement in the area of coverage. Provide sensors are constructed of a housing of high-impact, injection-molded thermoplastic. Provide PIR sensors that are temperature compensated, with a dual element sensor and a multi-element fresnel lens of POLY IR4 material.

2.5.2.4.2 Ultrasonic Sensors

Provide ultrasonic sensors that detect occupancy by sensing a change in pattern of reflected ultrasonic waves in the area of coverage. Provide sensors that are constructed of a housing of high-impact, injection-molded thermoplastic. Provide ultrasonic sensors that operate at 40 kHz.

2.5.2.4.3 Dual Technology Sensors

Provide dual technology sensors that meet the requirements for PIR sensors and ultrasonic sensors indicated above. If either the PIR or ultrasonic sensing registers occupancy, the luminaires must remain on.

2.5.2.4.4 High Bay Sensors

Provide occupancy/vacancy sensors specifically designed for high-bay mounting applications for all ceiling-mounted sensors mounted above 35 feet using PIR technology. Provide high-bay sensors with interchangeable lenses for 360 degree open area coverage or narrow rectangular warehouse aisle coverage.

2.5.2.4.5 Integrated Sensors

Provide integrated occupancy/vacancy sensors that mount directly to the luminaires as indicated in project plans.

2.5.2.4.6 Power Packs

UL 2043. Provide power packs to provide power to lighting control sensors as required in accordance with the manufacturer's specifications. Provide power packs that meet the following requirements:

a. Operate at an input voltage of 120-277 VAC, with an output voltage 12-24 VDC at 225 mA.

b. Constructed of plenum-rated, high-impact thermoplastic enclosure.

c. Utilizes zero-crossing circuitry to prevent damage from inrush current.

d. Maximum load rating of 16 amps for electronic lighting loads.

e. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

2.5.2.5 Photosensors

Provide photosensors that meet the following requirements:

a. Detect changes in ambient lighting level and enable dimming as required by sequence of operation by operating in an open-loop system.

b. Contain a detection cone, where the base of the cone may be circular or an elongated shape, and where the smallest angle between the edge and the axis of the cone is between 20 and 50 degrees. The cone axis may be tilted to the vertical when installed to give the sensor preferred directionality.

c. Sensors are ceiling-mounted or wall-mounted with sensitivity, filtering, range and viewing angle to meet requirements of sequence of operation, scope of work and construction documents.

d. Time delay that is adjustable from 1 to 30 seconds ON delay, and 1 to 30 minutes OFF delay to prevent cycling, with deadband adjustment of 25 percent to 100 percent above lower setpoint.

e. Output dimming signal is linear to light level with less than 1 percent variation. Cadmium sulfide photo-resistors are not acceptable.

f. Sensor is not combined in the same housing or location with occupancy or vacancy sensors if the proper location for one function compromises the successful operation of the other function, or in any way reduces the system's ability to meet the design intent.

2.6 EXIT AND EMERGENCY LIGHTING EQUIPMENT

2.6.1 Exit Signs

UL 924, NFPA 101. Provide wattage as indicated in the luminaire schedule on project plans. Provide LED Exit Signs that meet the following criteria:

a. Housing constructed of UV-stable, thermo-plastic.

b. UL listed for damp location.

c. Configured for universal mounting.

d. 6 inch high, 3/4 inch stroke red lettering on face of sign with chevrons on either side of lettering to indicate direction.

e. Single or double face as indicated in project plans and luminaire schedule.

2.6.1.1 Exit Signs with Battery Backup

Equip with automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than ten years. Emergency run time must be a minimum of 1-1/2 hours. LEDs must have a minimum rated life of 10 years. Provide self-diagnostic circuitry integral to emergency LED driver.

2.6.2 Emergency Lighting Unit (ELU)

UL 924, NFPA 101. Provide emergency lighting units (ELUs) completely assembled with wiring and mounting devices, ready for installation at the locations indicated. Provide in UV-stable, thermo-plastic housing with UL damp label as indicated. Emergency lighting units must be rated for 12 volts, except units having no remote-mounted light sources and having no more than two unit-mounted light sources may be rated six volts. Equip units with brown-out sensitive circuit to activate battery when input voltage falls to 75 percent of normal. Equip with two LED light sources, automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than ten years. Emergency run time must be a minimum of 90 minutes. LEDs must have a minimum rated life of 10 years. Provide self-diagnostic circuitry integral to emergency LED driver.

2.6.3 LED Emergency Drivers

UL 924, NFPA 101. Provide LED emergency driver with automatic power failure detection, test switch and LED indicator (or combination switch/indicator) located on luminaire exterior, and fully-automatic solid-state charger, battery and inverter integral to a self-contained housing. Provide self-diagnostic function integral to emergency driver. Integral nickel-cadmium battery is required to supply a minimum of 90 minutes of emergency power at indicated wattage, 10-50 VDCcompatible with LED forward voltage requirements, constant output. Driver must be RoHS compliant, rated for installation in plenum-rated spaces and damp locations, and be warranted for a minimum of ten years.

2.6.4 Self-Diagnostic Circuitry for LED Drivers

UL 924, NFPA 101. Provide emergency lighting unit with fully-automatic, integral self-testing/diagnostic electronic circuitry. Circuitry must provide for a one minute diagnostic test every 28 days, and a 30 minute diagnostic test every six months, minimum. Any malfunction of the unit must be indicated by LED(s) visible from the exterior of the luminaire. A manual test switch must also be provided to perform a diagnostic test at any given time.

2.6.5 Mini Inverters

UL 924, NFPA 101. Provide mini inverters that are designed to provide power to emergency luminaires. Provide mini inverters that are suitable for damp installations, operate at a voltage of 120-277 volts at 50/60 hertz, and are capable of operating 0-10V dimming override. Provide mini inverters that supply a minimum of 90 minutes of emergency power.

2.7 LUMINAIRE MOUNTING ACCESSORIES

2.7.1 Suspended Luminaires

a. Provide hangers capable of supporting twice the combined weight of luminaires supported by hangers.

b. Hangers must allow luminaires to swing within an angle of 45 degrees. Brace pendents 4 feet or longer to limit swinging.

c. Single-unit suspended luminaires must have hangers. Multiple-unit or continuous row luminaires with a separate power supply cord must have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end.

d. Provide all linear pendent and surface mounted luminaires with two supports per four-foot section or three per eight-foot section unless otherwise recommended by manufacturer.

e. Provide rods in minimum 0.18 inch diameter.

2.7.2 Recess and Surface Mounted Luminaires

Provide access to light source and LED driver from bottom of luminaire. Provide trim and lenses for the exposed surface of flush-mounted luminaires as indicated on project drawings and specifications. Luminaires recessed in ceilings which have a fire resistive rating of one hour or more must be enclosed in a box which has a fire resistive rating equal to that of the ceiling. For surface mounted luminaires with brackets, provide flanged metal stem attached to outlet box, with threaded end suitable for supporting the luminaire rigidly in design position. Flanged part of luminaire stud must be of broad base type, secured to outlet box at not fewer than three points.

2.7.3 Luminaire Support Hardware

2.7.3.1 Wire

ASTM A641/A641M. Galvanized, soft tempered steel, minimum 0.11 inches in diameter, or galvanized, braided steel, minimum 0.08 inches in diameter.

2.7.3.2 Wire for Humid Spaces

ASTM A580/A580M. Composition 302 or 304, annealed stainless steel, minimum 0.11 inches in diameter.

ASTM B164. UNS NO4400, annealed nickel-copper alloy, minimum 0.11 inches in diameter.

2.7.3.3 Threaded Rods

Threaded steel rods, 3/16 inch diameter, zinc or cadmium coated.

2.7.3.4 Straps

Galvanized steel, one by 3/16 inch, 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.

2.7.4 Power Hook Luminaire Hangers

UL 1598. Provide an assembly consisting of through-wired power hook housing, interlocking plug and receptacle, power cord, and luminaire support loop. Power hook housing must be cast aluminum having two 3/4 inch threaded hubs. Support hook must have safety screw. Luminaire support loop must be cast aluminum with provisions for accepting 3/4 inch threaded stems. Power cord must include 16 inches of 3 conductor No. 16 Type SO cord. Assembly must be rated 120 volts or 277 volts, 15 amperes.

2.8 EQUIPMENT IDENTIFICATION

2.8.1 Manufacturer's Nameplate

Each item of equipment must 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.

2.8.2 Labels

UL 1598. All luminaires must be clearly marked for operation of specific light sources and LED drivers. The labels must be easy to read when standing next to the equipment, and durable to match the life of the equipment to which they are attached. Note the following light source characteristics in the format "Use Only _____":

a. Correlated Color Temperature (CCT) and Color Rendering Index (CRI) for all luminaires.

b. Driver and dimming protocol.

All markings related to light source type must be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when light sources are in place. LED drivers must have clear markings indicating dimming type and indicate proper terminals for the various outputs.

2.9 FACTORY APPLIED FINISH

NEMA 250. Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum, meets requirements of corrosion-resistance testing.

PART 3 EXECUTION

3.1 INSTALLATION

IEEE C2, NFPA 70.

3.1.1 Light Sources

When light sources are not provided as an integral part of the luminaire, deliver light sources of the type, wattage, lumen output, color temperature (CCT), color rendering index (CRI), and voltage rating indicated to the project site and install just prior to project completion, if not already installed in the luminaires from the factory.

3.1.2 Luminaires

Set luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent luminaires and secure in accordance with manufacturers' directions and approved drawings. Provide accessories as required for ceiling construction type indicated on Finish Schedule. Luminaire catalog numbers do not necessarily denote specific mounting accessories for type of ceiling in which a luminaire may be installed. Provide wires, straps, or rods for luminaire support in this section. Install luminaires with vent holes free of air blocking obstacles.

3.1.2.1 Suspended Luminaires

Measure mounting heights from the bottom of the luminaire for ceiling-mounted luminaires and to center of luminaire for wall-mounted luminaires. Obtain architect approval of the exact mounting height on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Support suspended luminaires from structural framework of ceiling or from inserts cast into slab.

a. Provide suspended luminaires with 45 degree swivel hangers so that they hang plumb and level.

b. Locate so that there are no obstructions within the 45 degree range in all directions.

c. The stem, canopy and luminaire must be capable of 45 degree swing.

d. Rigid pendent stem, aircraft cable, rods, or chains 4 feet or longer excluding luminaire must be braced to prevent swaying using three cables at 120 degree separation.

e. Suspended luminaires in continuous rows must have internal wireway systems for end to end wiring and must be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces.

f. Utilize aligning splines on extruded aluminum luminaires to assure minimal hairline joints.

g. Support steel luminaires to prevent "oil-canning" effects.

h. Match supporting pendents with supported luminaire. Aircraft cable must be stainless steel.

i. Match finish of canopies to match the ceiling, and provide low profile canopies unless otherwise shown.

j. Maximum distance between suspension points must be 10 feet or as recommended by the manufacturer, whichever is less.

3.1.2.2 Recessed and Semi-Recessed Luminaires

a. Support recessed and semi-recessed luminaires independently from the building structure by a minimum of two wires, straps or rods per luminaire and located near opposite corners of the luminaire. Secure horizontal movement with clips provided by manufacturer. Ceiling grid clips are not allowed as an alternative to independently supported luminaires.

b. Support round luminaires or luminaires smaller in size than the ceiling grid independently from the building structure by a minimum of four wires, straps or rods per luminaire, spaced approximately equidistant around.

c. Do not support luminaires by acoustical tile ceiling panels.

d. Where luminaires of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support each independently and provide at least two 3/4 inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the luminaire.

e. Luminaires installed in suspended ceilings must also comply with the requirements of Section 09 51 00 ACOUSTICAL CEILINGS.

f. Adjust aperture rings on all applicable ceiling recessed luminaires to accommodate various ceiling material thickness. Coordinate cut-out size in ceiling to ensure aperture covers cut-out entirely. Install aperture rings such that the bottom of the ring is flush with finished ceiling or not more than 1/16 inch above. Do not install luminaires such that the aperture ring extends below the finished ceiling surface.

3.1.3 LED Drivers

Provide LED drivers integral to luminaire as constructed by the manufacturer.

3.1.4 Exit Signs

NFPA 101. Wire exit signs and emergency lighting units ahead of the local switch, to the normal lighting circuit located in the same room or area.

3.1.5 Lighting Controls

Refer to Section 25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS for additional lighting control installation requirements.

3.1.5.1 Scene Wallstations

Submit labeling templates for all scene wallstations, ganged faceplates and other manual control cover plates. Label each scene control button with approved scene description.

3.1.5.2 Occupancy/Vacancy Sensors

a. Provide quantity of sensor units indicated as a minimum. Provide additional units to give full coverage over controlled area. Full coverage must provide hand and arm motion detection for office and administration type areas and walking motion for industrial areas, warehouses, storage rooms and hallways.

b. Locate ceiling-mounted sensors no closer than 6 feet from the nearest HVAC supply or return diffuser.

c. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations.

3.1.5.3 Photosensors

Locate and aim sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor set-point in accordance with the manufacturer's recommendations and for the indicated light level of the area of coverage, measured at the work plane.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

3.2.1.1 Lighting Control Verification Tests

Verify lighting control system and devices operate according to approved sequence of operations. Verification tests are to be completed after commissioning.

a. Verify occupancy/vacancy sensors operate as described in sequence of operations. Provide testing of sensor coverage, sensitivity, and time-out settings in all spaces where sensors are placed. This is to be completed only after all furnishings have been installed. Submit occupancy/vacancy sensor verification test.

b. Verify photosensors operate as described in sequence of operations.

Provide testing of sensor coverage, aiming, and calibration in all spaces where sensors are placed. This is to be completed only after all furnishings have been installed. Submit photosensor verification test.

c. Verify wall box dimmers and scene wallstations operate as described in sequence of operations.

3.2.1.2 Emergency Lighting Test

Interrupt power supply to demonstrate proper operation of emergency lighting. If adjustments are made to the lighting system, re-test system to show compliance with standards.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Commissioning

NFPA 101. Factory Trained Field Service Technician is responsible for calibration and programming sequences for input devices and systems in accordance with the requirements described in the sequence of operation.

3.3.2 Training

3.3.2.1 Maintenance Staff Training

Submit a Maintenance Staff Training Plan at least 30 calendar days prior to training session that describes training procedures for Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide on-site training which demonstrates full system functionality, assigning schedules, calibration adjustments for light levels and sensor sensitivity, integration procedures for connecting to third-party devices, and manual override including information on appropriate use. Provide protocols for troubleshooting, maintenance, repair, and replacement, and literature on available system updates and process for implementing updates.

3.3.2.2 End-User Training

Submit an End-User Training Plan at least 30 calendar days prior to training session that describes training procedures for end-users on the lighting control system. Provide users with a list of control devices located within user-occupied spaces, such as photosensors and occupancy and vacancy sensors, including information on the proper operation and schedule for each device. Provide demonstration for each type of interface. Provide users with the building schedule as currently commissioned, including conditional programming based on astronomic time clock functionality. Provide users with the correct contact information for maintenance personnel who will be available to address any lighting control issues.

Provide laminated instructions to the user at each scene wallstation. Provide only instructions relevant to the functionality of the specific scene wallstation. Provide a description of each labeled scene control button. If the room utilizes occupancy/vacancy sensors or photosensors, include a description of this functionality on the instruction sheet.

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